Energy Systems & Design

ESPANOL
JAPANESE INFO
HOME
PRODUCTS
HOW IT WORKS
ASSESSMENTS
BALANCE OF SYSTEM
COMPONENTS
APPENDIX
DOWNLOADS
ARTICLES
DEFINITIONS
CLIENTS
PRICE LIST
STAFF
CONTACT US
LINKS
Download ES&D BROCHURE.pdf

"Innovative Micro-Hydro Systems Since 1980"

Mission Statement:

To sustain the Earth and provide ourselves and others with meaningful, enjoyable, purposeful work, by making alternatives to conventional power projects available and affordable to those beyond the power lines through the incorporation of transitional technologies.

Energy Systems & Design has been producing micro-hydroelectric components since 1980. We make equipment that converts the energy in moving water into electricity. We offer a wide array of products and services to the renewable energy (RE) marketplace and international installation services.

We offer the Stream Engine, a breakthrough in hydro technology, and we have recently introduced the LH1000, low-head propeller turbine, which operates from 1 to 3 metres of head or vertical fall of the water.

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Mission Statement:

To sustain the Earth and provide ourselves and others with meaningful, enjoyable, purposeful work, by making alternatives to conventional power projects available and affordable to those beyond the power lines through the incorporation of transitional technologies.

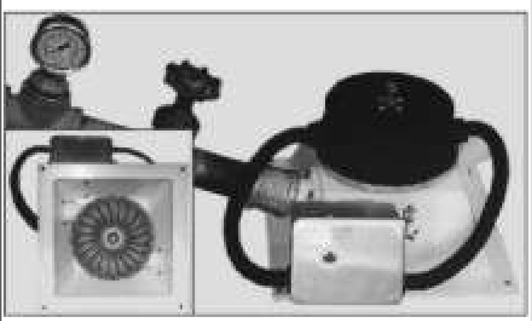
Energy Systems & Design has been producing micro-hydroelectric components since 1980. We make equipment that converts the energy in moving water into electricity. We offer a wide array of products and services to the renewable energy (RE) marketplace and international installation services.

We offer the Stream Engine, a breakthrough in hydro technology, and we have recently introduced the LH1000, low-head propeller turbine, which operates from 1 to 3 metres of head or vertical fall of the water.

www.microhydropower.com

Energy systems & Desing ofrece los servicios de diseño e instalación a clientes internacionales a precios razonables. Nuestro equipo de técnicos diseña e instala su sistema en nuestras instalaciones en Canadá y posteriormente lo instala en el lugar. Estamos preparados para manejar cualquier equipo, desde sistemas termo-hidráulicos de engría solar hasta sistemas fotoeléctricos, eólicos y micro-hidráulicos. Comuníquese con nosotros para obtener mas detalles.

ES&D ha fabricado partes micro hidro-eléctricas desde 1980, y ofrece una gran selección de productos y servicios pare el mercado de la energía renovable. Ahora ES&D ofrece el LH1000, una turbina-hélice de cabeza-baja, así como los servicios mundiales de instalación.

	**El Stream Engine (motor del arroyo) y el LH1000 emplean ambos, un alternador ajustable, equipado con magnetos permanentes. Eso permite al usuario balancear el rendimiento de la turbina con la carga eléctrica. Este alternador tiene una eficiencia mejor a la que tuvieron previas alternadores, y tienen la capacidad de rendimiento de más de 1kW, además de que no requiere virtualmente de mantenimiento. Los sistemas micro-hidráulicos de ES&D emplean componentes muy eficaces, fundidas con precisión, de aleaciones no corrosivas para asegurar laga vida y durabilidad. Un multi-metro digital acompaña cada turbina, para medir el rendimiento del amperaje. Estas unidades se pueden utilizar con sistemas independientes, o bien ligados a un tendido eléctrico.**

El Stream-Engine: Operación

Manuel (.pdf)

El Stream Engine esta diseñado para su empleo en los sistemas de pilas. La electricidad está generada a una capacidad constante, y está acumulada en las pilas, para su utilización en capacidades más grandes a la generación original. Durante los periodos de demanda baja, el poder está acumulado. Se emplea un invertidor siempre que la corriente-alterna de residencia es requerida.

El agua de un arroyo se encausa dentro de una tubería para conseguir cabeza (distancia vertical a la cae el agua) suficiente para dar poder al sistema. El Stream Engine funciona con una cabeza de cerca de 2m o más. El agua pasa por una boquilla en donde se acelera para chocar contra la "rueda-turgo" de bronce. Esto hace rodar el árbol primario del generador. Hasta 4 boquillas universales se pueden instalar sobre una maquina. Las boquillas se ajustan a medidas de 3mm hasta 25mm.

El Steam Engine: Instalación

Típicamente, estos sistemas funcionan a 12, 24, o a 48 voltios, con hilo conductor reconéctable, que permite instalarse un Stream Engine normal en la mayor parte de los sitios. Arrollamientos eléctricos especiales son también disponibles, estos pueden producir un voltaje elevado (120, 240v), en cualquier sitio.

El LH1000

Maunuel (.pdf)

 LH1000	**El LH1000, igual que el Stream Engine se diseñó para funcionar en asociación con los sistemas de energía basados en pilas. Se conserva el poder eléctrico para utilizarse siempre que el consumo sea más que la generación. La energía se conserva durante los periodos de demanda baja. Cuando se necesitan las cargas de corriente-alterna, componentes extras llamados "Balanza del Sistema" son necesarios para convertir la corriente-continua acumulada en electricidad de residencia (corriente-alterna).**

El LH1000: Operación

Para conseguir cabeza suficiente para operar el LH1000, el agua se encausa dentro de un conducto. La turbina está montada en una apertura al fondo del conducto, con el "tubo de draft" (draft tube) extendiendo hasta el "agua de salida"(tail water) abajo. El agua hace rodar la hélice, creando el poder del árbol primario. Esto, a su vez, da poder al generador, produciendo la electricidad.

El LH1000 funciona típicamente a 12, 24, 48 o 120 voltios. En caso de ser necesario, es posible adaptarlo especialmente para que funcione a 240 voltios. Empleando un generador de magnetos permanentes y ajustables, de misma manera como el Stream Engine, el LH1000 tiene un hilo-conductor reconéctable, para la utilización en una gran variedad de sitios.

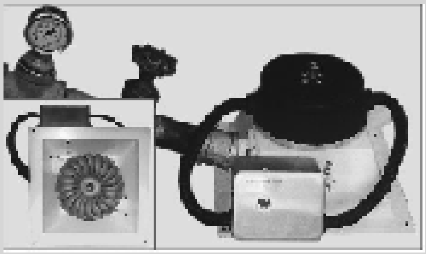
Energy Systems & Design, Ltd.

"Inovado Sistemas Micro-Hidráulica Desde 1980"

PO Box 4557 Sussex, NB
E4E 5L7 Canada

www.microhydropower.com <hydropow@nbnet.nb.ca> Tel: 506 433 3151 Fax: 506 433 6151

Fabricante del *"Stream Engine"*

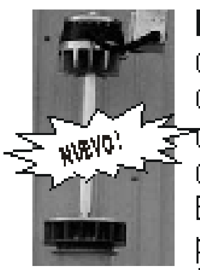


El *Stream Engine* (motor del arroyo) utiliza un alternador magnético permanente ajustable sin cepillos, que le permite al usuario armonizar las turbinas de salida con la carga eléctrica. Posee una mayor eficiencia que otros alternadores y es capaz de tener salidas de mas de 1 kilowatt (kW). Esta equipado con una rueda turgo áspera de bronce, con boquillas universales(adaptables a medidas desde 3mm (1/8 ") hasta 25mm (1 ") y un multimetro digital para medir la corriente de salida. El sistema completo esta hecho de aleaciones no corrosivas para asegurar su durabilidad y larga vida. Esta maquina puede producir energía desde cabezas tan bajas como 2 metros (6 pies) y hasta 100 metros (300 pies).

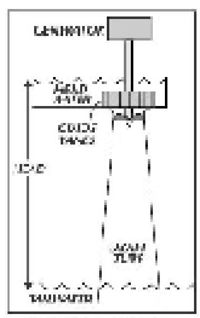
Stream Engine Output (Watts Continuous)

Head Metres (Feet)	Flow Litres/Sec (Gallons/Min) 0.63 (10)	1.3 (20)	2.5 (40)	4.7 (75)	6.3 (100)	9.5 (150)
3 (10)			50	90	120	
6 (20)		40	100	180	230	350
15 (50)	45	100	220	400	550	800
30 (100)	80	200	500	940	1100	
60 (200)	150	400	900	1500		

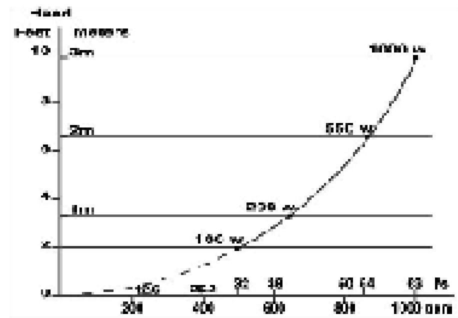
$1695 usd



El LH 1000 utiliza el mismo generador que el Motor del Arroyo (Stream Engine), sin embargo la turbina de agua de este modelo utiliza una cabeza de propulsión más baja en su diseño. Esto le permite a esta maquina producir energía desde cabezas de 0.5 metros (2 pies) y hasta 3 metros (10 pies). A su máxima cabeza y flujo, el LH 1000 tiene una salida de 1 Kw; suficiente como para alimentar tres hogares canadienses promedio.



LH1000 Installation



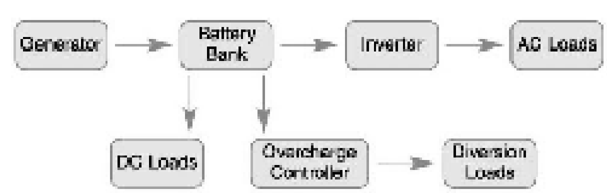
LH1000 Output (Watts Continuous)

$1695 usd

Otros servicios y productos incluyen consultas, análisis del sito, instalación, entrenamiento tecnológico, componentes micro- hidráulicos; Energy Systems & Design ofrece ruedas de turbina turgo y ruedas pelton de uretano, boquillas universales únicas (adaptables a medidas desde 3mm (1/8 ") hasta 25 mm (1"), transformadores de alto voltaje, invesores, controladores de carga, etc.

SE BUSCAN DISTRIBUIDORES

Energía micro-hidráulica es una tecnología madura en el mercado de energía renovable. ES&D ofrece soluciones energéticas de principio a fin a todos los sectores que utilizan el viento, el sol o el agua en el sector de energia renovable.

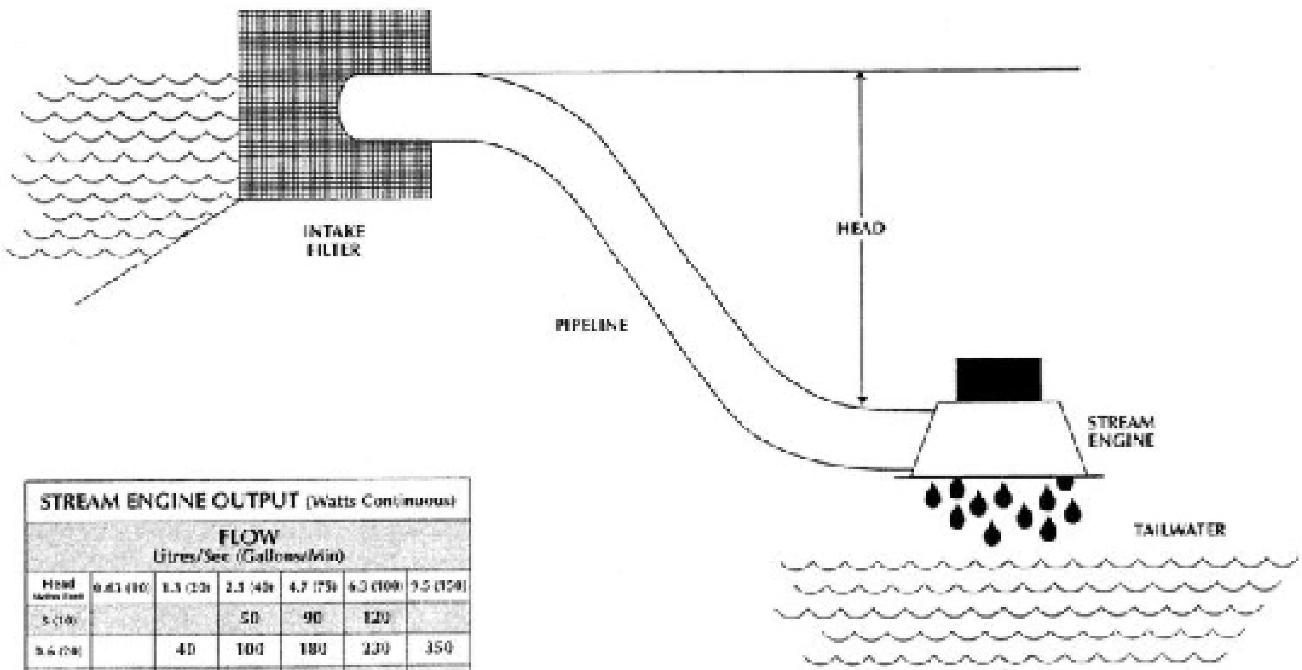


A Typical "Stand-Alone" RE System

www.microhydropower.com

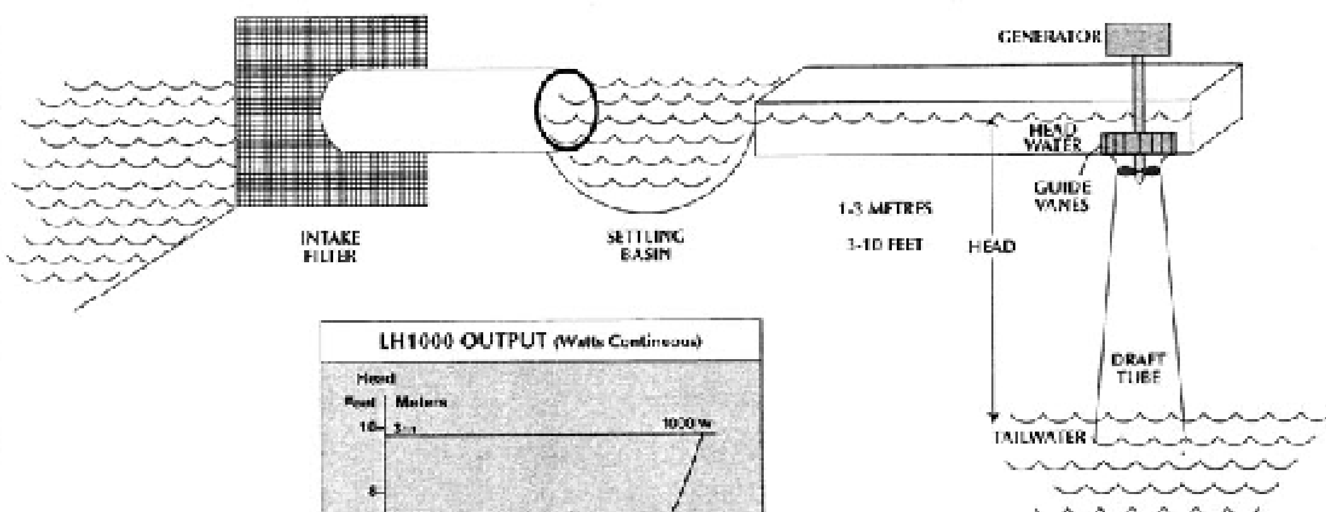
"Innovative Micro-Hydro Systems Since 1980"

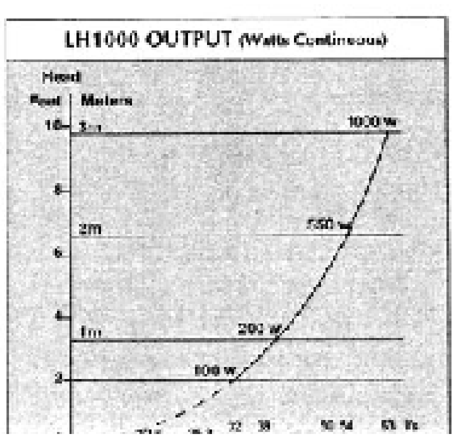
STREAM ENGINE INSTALLATION



STREAM ENGINE OUTPUT (Watts Continuous)						
	FLOW Litres/Sec (Gallons/Min)					
Head Metres (Feet)	0.63 (10)	1.3 (20)	2.5 (40)	4.7 (75)	6.3 (100)	9.5 (150)
3 (10)			50	90	120	
6.6 (20)		40	100	180	230	350
15 (50)	45	100	220	400	550	800
30 (100)	80	200	500	940	1100	
60 (200)	150	400	900	1500		

LH1000 INSTALLATION





Energy Systems & Design, Ltd.

Paul Cunningham / Kent Mc Neilly
PO Box 4557 Sussex, NB
E4E 5L7 Canada

Tel: 506 433 3151 Fax: 506 433 6151

SE BUSCAN DISTRIBUIDORES

Manual del Stream Engine | Manual del LH1000 | Aplicacion para Distribuidor Autorizado

CENTRALES DE ARROYO
STREAM ENGINE

Hidraulica Personal

MANUAL DE INSTRUCCIONES

Favor de leer cuidadosamente

Hecho en Canada
Por
Energy Systems and Design Ltd.
PO Box 4557
Sussex, NB
Canada E4E 5L7
Direccion electronica: support@microhydropower.com
Sitio en la Red www.microhydropower.com

¡Felicitaciones en la compra de una nueva Stream Engine! Con una installacion completa y un poco de matenimiento rutinario, su Central de Arrollo le proveera años de operaciones libre de problemas. Este manual le ayudara a installar su Stream Engine asi como asistirle en localizacion de fallas y resulucion a las mismas. Por supuesto usted puede contactar Energy Systems & Design Ltd si usted se encuentra con un problema.

Que su lectura prueben el exito!

POR FAVOR LEER CUIDADOSAMENTE

Es muy importante mantener el rotor del alternador lejos de contactar el stator (parte estacionaria bajo el rotor). Si esto ocurre, resultaria en daños muy serios.

Cuando este operando su maquina con un pequeño espacio aerio (la distancia entre el rotor del alternador y el stator) usted debe chequear el espacio cada vez que se haga algun ajuste.

Esto lo hace metiendo una tarjeta de presentacion (0.010" o 0.25mm de grueso) en el espacio cuando el rotor este inmovil. Chequee todo alrededor del rotor. Esta tambien es la forma de chequear el desgaste de los cojinetes cada mes.
Si usted no puede insertar la tarjeta entre el espacio, ya sea un poco o toda, es necesario ajustar el rotor hacia arriba (vea EL AJUSTE DE SALIDA de este manual).

Cuando este haciendo ajustes en el espacio de aire, asegurese que el tornillo mas grande este apretado (a la derecha) contra el eje y el tornillo pequeño este tambien apretado (a la derecha) para poder topar las dos partes en su lugar.

Tabla de Contenido

INTRODUCCION

Este manual describe la Stream Engine (Central de Arroyo), la cual es fabricada por Energy Systems and Design Ltd. El instalador debe tener conocimiento de plomeria y sistemas electricos y el usuario debe tenerlo tambien. Estas maquinas son pequeñas, pero pueden generar voltages muy altos. Aun maquinas de 12 Voltios pueden producir alto voltage bajo ciertas condiciones. Practique toda debida seguridad. La electricidad no se ve y puede ser mortal.

Es muy importante consultar con oficiales locales antes de conducir cualquier modificacion del arrollo. ES&D aconseja las siguientes leyes locales y ordenanzas que hacen referencia a los arroyos.

Electricidad es producida de la energia potencial con agua en movimiento de un punto alto a uno bajo. Esta distancia es llamada direccion o cabeza y esta medida en unidades de distancia (pies, metros) o en unidades de presion (peso por pulgada cuadrada, o kilo-Pascals). La corriente es medida en unidades de volumen (galones por minuto- gpm, o litros por segundo- L/s), Y es la segunda porcion de la ecuacion de energia. La energia disponible esta relacionada al flujo y la cabeza.

La Central de Arroyo esta diseñada a operar sobre una gran variedad de cabezas y flujos. Esto se alcanza con el uso de la rueda Turgo. Los diametros de las boquillas o inyectores estan disponibles en diametros de 1/8 a 1" y hasta cuatro boquillas o inyectores pueden ser usados en una maquina, para utilizar cabezas tan bajas como hasta cuatro pies y tan altas como centenares.

La Central de Arroyo usa un magneto permanente tipo alternador. Este diseño elimina la necesidad de cepillos y el mantenimiento de los mismos, mientras aumenta eficiencia. La salida de la Central de Arroyo puede ser optimizada con simplemente ajustar el espacio libre del rotor desde el stator.

EVALUACION DEL LUGAR

Cierta informacion debe ser determinada segun su lugar, para poder usar al maximo su potencial de salida. Antes que todo, debe determinarse cabeza y corriente. Otros factores son: Distancia de la tuberia, que tanta energia puede esperarse.

La energia es generada a una taza constante por la Central de Arroyo (Stream Engine) y guardada en baterias como una corriente directa (CD). La energia es suplida cuando se necesite por las baterias, las cuales guardan la energia durante periodos de poco consumo para uso en periodos donde el consumo excede la taza de generacion. Los aparatos electricos pueden ser directamente operados desde las baterias o alternando la energia CA a 120 Voltios por medio de un invertidor que convierte la energia DC a AC.

Los lugares pueden variar, asi que considere cuidadosamente la corriente y la cabeza cuando escoja el suyo. Recuerde, maxima cabeza puede ser alcanzaba con poner la Stream Engine o Central de Arroyo a la elevacion mas baja posible, pero si va demasiado bajo puede causar que la maquina se sumerja (o que se la lleve la corriente!)

MEDIDA DE CABEZA O DIRECCION

La cabeza puede ser medida usando varias tecnicas. Una manguera de jardin o una tubo puede ser sumergido con una punta corriente arriba y la otra corriente abajo. Asegure la punta que esta dirigida hacia la corriente de arriba; con rocas o pida a un asistente que la sostenga; el agua debe salir por la punta de abajo, especialmente si la tuberia es pre-llenada. Una vez el agua esta fluyendo, levante la punta de la corriente de abajo hasta que se detenga. Haga esto despacio ya que el agua tiende a oscilar. Cuando la corriente ha estabilizado, mida la distancia cocida al nivel del agua en el arroyo con una cinta metrica. Esto le dara una medida muy acertada de esta seccion del arroyo. Marque el area y luego repita el procedimiento hasta que la entera distancia esta cubierta.

Otra tecnica es de usar el medidor transito del encuestador. Este metodo puede ser aproximado usando un nivelador de carpintero o una “story pole”. Esta tecnica esta tambien hecha en series de pasos para llegar a la quebrada principal. Una variacion de este metodo es el uso de altimetros. Casio hace un reloj pulsera que tiene un altimetro.

MEDIDA DE LA CORRIENTE

El metodo mas facil de medir pequeñas corrientes es canalizando el agua dentro de una tuberia usando una presa temporaria y llenando un lata medidora. Midiendo el tiempo para llenar los contenedores le permite calcular cantidad de la corriente.

El metodo wier es mas vesatil y pude provar mas eficiente para corrientes con altas quebradas o cabezas. Esta tecnica usa una entrada con cortada rectangularo una pedazo de metal puesta dentro de la quebrada como una presa. El agua es canalizada dentro del weir y la profundidad se mide desde la punta de la estaca que esta nivelada con la orilla del weir y muchos pies arriba de la corriente.

Midiendo la corriente a diferentes horas del dia le ayuda a estimar un maximo y un minimo de corriente usable. Si el recurso de agua esta limitado temporalmente, usted tendra que depender en otros recursos de energia durante tiempos secos (viento , solar).. Mantenga en la mente que se debe dejar una cantidad rasonable de agua (No la use toda, esa agua contiene formas microscopicas de vida).

Cuando la corriente y la cabeza estan determinados, la salida de la esperada energia puede ser determinada desde la siguiente tabla. Recuerte que los valores de esta tabla representan la salida generada y que la energia actual llevada a las baterias sera reducida por las lineas de transmision, convertidores de energia y otros equipos requeridos por el sistema. Todos los sistemas deben ser cuidadosamente planificado para maximizar la salida de energia.

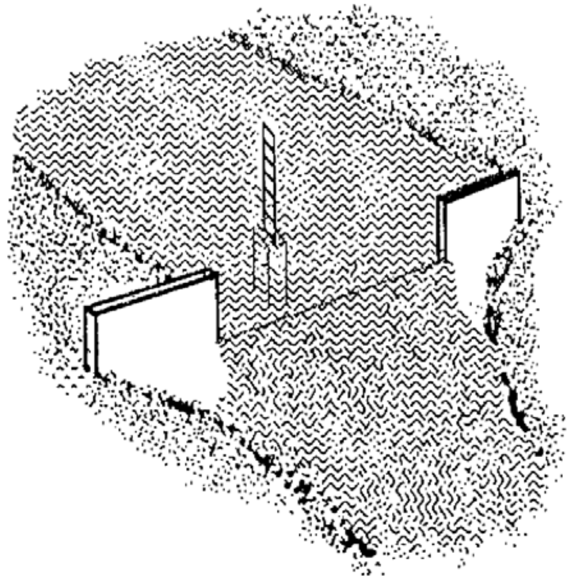
TABLA MEDIDORA WEIR

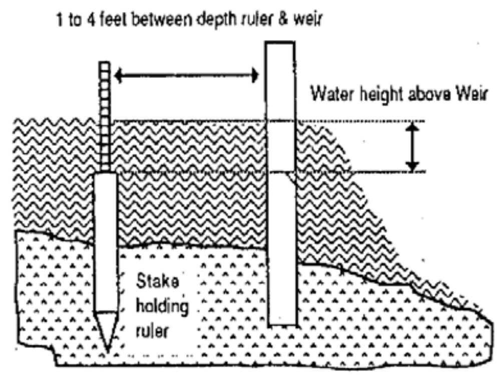
La tabla muesta la corriente de agua que fluira en galones por minutos (gpm) durante a una pulgada weir de ancho y desde 1/8 hasta 10-7/8 pulgadas de hondo.

Inches		1/8	1/4	3/8	1/2	5/8	3/4	7/8
0	0.0	0.1	0.4	0.7	1.0	1.4	1.9	2.4
1	3.0	3.5	4.1	4.8	5.5	6.1	6.9	7.6
2	8.5	9.2	10.1	10.9	11.8	12.7	13.6	14.6
3	15.5	16.5	17.5	18.6	19.5	20.6	21.7	22.8
4	23.9	25.1	26.2	27.4	28.5	29.7	31.0	32.2
5	33.4	34.7	36.0	37.3	38.5	39.9	41.2	42.6
6	43.9	45.3	46.8	48.2	49.5	51.0	52.4	53.9
7	55.4	56.8	58.3	59.9	61.4	63.0	64.6	66.0
8	67.7	69.3	70.8	72.5	74.1	75.8	77.4	79.1
9	80.8	82.4	84.2	85.9	87.6	89.3	91.0	92.8
10	94.5	96.3	98.1	99.9	101.7	103.6	105.4	107.3

Example of how to use weir table:
Suppose depth of water above stake is 9 3/8 inches. Find 9 in the left-hand column and 3/8 in the top column. The value where they intersect is 85.9 gpm. That's only for a 1-inch weir, however. You multiply this value by the width of your weir in inches to obtain water flow.

Suponga que la profundidad del agua arriba de una estaca es 9 3/8". Encuentre 9 en la columna izquierda y 3/8 en la columna de arriba. El valor donde esta intersectado es 85.9 gpm. Como se eso es solo por una weir pulgada. Usted multiplica este valor por el grueso de su weir en pulgadas para obtener la corriente de agua.





ACOMEDITA, TUBERIA Y TAILRACE

Todos los sitemas hidrahulicos necesitan tuberias. Hasta sitemas que opean directamente desde la presa necesitan al menos una tuberia corta. Es muy importante usar el tipo correcto y el tamaño de tuberia para minimizar restricciones en la corriente de las boquillas. Cuando sea posible las tuberias deben ser enterradas, esto estabiliza la linea y previene que los animales lo mastiquen.

En la punta de adentro de la tuberia, se debe instalar un tubo. Una caja coladora puede ser usada con una tuberia entrando en el otro lado, o agregue una seccion con una tuberia llena de agujeros envuelta en una tela o pequeños agujeros y sin una tle. Asegures que las entradas con los filtors son mas pequeños que la boquilla mas pequeña que se utilza.

La acometida debe estar arriba de la quebrada para que no chupe lodo y debe ser suficientemente profunda para que no chupe aire. La estructura de la acometida debe ser colocada a un lado de la corriente principal de la quebrada para que la fuerza de la corriente de agua y su basura pasen de largo. Rutinariamente limpie la acometida de hojas u otra basura.

Si toda la tuberia no corre continuamente hacia abajo, por lo menos la primera seccion debe correr, de tal manera que el agua comience a fluir. Una valvula de desvio puede utilizarse. Esta debe ser instalada a un punto bajo de la tuberia.

Para las tuberias que pasan sobre las presas, la corriente de abajo puede ser llenada a mano. Una vez llenada la valvula de apagado en la turbina puede ser abierta para empezar la corriente. Si la presion completa no se ha desarrollado, una bomba de mano se debe utilizar para remover el aire atrapado a ese punto.

A la punta de la turbina de la tuberia la valvula de desvio sera necesaria para que permita que el agua corra a traves de la tuberia sin afectar la turbina, PURGING la linea de aire o aumentando la corriente pra prevenir congelamiento.

La valvula de apagado debe ser intalada en la boquilla en la quebrada de arriba. Una bomba de presion debe ser instalada arriba de la valvula de apagado para que la cabeza estatica (sin corriente de agua) y la cabeza dinamica (agua fluyendo) puedan ser leidas.

La valvula de apague en la tuberia debe siempre ser apagada lentamente para prevenir martillamiento del agua (la columna de agua en la tuberia que viene a un frenazo abrupto). Esto puede facilmente destruir su tuberia y por esta razon usted debe installar una valvula de escape de presion justamente arriba de la valvula de apagado. Esto tambien puede ocurrir si hay basura que tapa la boquilla.

Las boquillas pueden ser intaladas o cambiadas removiendolas o desatornillandolas de los cuatro tornillos usando un cangrejo de 7/16". El uso de una tuberia flexible hace mas facil el removimiento de la plomeria de la boquilla. (page 6)

La caparazon de la turbina puede ser montada en dos tablas para suspenderlo arriba de la corriente. Se recomienda tener la Stream Engine en una pequeña caparazon o bajo alguna cubierta para mantenerla seca y proveer un espacio equipo extra.

El montado de la maquina en concreto tambien es posible (Tambien puede provar temporalmente hacer el montado de madera de primero si lo desea). La apertura bajo la caparazon para atrapar el agua debe ser al menos del tamaño de la caparazon de la turbina, y preferiblemente un poquito mas grande. Asegurese que el canal de salida provee suficiente flujo para laa salida del agua. La entrada de la caparazon es 9-1/2" cuadradas, los agujeros de los tornillos son una 11" cuadrada, y la caparazon es 12" cuadradas.

En climas frios, sera necesario construir una trampa en la salida. Esto previene que el aire de afuera entre en la caparazon y que cause congelamiento.

BATTERIAS, INVERTIDORES Y CONTROLADORES

Sistema de Voltage

Un pequeño sistema con una pequeña distancia de transmision se diseñada usualmente a operar a 12 Voltios. Grandes sitemas pueden ser de 12 Voltios, pero si alta energia es deseada o la distancia de transmision es larga, entonces un sistema de 24 voltios o mas alto puede ser preferible. Esto es especialmente realidad si todas las fuentes son de energia invertida. En un sistema de 12 voltios que opera a bajo nivel de energia, puede ser ventajoso de operar todas las fuentes directamente desde baterias. Hay muchos aparatos de 12 Voltios y pequeños invertidores disponibles. En sistemas de 24 voltios, es preferible operar las fuentes directamente (aunque no hay muchos aparatos electronicos disponibles).

En sitemas de alta energia, es usualmente mejor usar un invertidor para convertir el voltage de bateria a energia regular de 120 VAC. Esto se ha hecho feasible con la **vision de** invertidores de alto poder.
Miles de sistemas de energia domiciliar estan en operacion con solo fuentes CA.

Capacidad y tamaño de bateria

Un sistema tipico hidraulico debe tener la capacidad de almacenar hasta dos dias de bateria. Esto generalmente mantiene las celulas de acido dirigido operando durante la carga media donde son mas eficientes y duran mas. Las baterias alkalinas al igual que las de de hiero niquel y las de tipo cadium niquel pueden tener una capacidad baja ya que pueden ser completamente descargadas sin dañarse.

Las baterias deben estar afuera del lugar de vivienda, o bajo ventilacion adecuada ya que mientras la carga aumenta tiende a producir gas hidrogeno y gases corrosivos. Tambien, la consumcion de agua aumenta; para mantener el nivel del agua se debe usar agua destilada.

Control de Carga

Un sistema hidraulico requiere que las cargas esten presentes para la energia tenga a donde ir. De otra manera el voltage del sistema puede aumentar a alto niveles. Esta situacion provee una oportunidad para hacer algo con el exceso de energia (Una descarga puede ser utilizada para calentar agua).

Mientras las baterias se cargan completamente, sus voltages aumentan. A un punto el proceso de carga debe detenerse y la energia debe ser desviada a una descarga (hay que adivinar un poco). El punto a donde el voltage debe estar es de 13.5 a 14.5 para un sistema de 12 voltios dependiendo en el promedio de la carga. Mientras mas alta la carga, mas alto puede llegar el voltage. Si las baterias estan siempre cargandose, el limite del voltage debe estar en el promedio bajo.

Algunos ejemplos de un buen controlador de carga son el TRACE C-35, C-40 y el ENERMAXER. Ambos cambian la energia a una descarga cuando el nivel de carga deseado se ha alcanzado. El ENERMAXER tiene un punto preparado y usa un cambio solido de estado para descargar gradualmente a un voltage . Descargas son usualmente resistivas, como lo son los calentadores, pero puede ser cualquier cosa que sea compatible con el sistema.

Un metro de voltage o un metro de horas de watt puede ser usado para monotorizar el nivel de la carga de la bateria. El voltage de la bateria es casi una funcion del nivel de carga y varia segun el promedio y nivel de carga. Mientras usted gana experiencia, el voltage de la bateria puede ser usado para medir el nivel de carga con exactitud.

ALAMBRADO DEL CENTRO DE CARGA

Cada sistema requiere algun alambrado para conectar varios componentes. Los centros de carga estan disponibles como un paquete completo que facilita la coneccion de las cargas a los fuentes de carha. Todos los circuitos en el sistema deben usar alambres de tamaño adecuado y tener fusibles o flipones con suficiente capacidada para llevar la carga esperada. El Stream Engine debe estar fundido ya que puede sufrir un corto o una falla similar al igual que cualquier cosa en ele sistema.

Dentro de la caja de empalme a un lado de la maquina existen dos bloques terminales para el alambrado de la bateria. La terminal negativa esta atornillada a una caja y la terminal positiva atornillada a un plato plastico. Las puntas del alambre de transmision son insertadasdentro de estos dos conectores (despues de haberse pelado la insulacion) y despues amarrado. Asegurese que el alambrado de la bateria este correctamente conectado o el rectificador sera destruido. No opere la maquina sin estar conectada a las baterias ya que altos voltages pueden ser generados.

El multimetro en las terminales manubriadoras (vea nueva tecnica de medidas pg17) medira la actual salida y es comparable a un velocimetro de un carro. Un medidor de voltage conectado a las baterias indicara aproximadamente el nivel de carga, como se describe en el nivel de carga arriba y es comparagle a una valvula de gas.

DISEÑO EJEMPLO

Este ejemplo muestra como proceder con una completa instalacion. Los parametros del lugar ejemplo son:

120’ de cabeza sobre una distancia de 1000’
Una corriente de 30gpm (casi todo el tiempo)
100’ de distancia desde la casa a la maquina hidraulica
Un sistema de 12 Voltios

La primera cosa que nosotors hacemos es determinar el tamaño de la tuberia. A pesar que el poder maximo es producido desde un tubo de tamaño especificado cuando la perdida de la cabeza es 1/3 de la cabeza estatica, mas energia puede ser obtenida desde la misma corriente con un tubo mas grande el cual tiene poca perdida. Por lo tanto, el tamaño de la tuberia debe ser optimizado basado en economia. En cuanto la cabeza disminuye, la eficiencia del sistema disminuye, y es importante mantener baja la perdida de direccion.

La grafica de la tuberia de corriente nos muestra que un tubo de polietileno con dos pulgadas de diametro tiene una perdida direccion de 1.77 pies de cabeza por 100 pies de tuberia a una corriente promedio de 30 gpm. Este es 17.7 pies de perdida por 1000 pies de tuberia.

Usando PVC de dos pulgadas nos da una perdida de 1.17 pies de cabeza por 100 pies de tuberia o 11.7 pies por 1000 pies.

El polietileno viene en un carrete continuo porque es flexible (y mas resistente a las heladas). PVC viene en tamaños mas cortos y tiene que ser pegado uno a otro o comprada con empaques (para tamaños mas grandes). Digamos que seleccionamos polietileno.

El maximo poder ocurre con una corriente de como 45 gpm ya que esa nos da una perdida de direccion de 3.75' por 100' de tuberia, o 37.5''de perdida por nuestro 1000' de tuberia. Esta es una perdida de 37.5'/120'cabeza=31% de perdida.
Una corriente de 30gpm da una cabeza neta de 102.3' (120'-17.7'). Las perdidas causadas por los diferentes tamaños de tuberia y el sedaso de admisiondisminuira aun mas la dinamica de la cabez, asi que 100' es una buena figura para la cabeza neta.

A esta cabeza y la condicion de la corriente, la salida de la maquina es igual a unos 300 watts.

Desde que nosotros requerimos 12 voltios y la distancia de la transmision es corta, podemos generar y transmitir 12 voltios usando la Stream Engine. Esta central de arroyo puede tambien ser usada para altos voltages como 24 y 48 y la energia puede ser transmitida a distancias mas largas.

Observando la grafica de las corrientes en las boquillas, vemos que una boquilla de 3/8" producira una corriente de 27.6 gpm a una cabeza de 100'. Este es muy parecido al punto de diseño pero producira un poco menos de rendimiento. Necesitamos ir a 100' con 300 watts en nuestro sitio. Esto sera como 20amps a 15 voltios en el generador. Note que habra una perdida de voltage en la linea y la bateria de 12 voltios necesita mas voltage que la nominal para cargarse. Asi los 20 amps deben pasar atraves 200' de recorrido de alambre. La perdida de resistencia debe mantenerse tan baja como la economia lo permita, al igual que la perdida de tuberia.

Digamos que deseamos tener como 10% de perdida. Esto es 30 watts fuera de los 300 originales. La formula de la perdida de resistencia es I2R= watts cuan I= Intensidad (corriente en amps) y R= Resistencia (en ohms).

(20 amps) x (20 amps) x R (ohms)= 30 watts
400 amps x R (ohms) = 30 watts

R=30 watts/400 amps
R= 0.075 ohms

Este el el alambre de resistencia que producira un 10% de perdida. La grafica de la perdida de alambre por 1000', asi:

1000'/200' x 0.075 ohms=0.375 ohms por 1000'.

La grafica muestra 6 ga. El alambre tiene una resistencia de 0.40 ohms por 1000', asi:

200'/1000' x .40 ohms+ 0.08 ohms. Esto es cerca al nivel deseado.
20 amps x 20 amps x 0.08ohms =32 watts de perdida.

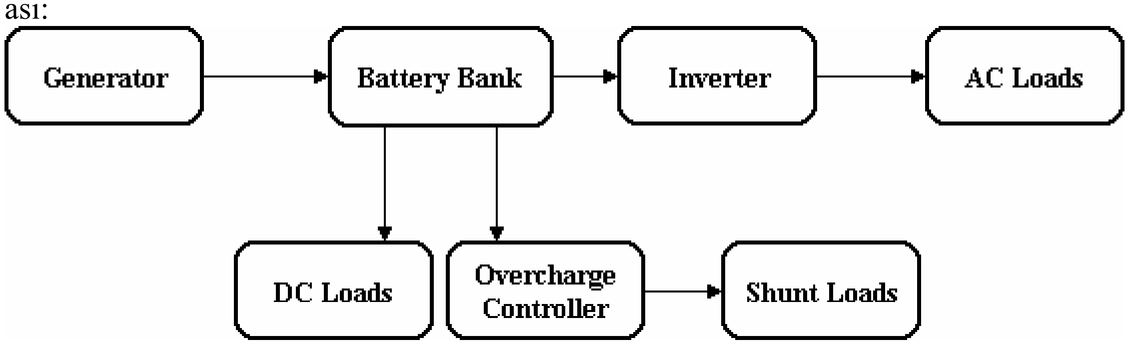
Aumentando el tamaño del alambre reduce aun mas las perdidas. La perdida de voltage en el alambre es igual a: IR=20ampsx.08 ohms= 1.6 voltios (page 10)

Asi que si el voltage de la bateria es 13.4 el generador estar operando a 15.0 volts. Mantenga en mente que son siempre las baterias las que determinan el voltage del sistema. Esto es, todos los voltages en el sitema suben y bajan segun el estado de carga de la bateria.

En el area, estaremos generando 20 amps continuamente. Si usamos baterias de acido plomo y deseamos tener dos dias de almacenamiento entonces:

20amps x 24hrsx 2 dias+= 960amps. Hrs de capacidad

Probablemente usaremos un invertidor and controlador de corriente con el sistema. El diagrama para este sistema se miraria
asi:



AJUSTE DE RENDIMIENTO

Para que la maquina produsca el rendimiento mas alto, la altitud del rotor debe ser ajustada. Esto involucra elevando o bajando el rotor para aumentar el cambio constante del nivel magnetico. Esto hace necesario emparejar el rendimiento de la turbina con la del generador.

Despues que la maquina este instalada, realice un trayecto inicial; para establecer el nivel del rendimiento de la energia. Esto puede deteminarse usando un ammetro para medir corriente o un metro digital para medir el voltage. Una buena idea es mantener un logbook para anotar cualquier cambio en el rendimiento en relacion a lo marcado.
Despues que todo este conectado, arranque la maquina abriendo la valvula de paro.
Dejelo que corra suficientemente para que el nivel de rendimiento se estabilice y apunte la corriente (o voltage) Luego apague la valvula de paro.
La maquina viene con el rotor puesto muy serca al stator (la parte estacionaria de la maquina). Para aumentar la distancia y reducir el cambio constante de nivel magnetico, usted debe rotar el tornillo mas grande con cabeza de 19mm (3/4") sobre el rotor mientras lo sostiene estacionariamente. Eso se hace insertando un pin de ¼" suplido en uno de los agujeros en la orilla del rotor. Luego el pequeño tornillo con cabeza de 11mm (7/16") movera el rotor verticalmente 1.25mm (0.050"). Si elevando el rotor causa la corriente (o el voltage) que aumente, entonces continue haciendolo asi hasta que no haya ningun aumento. Si un punto es alcanzado donde ocurre una disminucion, entonces el rotor debe ser bajado. Con soltar el tornillo mas grande y apretando el mas pequeño es como esto se hace. Rotando el tornillo mas pequeño causa que el rotor se mueva verticalmente a la misma distancia por tuno asi como el tornillo grande lo hace. Cuando usted ha encontrado la mejor posicion (no aumento en la corriente o voltage), asegurese que el tornillo grande es rotado hasta que este apretado. Ahora el tornillo mas pequeño debe ser apretado muy seguro para sellar todo en su lugar. No se deben hacer mas ajustes a menos que se cambien el tamaño de las boquillas.
Cuando se ajuste el rotor hacia abajo, puede alcanzar el punto donde hara contacto con el stator. Si esto ocurre, ajustelo siempre hacia arriba por lo menos un ¼ de rote al tornillo mas grande. Si se opera la maquina con el rotor mas cerca que esto puede causar daño en la maquina.

****Antes de iniciar la maquina, siempre rote el rotor a mano para chequear por sobage****
Remueva el pin en la orilla del rotor antes de iniciar la maquina.

El tamaño optimo de la boquilla se puede encontrar usando una tecnica similar.

Energy Systems and Design ha introducido un nuevo tipo de boquilla a su generador hidroelectrico. Esto hace posibble crear cualquier tamaño de boquilla chorro que sea requerida con simplemente cortando la boqilla al apropiado tamaño. Se puede cortar con una sierra, o con cualquier sierra fina. El final de la boquilla debe ser terminada con un pedazo de lija. Esto se hace mejor si se pone la lija en una mesa y sobando la boquilla contra ella. Las marcas ya estan en las boquillas para asistir con el corte al tamaño correcto. Los numeros estan en milimetros y corresponde a las pulgadas de la siguiente manera:

Mm	3	4.5	6	8	10	13	16	19	22	25
Pulg	1/8	3/16	¼	5/16	3/8	½	5/8	¾	7/8	1"

Tamaños impares tambien se pueden producir. Las aperturas de las boquilla es como 6% mas grande que el chorro de agua actual que sale de el. Otra posibilidad es hacer la apertura mas grande hasta que la corriente deseada es obtenida. Un aro O es provista para poder sellar la cara. Esto previene que el agua gotee hacia las afueras de la maquina.

Para los tamaños de boquillas mas pequeños, la boquilla tendra que ser instalada con el area numerada hacia arriba, para que la punta no haga contacto con la rueda de la turbina.

Modelos de Alto Voltage

Cuando opera una Stream Engine usando transformadores, esta necesitara diferente tecnica para poder optimizar el rendimiento. Esto se puede hacer en la turbina ajustando para un maximo voltage en lugar de una corriente maxima. El voltage CA puede ser medido al otro lado de cualquiera de las dos terminales de salida. Estas terminales son las mismas en la tabla terminal de bajo voltage o sistemas DC. Haga ajustes en el espacio de aire del rotor segun las instrucciones que se dieron al inicio del manual. Un swich de encendido y apagado es suplida para la energia CA. En uso normal el swich se deja encendido.

TABLA DE FLUJO DE BOQUILLAS EN PROMEDIO DE GALONES DE LOS EEUU POR MINUTO. (Add Table)

ESAMBLAJE DE LOS COJINETES Y SERVICIOS

Para poder remover el generador usted debe primero remover la rueda de la turbina. La rueda de la maquina se desatornilla del eje agarrando el rotor usando una barilla de ¼" de diametro insertela dentro de uno de los agujeros en la orilla del rotor. La rueda de la trubina es ensamblada con una tuerca y un **spacer** en la parte de arriba. El eje esta hecho con hilos estandares de mano derecha para la rueda de la turbina para que lo desatornille segun la direccion de las agujas de un reloj cuando se ve al eje (con la maquina boca abajo) Entonces usted puede remover los cuatro tornillos con 4mm (5/32"0) hex drive.

Usted debe poner los cojinetes tan pronto como note cualquier desajuste. Si ellos estan muy sueltos, puede resultar en daños severos al rotor y el stator. Esta maquina usa tres 6203 cojinetes de rueda con sellos de contacto. En maquinas mas muevas estas estan hechas a presion dentro del compartimiento del alternador y debe ser intalado y removido usando una prensa de capacidad adecuada y con mango de apropiado tamaño. Actualmente los cojinetes en la maquina estan muy sueltos en la caparazon agujereaday puede ser remplazada a mano SI no hay mucho oxido.

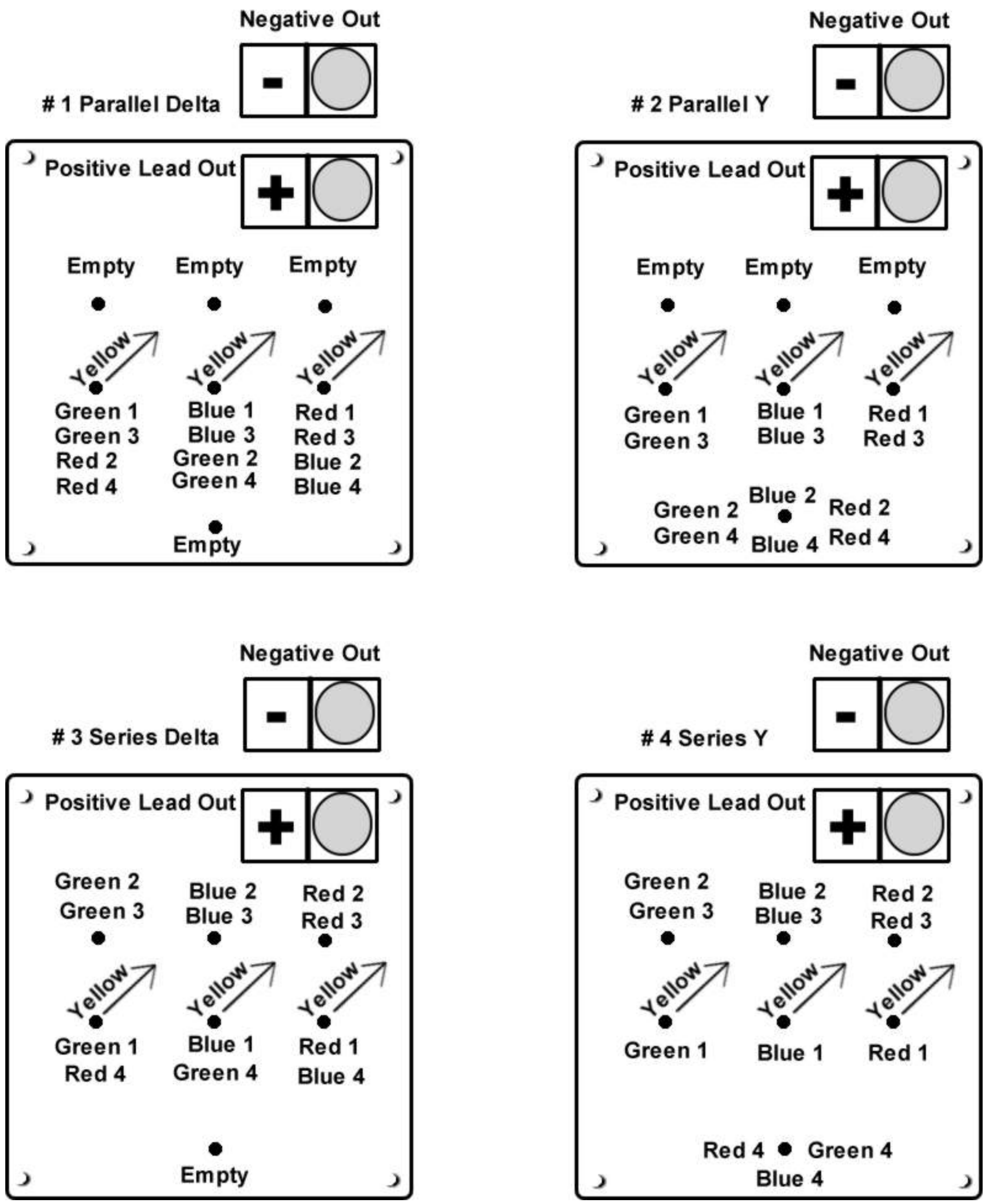
Para reemplazar los cojinetes:

Usando el pin del rotor para agarrar el eje, deshile el corredor desde el eje generador.

Remueva el rotor. Para remover el rotor y elevar el eje del rotor como se describe en el ajuste de rendimiento hasta que la atraccion magnetica es suficientemente baja para separar el montaje rotor/eje desde la caparazon y el stator.
Afloje 4 tornillos y tuercas que retienene los cojinetes.
Con la Stream Engine sentada invertida, usando sus pulgares, empuje para afuera los cojinetes desde la manga o golpee los cojinetes para afuera. Esto requiere una prensa en algunas situaciones.
Limpie la manga de los cojinetes e inserte nuevos cojinetes 6203LLU.
Reensamblelos.

DIAGRAMA DE ALAMBRADO

Estos diagramas representas cuatro posibles combinaciones del rendimiento del alambrado. Estan en orden de potencial. Si usted encuentra que el ajuste del vacio de aire esta a un minimo y desea intentar para mas energia, entonces trate una combinacion mas alta. Si usted encuentra que el vacio de aire es mucha, intente el proximo mas bajo. Noteque solo existe un pequeño cambio en potencial entre #2 y #3.



(Page18)

ESQUEMAS DE ALAMBRADO

12Voltios	24 Voltios	48 Voltios
Paralela Delta	**Series Delta**	**Series Y**
Todas las cabezas	hasta 60’/18m	hasta 60’/18m
	Paralela Delta	**Serie Delta**
	30’/9m y mas	30’/9m a 250’/75m
		Paralela Delta
		140’/43m y mas

Note: En cualquier lugar, mas de un esquema puede funcionar. Pero uno solo funcionara mejor.

La configuracion Paralela Wye no se menciona porque es muy similar a la series delta. Se diferencia por 15%. Si usted tiene un lugar donde las series delta es usada y usted cree que el rendimiento puede ser mejor, intentelo. Recuerde ajustar el rotor para el rendimiento mas alto cuando este cambiando el alambrado.

TECNICA DE MEDIDA DE CORRIENTE NUEVA

Previamente, todas las Stream Engines estaban equipadas con ammetros analogos. Ahora, un eje empotrado (resistencia a precision) esta instalada en la caja de empalme el cual permite que la corriente sea medida digitalmente. Esto se hace con el suplido DMM (Multimetro digital). Para medir la corriente producida por el generador, ponga la escala DMMa “DC mili-volts” o “200m” a la posicion de las nueve empunto. No use la escala de amps. Conecte lo negativo en el agujero de abajo y el positivo en el agujero de enmedio. Connecte los cables dentro del color correspondiente en el conector sobre el eje de la caja de empalme. Esto le dara lecturas de las corrientes desde 0.1 amps a 99.9 amps. Por supuesto, el DMM puede ser utilizado para otras cosas con su sistema de energia renovable.

LH1000

Turbina con Elice de cabeza baja

Hidroelectrica Personal

Manual del Usuario

POR FAVOR LEA CUIDADOSAMENTE

Hecho en Canada
por

Energy Systems and Design Ltd.

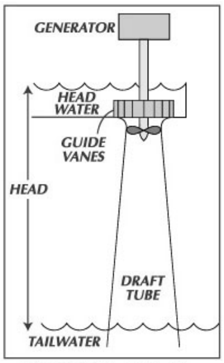
P.O. Box 4557
Sussex, NB
Canada E4E 5L7

Tel: (506) 433-3151
Fax: (506) 433-6151
Email: support@microhydropower.com
Website: www.microhydropower.com

INTRODUCCION

Este manual describe la modelo **LH 1000**, que esta fabricada por **Energy Systems & Design LTD**. El instalador y el usuario deben tener conocimiento de plomeria y electricidad.

Esta maquina es pequeña, pero puede generar alto voltage. Hasta las maquinas de 12-voltios pueden producir altos voltages bajo ciertas condiciones. Practica toda seguridad. La electricidad no se ve y puede ser fatal.



LH1000 Installation

La Electricidad es producida de la energia potencial con agua en movimiento de un punto alto a uno bajo. Esta distancia es llamada direccion o cabeza y esta medida en unidades de distancia (pies, metros) o en unidades de presion (peso por pulgada cuadrada, **kilo-Pascals**). La corriente es medida en unidades de volumen (galones por minuto- gpm, o litros por segundo- L/s), Y es la segunda porcion de la ecuacion de energia. La energia disponible esta relacionada al flujo y la cabeza.

LH1000 esta diseñada a operar en una extension fija de cabezas y corrientes desde 0.6-3m (de2 a 10'), empleando una helice metal poliuretano y un ensamblaje guia de vena. La **LH1000** usa alternador con magnetos tipo permanente. Este diseño elimina la necesidad de cepillos y el mantenimiento que viene con ellos, mientras aumenta eficiencia. El rendimiento de la **LH1000** puede ser optimizado con simplemente ajustar el espacio del rotor desde el stator.

EVALUACION DEL LUGAR

Cierta informacion debe ser determinada segun su lugar, para poder usar al maximo su potencial de salida. Antes que todo, debe determinarse cabeza y corriente. Otros factores son: Distancia de la transmision, especificaciones de la y el voltage del sistema. Estos factores determinan que tanta energia se puede esperar.
La energia es generada a un promedio constante por la **LH1000** y guardada en baterias como una corriente directa (CD). La energia es suplida cuando se necesite por las baterias, las cuales guardan la energia durante periodos de poco consumo para uso en periodos donde el consumo excede la taza de generacion. Los aparatos electricos pueden ser directamente operados desde las baterias o alternando la energia CA a 120 Voltios por medio de un invertidor que convierte la energia DC a AC.

Los lugares pueden variar, asi que considere cuidadosamente la corriente y la cabeza cuando escoja el suyo.

MEDIDA DE CABEZA O DIRECCION

La cabeza puede ser medida usando varias tecnicas. Una manguera de jardin o una tubo puede ser sumergido con una punta corriente arriba y la otra corriente abajo. Asegure la punta que esta dirigida hacia la corriente de arriba; con rocas o pida a un asistente que la sostenga; el agua debe salir por la punta de abajo, especialmente si la tuberia es pre-llenada. Una vez el agua esta fluyendo, levante la punta de la corriente de abajo hasta que se detenga. Haga esto despacio ya que el agua tiende a oscilar.. Cuando la corriente ha estabilizado, mida la distancia cocida al nivel del agua en el arroyo con una cinta metrica. Esto le dara una medida muy acertada de esta seccion del arroyo. Marque el area y luego repita el procedimiento hasta que la entera distancia esta cubierta.

Otra tecnica es de usar el medidor transito del encuestador. Este metodo puede ser aproximado usando un nivelador de carpintero o una “story pole”. Esta tecnica esta tambien hecha en series de pasos para llegar a la quebrada principal. Note que con esta maquina tipo reaccion, se utiliza toda la cabeza. No se pierde ninguna cabeza o direccion como se pierde en una maquina de impulso.

MEDIDA DE LA CORRIENTE

El metodo Weir puede ser usado con esta maquina en corrientes altas. Esta tecnica usa una entrada con cortada rectangular o una pedazo de metal puesto dentro de la quebrada como una presa. El agua es canalizada dentro del weir y la profundidad se mide desde la punta de la estaca que esta nivelada con la orilla del weir y muchos pies arriba de la corriente.

Midiendo la corriente a diferentes horas del dia le ayuda a estimar un maximo y un minimo de corriente usable. Si el recurso de agua esta limitado temporalmente, usted tendra que depender en otros recursos de energia durante tiempos secos (viento , solar).. Mantenga en la mente que se debe dejar una cantidad rasonable de agua (No la use toda, esa agua contiene formas microscopicas de vida).

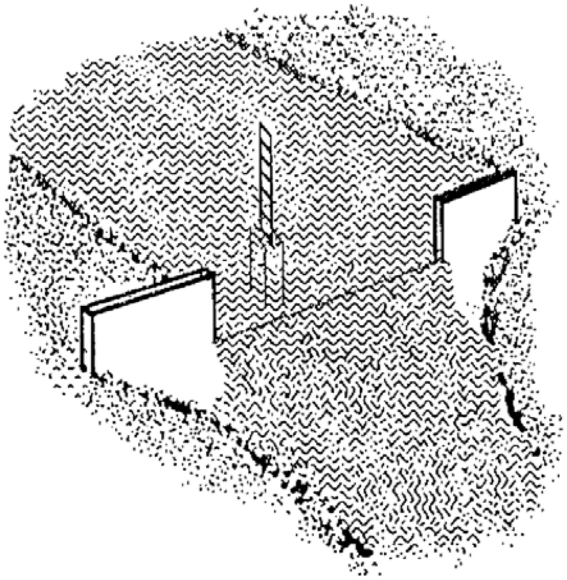
Cuando la corriente y la cabeza estan determinados, el rendimiento de la energia esperada puede ser determinada desde la siguiente tabla. Recuerte que los valores de esta tabla representan la salida generada y que la energia actual llevada a las baterias sera reducida por las lineas de transmision, convertidores de energia y otros equipos requeridos por el sistema. Todos los sistemas deben ser cuidadosamente planificado para maximizar la salida o rendimiento de la energia.

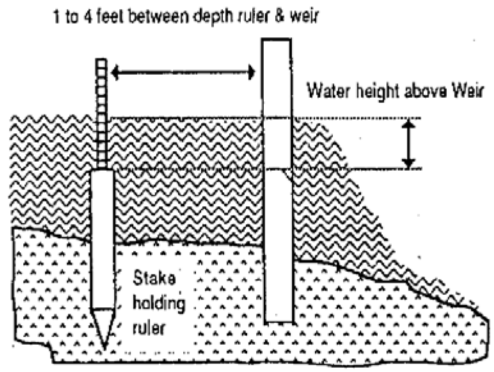
TABLA MEDIDORA WEIR

La tabla muestra la corriente de agua que fluira en galones por minutos (gpm) durante a una pulgada weir de ancho y desde 1/8 hasta 10-7/8 pulgadas de hondo.

Inches		1/8”	1/4”	3/8”	1/2”	5/8”	3/4”	7/8”
0	0.0	0.1	0.4	0.7	1.0	1.4	1.9	2.4
1	3.0	3.5	4.1	4.8	5.5	6.1	6.9	7.6
2	8.5	9.2	10.1	10.9	11.8	12.7	13.6	14.6
3	15.5	16.5	17.5	18.6	19.5	20.6	21.7	22.8
4	23.9	25.1	26.2	27.4	28.5	29.7	31.0	32.2
5	33.4	34.7	36.0	37.3	38.5	39.9	41.2	42.6
6	43.9	45.3	46.8	48.2	49.5	51.0	52.4	53.9
7	55.4	56.8	58.3	59.9	61.4	63.0	64.6	66.0
8	67.7	69.3	70.8	72.5	74.1	75.8	77.4	79.1
9	80.8	82.4	84.2	85.9	87.6	89.3	91.0	92.8
10	94.5	96.3	98.1	99.9	101.7	103.6	105.4	107.3

Suponga que la profundidad del agua arriba de una estaca es 9 3/8”. Encuentre 9 en la columna izquierda y 3/8 en la columna de arriba. El valor donde esta intersectado es 85.9 gpm. Como se eso es solo por una weir pulgada. Usted multiplica este valor por el grueso de su weir en pulgadas para obtener la corriente de agua.





ACOMETIDA, TUBERIA Y TAILRACE

Todos los sitemas hidrahulicos necesitan tuberias. Hasta sitemas que opean directamente desde la presa necesitan al menos una tuberia corta. Es muy importante usar el tipo correcto y el tamaño de tuberia para minimizar restricciones en la corriente de las boquillas. Cuando sea posible las tuberias deben ser enterradas, esto estabiliza la linea y previene que los animales lo mastiquen.

En la punta de adentro de la tuberia, se debe instalar un filtro. Una caja coladora puede ser usada con una tuberia entrando en el otro lado, o agregue una seccion con una tuberia llena de agujeros envuelta en una malla o un tubo con pequeños agujeros y sin una malla. Una malla con un tamaño de 20mm (3/4) y aun mas pequeña se puede usar ya que basura de este tamaño pasara a traves de la maquina. Sin embargo, es importante mantener los palos fuera de la acometida ya que estos pueden quedar atrapados en la maquina. Esto talvez necesite una malla mas pequeña.

Una pila de reposo debe ser usada con esta maquina. Esta es una piscina de velocidad baja que permite que los escombros reposen de tal manera que no entren en la maquina y gasten la orilla de la helice y la caparazon de la vena guia

Vea la ilustracion de la instalacion de la LH1000 atras de este manual

La turbina puede se montada en la corriente, dentro de un agujero de 17cms (7"), con el tubo del eje extendiendose a la cola del agua de abajo. Pequeñas rendijas con tornillos son adecuadas para retener la maquina. El tubo del draft se conecto a la mquina usando mangas de hule y prensas de mangueras. Estos son accesorios estandares de plomeria. La tuberia PVC de 150mm (6") de diametro con una pared de 4mm (0.160") de grueso se usa entre la vena ensambladora guia y el tubo del draft. Instale la manga de hule en la parte de abajo de la vena guia como para crear una transision suave desde uno al otro. Es recomendable que tenga la LH1000 en una caparazon pequeña o bajo alguna cubierta para mantenerla seca y proveer un lugar para equipo auxiliar. Montando la maquina en concreto tambien es posible (tal vez debe tratar primero con un empalme de madera).

PERDIDA DE FRICCION EN LA TUBERIA - PVC Clase 160 PSI Tuberia Plastica

Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM	Pipe Diameter, Inches										
	1	**1.25**	**1.5**	**2**	**2.5**	**3**	**4**	**5**	**6**	**8**	**10**
1	0.05	0.02									
2	0.14	0.05	0.02								
3	0.32	0.09	0.04								
4	0.53	0.16	0.09	0.02							
5	0.80	0.25	0.12	0.04							
6	1.13	0.35	0.18	0.07	0.02						
7	1.52	0.46	0.23	0.08	0.02						
8	1.93	0.58	0.30	0.10	0.04						
9	2.42	0.71	0.37	0.12	0.05						
10	2.92	0.87	0.46	0.16	0.07	0.02					
11	3.50	1.04	0.53	0.18	0.07	0.02					
12	4.09	1.22	0.64	0.20	0.09	0.02					
14	5.45	1.63	0.85	0.28	0.12	0.04					
16	7.00	2.09	1.08	0.37	0.14	0.04					
18	8.69	2.60	1.33	0.46	0.18	0.07					
20	10.6	3.15	1.63	0.55	0.21	0.09	0.02				
22	12.6	3.77	1.96	0.67	0.25	0.09	0.02				
24	14.8	4.42	2.32	0.78	0.30	0.12	0.04				
26	17.2	5.13	2.65	0.90	0.35	0.14	0.05				
28	19.7	5.89	3.04	1.04	0.41	0.16	0.05				
30	22.4	6.70	3.45	1.17	0.43	0.18	0.05				
35		8.90	4.64	1.56	0.62	0.23	0.07				
40		11.4	5.89	1.98	0.78	0.30	0.09	0.02			
45		14.2	7.34	2.48	0.97	0.37	0.12	0.04			
50		17.2	8.92	3.01	1.20	0.46	0.14	0.04			
55		20.5	10.6	3.59	1.43	0.55	0.16	0.05			
60		24.1	12.5	4.21	1.66	0.64	0.18	0.07	0.02		
70			16.6	5.61	2.21	0.85	0.25	0.09	0.03		
80			21.3	7.18	2.83	1.08	0.32	0.12	0.04		
90				8.92	3.52	1.36	0.39	0.14	0.07		
100				10.9	4.28	1.66	0.48	0.18	0.07	0.02	
150				23.2	9.06	3.50	1.04	0.37	0.16	0.05	
200					15.5	5.96	1.75	0.62	0.28	0.07	0.02
250					23.4	9.05	2.65	0.94	0.42	0.12	0.05
300						12.6	3.73	1.34	0.58	0.16	0.05
350						16.8	4.95	1.78	0.76	0.21	0.07
400						21.5	6.33	2.25	0.97	0.28	0.10
450							7.87	2.81	1.20	0.32	0.12
500							9.55	3.41	1.45	0.42	0.14
550							11.4	4.07	1.75	0.48	0.16
600							13.4	4.78	2.05	0.58	0.18
650							15.5	5.54	2.37	0.67	0.23
700							17.8	6.37	2.71	0.76	0.25
750							20.3	7.22	3.10	0.86	0.30
800								8.14	3.50	0.97	0.32
850								9.11	3.89	1.08	0.37
900								10.1	4.32	1.20	0.42
950								10.8	4.79	1.34	0.46
1000								12.3	5.27	1.45	0.51

BATTERIAS, INVERTIDORES Y CONTROLADORES

Voltage del sistema

Un pequeño sistema con una pequeña distancia de transmision se diseñada usualmente a operar a 12 Voltios. Grandes sitemas pueden ser de 12 Voltios, pero si alta energia es deseada o la distancia de transmision es larga, entonces un sistema de 24 voltios o mas alto puede ser preferible. Esto es especialmente realidad si todas las fuentes son de energia invertida. En un sistema de 12 voltios que opera a bajo nivel de energia, puede ser ventajoso de operar todas las fuentes directamente desde baterias. Hay muchos aparatos de 12 Voltios y pequeños invertidores disponibles. En sistemas de 24 voltios, es preferible operar las fuentes directamente (aunque no hay muchos aparatos electronicos disponibles).
En sitemas de alta energia, es usualmente mejor usar un invertidor para convertir el voltage de bateria a energia regular domestica Energia CA. Esto se ha hecho feasible con la vision de invertidores de alto poder. Miles de sistemas de energia domiciliar estan en operacion con solo fuentes CA.

Capacidad y tamaño de bateria
Un sistema tipico hidraulico debe tener la capacidad de almacenar hasta dos dias de bateria. Esto generalmente mantiene las celulas de acido dirigido operando durante la carga media donde son mas eficientes y duran mas. Las baterias alkalinas al igual que las de de hiero niquel y las de tipo cadium niquel pueden tener una capacidad baja ya que pueden ser completamente descargadas sin dañarse.

Las baterias deben estar afuera del lugar de vivienda, o bajo ventilacion adecuada ya que mientras la carga aumenta tiende a producir gas hidrogeno y gases corrosivos. Tambien, la se debe agregar agua destilada cuando sea necesario para mantener el nivel de electrolito.

Control de Carga

Un sistema hidraulico requiere que las cargas esten presentes para la energia tenga a donde ir. De otra manera el voltage del sistema puede aumentar a alto niveles. Esta situacion provee una oportunidad para hacer algo con el exceso de energia (Una descarga puede ser utilizada para calentar agua).

Mientras las baterias se cargan completamente, sus voltages aumentan. A un punto el proceso de carga debe detenerse y la energia debe ser desviada a una descarga (hay que adivinar un poco). El punto a donde el voltage debe estar es de 13.5 a 14.5 para un sistema de 12 voltios dependiendo en el promedio de la carga. Mientras mas alta la carga, mas alto puede llegar el voltage. Si las baterias estan siempre cargandose, el limite del voltage debe estar en el promedio bajo.
Un metro de voltage o un metro de horas de watt puede ser usado para monotorizar el nivel de la carga de la bateria. El voltage de la bateria es casi una funcion del nivel de carga y varia segun el promedio y nivel de carga. Hay muchos monitores comercialmente disponigles que pueden mostrar convenientemente estos factores al usuario, incluyento el estado de carga.

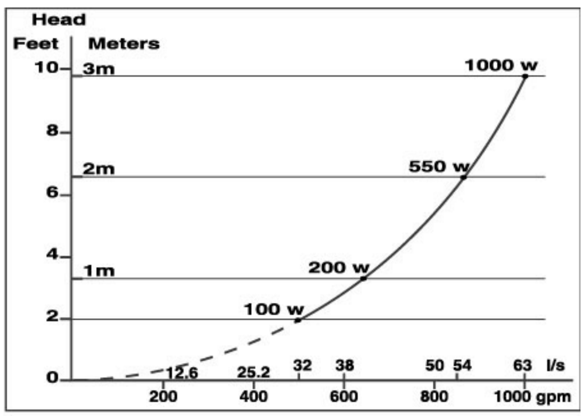
ALAMBRADO DEL CENTRO DE CARGA

Cada sistema requiere algun alambrado para conectar varios componentes. Los centros de carga estan disponibles como un paquete completo que facilita la coneccion de las cargas a los fuentes de carga. Todos los circuitos en el sistema deben usar alambres de tamaño adecuado y tener fusibles o flipones con suficiente capacidada para llevar la carga esperada. El LH1000 debe estar fusionado ya que puede sufrir un corto o una falla similar al igual que cualquier cosa en el sistema.

Dentro de la caja de empalme a un lado de la maquina existen dos bloques terminales para el alambrado de la bateria. La terminal negativa esta atornillada a una caja y la terminal positiva atornillada a un plato plastico. Las puntas del alambre de transmision son insertadasdentro de estos dos conectores (despues de haberse pelado la insulacion) y despues amarrado.

El eje de presicion intallada en la caja de empalme dara la lectura del rendimiento de la hidroelectrica en ampareage si el multimetro digital esta conectado a los enchufes (codificado con colores en el cuerpo del eje), y rotado a 200m (la posicion de las 9 empunto). Un voltimetro conectado a las baterias indicara aproximadamente el nivel de carga, como esta descrito en el "Nivel de Carga" arriba y un ammetro indicara el rendimiento de la maquina.

LH POWER OUTPUT



LH1000 Output (Watts Continuous)

EXEMPLO DE DISEÑO

Este ejemplo muestra como proceder con una instalacion completa. Los parametross del lugar ejemplo son:

> 120' de cabeza sobre una distancia de 1000'
> Una corriente de 30gpm (casi todo el tiempo)
> 100' de distancia desde la casa a la maquina hidraulica
> Un sistema de 12 Voltios

La primera cosa que se debe determinar es el tamaño de la tuberia. Dado que hay friccion entre la tuberia y el agua que fluye, esta friccion se puede reducir aumentando el tamaño de la tuberia para minimizar la friccion de los limites de aceptacion. Por lo tanto, el tamaño de la tuberia debe ser optimizado basado en economia y desarrollo.

La grafica de la tuberia nos muesta que ocho pulgadas (aprox. 20cm) de diametro en tuberia PVC tiene una perdida de cabeza de 0.97 pies de cabeza por 100 pies (30mts) de tuberia a una

corriente promedio de 800 GPM (50 lts). Esto es como 0.5’ (15cm) de perida por 50 pies (15m) de tuberia.
PVC viene en tamaños cortos y se pegan juntos o comprados con empaques.

La salida maxima ocurre con una corriente de como 800 GPM (50 l/s). Note que con esta maquina, la corriente es determinada por la cabeza, ya que no hay boquillas que se puedan ajustar para cambiar la corriente.

1 pie de perdida/100 pies de tuberia = x pies de perdida/50 pies de tuberia
x = 0.5 pies (15cm) de perdida de cabeza

Luego, restamos las perdidas de la cabeza desde la cabeza medida (a menudo referida como estatica o el total de la cabeza (head gross). Abreviado Hg) en orden de determinar la actual cabeza operacional (siempre referida como dinamica o cabeza neta. Abreviada Hn):

6 pies de cabeza (Hg)-0.5 pies de perdida de cabeza = 5.5 pies (1.85m) de cabeza actual (Hn)

Ahora se sabe que la **LH 1000** sera operada a una cabeza actual, o dinamica, cabeza de 5.5 pies (1.85m) Hn. Con referencia a la tabla de salida, se puede determinar que la LH1000 puede, realisticamente, producir aproximadamente 400w.

RESISTENCIA DEL ALAMBRE COBRE

Wire Gauge	Diameter Inches	Ohms per 1000'	Ohms per Mile
0000	0.460	0.05	0.26
000	0.410	0.06	0.33
00	0.364	0.08	0.42
0	0.324	0.10	0.52
2	0.258	0.16	0.84
4	0.204	0.25	1.34
6	0.162	0.40	2.13
8	0.128	0.64	3.38
10	0.102	1.02	5.38
12	0.081	1.62	8.56
14	0.064	2.58	13.6
16	0.051	4.10	21.6
18	0.040	6.52	34.4

Desde que necesitamos 12 voltios y la distancia de transmision es corta, podemos generar y transmitir 12 voltios usando la **LH1000**. Esta **LH1000** puede tambien ser usada para voltages altos como 24 y 48, y la energia puede ser transmitida a distancias mas lejanas. Necesitamos ir 100'(30m) con 400 watts a nuestro lugar. El amperage puede ser determinado usando la formula: voltios x amperage = watts. Asi, un sistema de 12v usualmente opera a un voltage actual de como 15v, por lo tanto: 400/15 = 26.7 amps. La maquina necesitara ser alambrada paralelamente delta para este sitio.

Esto sera como 26.7 amps a 15 voltios al generador. Note que habra alguna caida en el voltage en la linea y las baterias de 12 voltios necesita un poco mas de alto voltage que el nominal para ser cargadas. Asi los 26.7 amps deben pasar a traves de 200'(60m) de alambre por la distancia a las baterias y de regreso la cual completa los circuitos. Como hay friccion entre el agua y la tuberia que la lleva, causa fugas, asi hay resistencia entre la electricidad y el conductor que lo lleva y es medido en unidades llamadas ohms. Perdida de resistencia debe mantenerse tan baja como la economia lo permita, al igual que las perdidas de tuberia. Asumamos que un 5% de perdida es aceptable en este sitio, resultando en una perdida de 25 watts.

La formula para calcular resistencia es I (amps) x I (amps) x R (resistance) = w (watts). Ponemos nuestras figuras conocidas dentro de la formula para aprender la resistencia que necesitamos en un conductor de cobre para alcanzar esto.

$$26.7 \times 26.7 \times R = 25w$$
$$711 \times R = 25w$$
$$R = 0.04 \text{ ohms}$$

Se ha calculado que el conductor de cobre con perdidas de 0.04 ohms sobre una distancia total de 200'(60m) que resultara en un 5% aceptable de perdida. La grafica de alambre de perdida muestra perdidas de 1000' (300m) de alambre o asi:

1000'/200' x 0.04 ohms = 0.2 ohms por 1000'.

La grafica muestra 2 ga. De alambre tiene una resistencia de 0.16 ohms por 1000', asi

200'/1000' x 0.16 ohms = 0.032 ohms.

Esta es suficientemente cerca al nivel deseado, que con un poquito mas de investigacion podemos determinar si esto resultara en perdidas aceptables de energia:

26.7 amps x 26.7 amps x 0.032 ohms = 22.8watts de perdida.

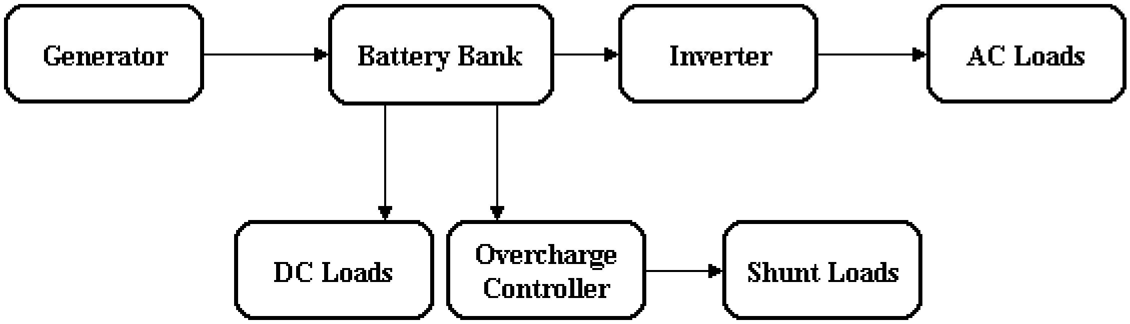
Aumentando el tamaño del alambre puede aun mas reducir las perdidas, pero tambien puede aumentar los costos, ya que el alambre mas grande es generalmente mas caro. Resistencia en un distancia de alambre resulta en perdida de energia que se ve como caida de voltage desde un punto en la linea a otro. Por ejemplo, si su voltage, es medido al generador, es 15vdc, luego puede ser asumido que si el voltage donde se midio junto a la linea de bateria, debera ser mas bajo mientras usted se aleja del generador: Voltage drop= I (amps) x R (ohms resistencia en su circuito). Asi:

Voltage drop (v) = 26.7 amps x 0.032 ohms = 0.85 volts

Por ende, si el voltage de su generador es 15vdc, el voltage de su bateria sera 14.15vdc. Recuerde que son siempre las baterias que determinan el voltage del sistema, ya que son la fuerza estabilizadora en su sistema. Todos los voltages en el sistema aumentaran y disminuiran correspondiente al voltage de la bateria, o el estado de la carga de bateria. En este lugar, estaremos generando 26.7 amps continuamente. Tipicamente, el tamaño de un banco de bateria es capaz de guardar dos dias de carga. Si escogemos baterias de acido plomo y deseamos dos dias mas de capacidad, entonces usamos la formula: amps x hours x days = amp/hrs capacidad. Asi:

33 amps x 24 hrs x 2 days = 1584 amp. Hrs. Capacidad

El Trojan L-16 Tiene un porcentage de 6vdc y 350 amp/hr. Usando estos usted debera requerir al menos ocho baterias; tendra cuatro alambres paralelos, con cada alambre consistente de dos baterias en serie a dar los 12vdc en el sistema de voltios que se ha escogido. Esto le dara 1400 amp/hrs a una capacidad 12vdc, la cual es como dos dias de almacenage. Un invertidor y un controlador de carga son usados usualmente en el sistema. El diagrama para ese sistema se mirara asi:



AJUSTE DE RENDIMIENTO

Para que la maquina produsca el rendimiento mas alto, la altitud del rotor debe ser ajustada, para igualar la energia magnetica del rotor a la energia de la quebrada en el sitio. Ya que todos los sitios varian uno del otro, es importante ajustar el rotor para un maximo rendimiento. Esto involucra elevando o bajando el rotor para aumentar el cambio constante del nivel magnetico. Hasta encontrar el optimo nivel.

Despues que la maquina este instalada, realice un trayecto inicial; para establecer el nivel del rendimiento de la energia. Esto puede deteminarse usando un ammetro para medir corriente o un metro digital para medir el voltage conectado en un conector de afuera en el eje de precision encontrado en la caja de empalme. Es buena idea mantener un cuaderno de bitacora para anotar cualquier cambio en el rendimiento en relacion a lo marcado y monitorizar su desarollo a largo tiempo. Despues que todo este instalado, inicie la **LH1000** abriendo la fuente de agua. Dejelo que corra suficientemente para que el nivel de rendimiento se estabilice y apunte la corriente (o voltage) Luego apague el chorro.

La **LH1000** viene con el rotor (el plato de cromo) que esta muy cerca al stator (el estacionario, de fondo negro del generador). Para aumentar la distancia, y reducir el nivel del flujo magnetico, usted primero debe, mientras sostiene el estacionario rotor con el 1/4-“ pin del rotor puesto en el agujero a la orilla del rotor, suelte el pequeño tornillo con cabeza (7/16"). Despues, agarre el rotor estacionario con el pin, y apriete el tornillo mas grande, lo cual forzara al rotor a subir. Cada rotage del tornillo movera el rotor verticalmente a 0.050" o 1.25 mm. Si subiendo el rotor causa que la corriente (o usted puede estar monitorizando el voltage en un sitio de alto voltage) aumente, entonces continue haciendolo asi hasta que no siga aumentando. Si un punto es alcanzado donde ocurre una disminucion, entonces el rotor debe ser bajado. Con soltar el tornillo mas grande y apretando el mas pequeño es como esto se hace. Rotando el tornillo mas pequeño causa que el rotor se mueva verticalmente a la misma distancia por rotacion asi como el tornillo grande lo hace. Cuando usted ha encontrado la mejor posicion (no aumento en la corriente o voltage), asegurese que el tornillo grande es rotado hasta que este apretado. Ahora el tornillo mas pequeño debe ser apretado muy seguro para sellar todo en su lugar. No se deben hacer mas ajustes a menos que las condiciones en el sitio cambien.
Cuando se ajuste el rotor hacia abajo, puede alcanzar el punto donde hara contacto con el stator. Si esto ocurre, ajustelo siempre hacia arriba por lo menos un ¼ de rote al tornillo mas grande. Si se opera la maquina con el rotor mas cerca que esto puede causar daño en la maquina.
** Antes de iniciar la maquina, siempre rote el rotor a mano para chequear por sobage **.
Remueva el pin desde la orilla del rotor, antes de iniciar la maquina.

ESAMBLAJE Y SERVICIOS

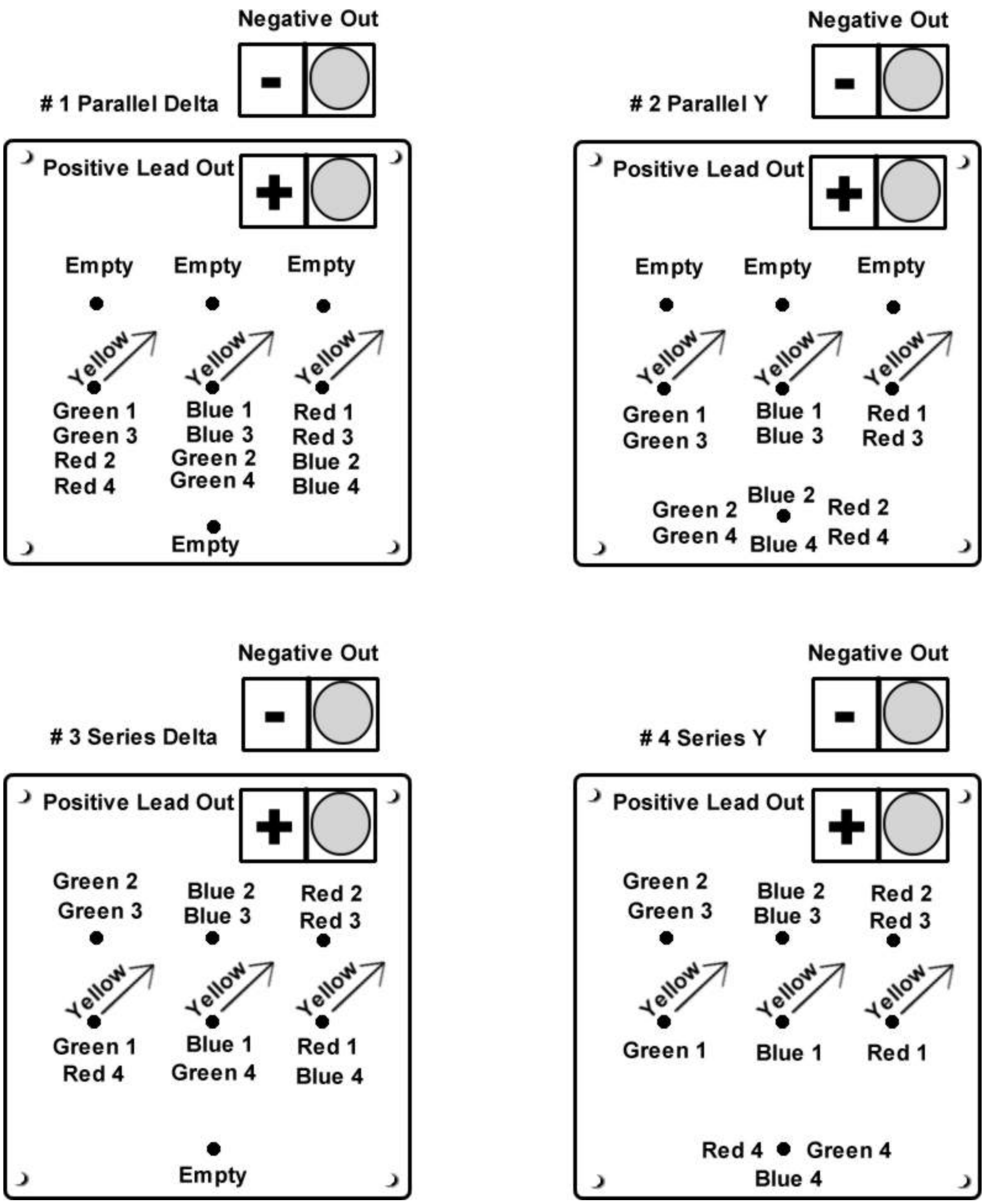
Para poder remover el generador usted debe primero remover el alambrado desde las terminales en el bloque claro de plastico en la caja de empalme. Asegurese de anotar su posicion para una futura reinstalacion. Una alternativa es remover la caja de empalme desde la base del alternador removiendo los dos tornillos en el bracket. Luego desartonille los 4 tornillos que conectan el generador a la base fina de aluminio, usando la llave inglesa allen suplida con el LH1000. Los cuatro tornillos estan localizados bajo la base del generador y entre lazados hacia arriba dentro del generador. Luego desartonille el cono de la nariz de poliuretano desde la base de la unidad, localizado adentro de la vena guia de ensamblage, al final del eje hacia la derecha con direccion a las agujas del reloj. Proceda a remover la helice removiendo la tuerca de raton de ¾" (19mm), luego la arandela y finalmente deslice la helice desde el eje. Ahora hale el generador y el ensamblage del eje hacia arriba y fuera de la base del generador y la caparazon del eje. El eje se desatornilla como removiendo el largo eje de la turbina desde el eje del generador.

La base fina del alternador puede ser removida desde la caparazon del eje, desatornillelo. La caparazon del eje tambien puede ser desatornillada desde la base vena guia. La base guia de aluminio esta conectada a la guia vena de ensamblage de poliuretano con cuatro tornillos allen con cabeza ¼-20 que pueden ser removidos usando la llave inglesa provista y uno de 7/16 (11mm).

Reemplace los cojinetes tan pronto como usted note que estan un poco flojos o sueltos y chequee si el espesor aereo del espacio cambia. Si estan muy sueltos, puede resultar en serio daño a los dos rotor y stator. Esta maquina utiliza cojinetes 6203 con pelotitas selladas con hule, en el generador, y tiene un cojinete lubricado por agua localizado en la vena guia base. Estas estan hechas a la medida para que quepan dentro de la caparazon del alternador y en la base guia vena.

DIAGRAMAS DE ALAMBRADO

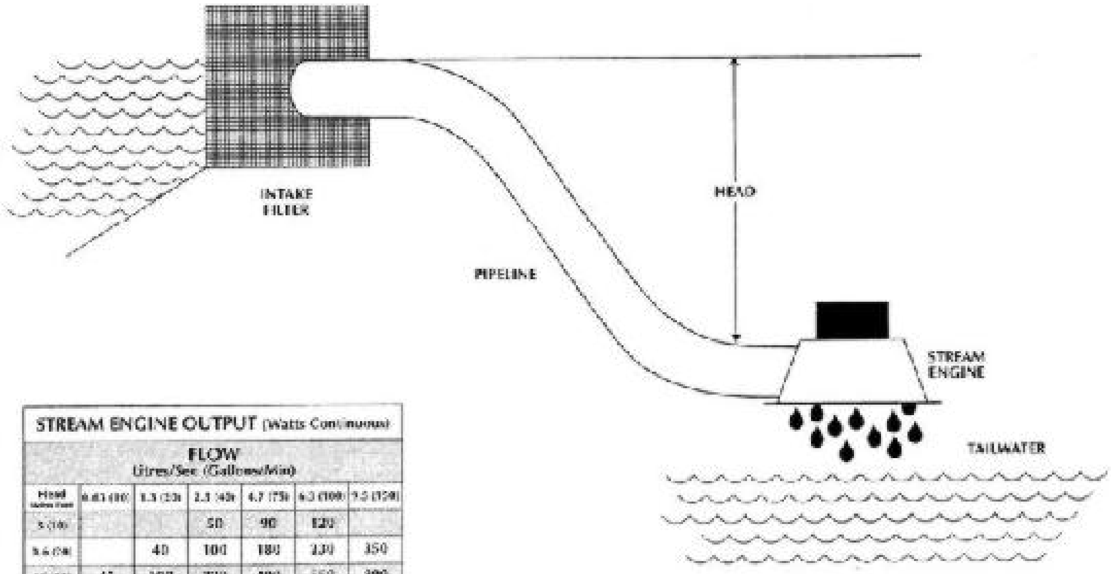
Estos diagramas representas cuatro posibles combinaciones del rendimiento del alambrado. Estan en orden de potencial. Si usted encuentra que el ajuste del vacio de aire esta a un minimo y desea intentar para mas energia, entonces trate una combinacion mas alta. Si usted encuentra que el vacio de aire es mucha, intente el proximo mas bajo. Noteque solo existe un pequeño cambio en potencial entre #2 y #3.



TECNICA ACTUAL DE MEDIDA

Una maniobra pre fabricada es instalada en la caja de empalme, la que permite que la corriente sea medida digitalmente. Esto se hace con el suplido DMM (digital multimetro). Para medir la corriente producida por el generador, ponga la escala DMM a "DC milli-volts" o "200 m" a la posicion de las nueve empunto. Conencte las guias dentro del correspondiente color codificado en el gato en el eje en la caja de empalme. Esto le dara lecturas actuales desde 0.1 amps a 199.9 amps. Por supuesto, el DMM puede ser usado para otras tareas con su sistema de energia renovable.

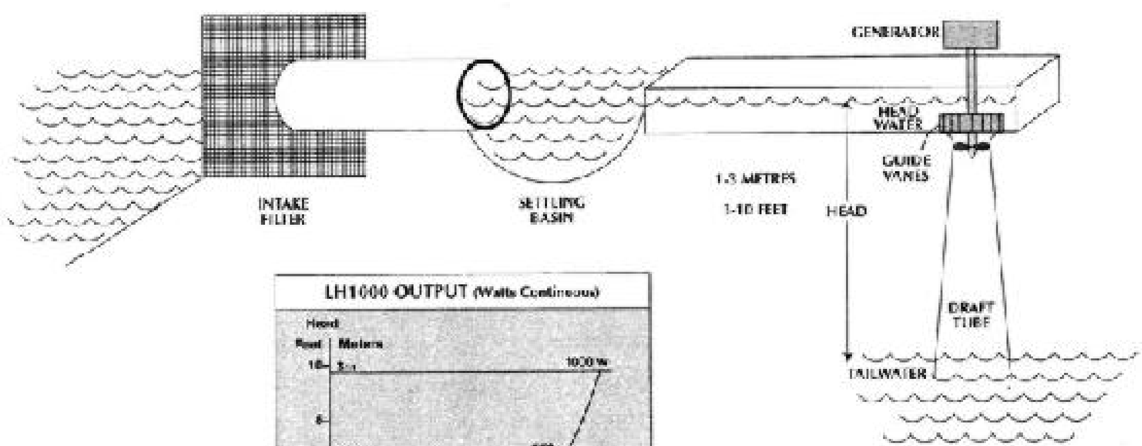
STREAM ENGINE INSTALLATION



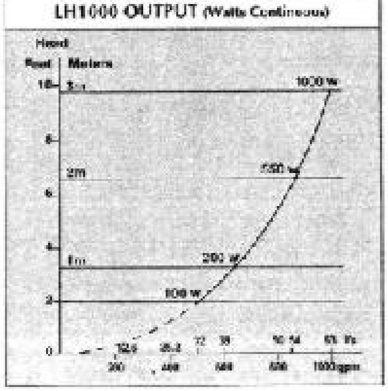
STREAM ENGINE OUTPUT (Watts Continuous)

Head	FLOW Litres/Sec (Gallons/Min)					
	0.63 (10)	1.3 (20)	2.5 (40)	4.7 (75)	6.3 (100)	9.5 (150)
3 (10)			50	90	120	
6 (20)		40	100	180	230	350
15 (50)	45	100	220	400	550	800
30 (100)	80	200	500	940	1100	
60 (200)	150	400	900	1500		

LH1000 INSTALLATION



LH1000 OUTPUT (Watts Continuous)



Energy Systems & Design, Ltd.

Paul Cunningham / Kent McNeilly
PO Box 4557 Sussex, NB
E4E 5L7 Canada

Tel: 506 433 3151 Fax: 506 433 6151

SE BUSCAN DISTRIBUIDORES

Dealer Information Form
Aplicacion para Distribuidor Autorizado

Nombre (Legal) de la Compañia:____________________

Limitada Asociacion Propietario unico Fecha de Incorporacion:____________

Es usted fabricante?_______ Si lo es, que fabrica? ____________________

#Impuesto sobre el Valor Agregado:____________________

Requiere orden de compra? Si No

Nombre del Comprador:____________________

Telefono/email: ____________________

Encargado de Cuentas a pagar: ____________________

Telefono/Email: ____________________

Nombre del Recibidor:____________________

Telefono/Email:____________________

Direccion Postal:

Calle:____________________

Ciudad: ____________ Provincia: __________Codigo Postal: ___________ Pais: ____________

Telefono: ______________ Facsimil______________ Email: ______________

Direccion fisica (si es diferente a la Postal):

Calle: ____________________

Ciudad: ____________Provincia: __________Codigo Postal: ___________ Pais: ____________

Telefono: ______________ Facsimil: ______________ Email: ______________

Metodo del Envio (Por favor marque su preferencia)

Servicio Estandard de ES&D ________ Su propia cuenta de envios __________

Provea la informacion de su cuenta de envio abajo

Su Firma: ____________________ Fecha: ____________

Nombre (Letra de molde): ____________________ Titulo: ____________

Esta forma no es una aplicacion de credito. Todas las ordenes internacionales necesita ser pagada por adelantado.

"Innovative Micro-Hydro Systems Since 1980"

Introduction


Stream Engine

The Stream Engine employs a brushless, permanent magnet alternator which is adjustable, enabling the user to match turbine output to the electrical load. It has higher efficiency than previous alternators, and is capable of outputs over 1 kilowatt (kW). It is equipped with a rugged bronze turgo wheel, universal nozzles (adaptable to sizing from 3 mm (1/8 inch) to 25 mm (1 inch), and a digital multimeter which is used to measure output current. The entire system is made of non-corrosive alloys for long life and durability. This machine can produce power from heads as low as 2 metres (6 feet) to over 100 metres (300 feet).


The LH1000

The LH1000 uses the same generator as the Stream Engine, however the water turbine component uses a low head propeller design. The enables the machine to produce power from heads of 0.5 metres (2 feet) up to 3 metres (10 feet).At the maximum head, the output is 1 Kw.

The â€œWater Babyâ€• is Energy Systems & Design's solution to sites where the flow is very low, as low as 3 gpm (0.18 l/s), and the head is above 50 feet (15m). It uses a double stator, brushless permanent magnet generator with a 2" (50mm) pitch diameter bronze turbine wheel. At a head of 100 feet (30m) and a flow of 3 gpm (0.18 l/s) the output is 25 watts; at 24 gpm (1.5 l/s) the output is 250 watts.


The Water Baby

Â Â **Please be patient with us as we update our website with more information soon.**

View & print our brochure!

* *Get Adobe Reader*

www.microhydropower.com

Energy Systems & Design

"Innovative Renewable Energy Systems Since 1980"

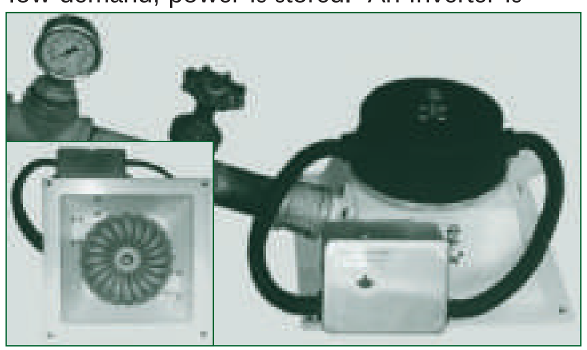
P.O. Box 4557
Sussex, NB
Canada E4E 5L7
Tel.: (506) 433-3151
Fax: (506) 433-6151
E-mail: hydropow@nbnet.nb.ca Web: microhydropower.com

Energy Systems and Design has been producing micro-hydroelectric components since 1980, and offers a wide array of products and services to the renewable energy (RE) marketplace. Now, ***ES&D*** offers the ***LH1000***, low-head propeller turbine, and international installation services.

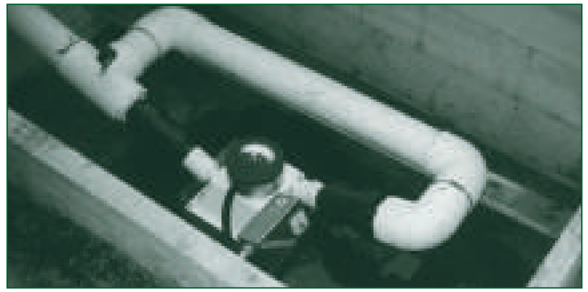
The ***Stream Engine*** and ***LH1000*** both employ a brushless, permanent magnet alternator which is adjustable, enabling the user to match turbine output to electrical load. It has a higher efficiency than previous alternators, and is capable of outputs over 1 kW, while requiring virtually no maintenance. **ES&D**'s microhydro systems employ high efficiency, precision-cast parts, and non-corrosive alloys for long life and durability. A digital multimeter accompanies each turbine for measuring output amperage. These units can be used in stand-alone, or grid-tied systems.

STREAM ENGINE OPERATION

The ***Stream Engine*** is designed for use in battery-based power systems, with electricity generated at a steady rate, and stored in batteries for use at higher rates than is generated. During times of low demand, power is stored. An inverter is used when residential AC power is desired. Water from a stream is channeled into a pipeline to gain enough **head** (the vertical distance the water falls) to power the system. The ***Stream Engine*** operates at heads of about 2m (6 feet) and upward. The water passes through a nozzle, where it accelerates, strikes the bronze turgo wheel, and turns the generator shaft. Up to 4 universal nozzles can be installed on one machine. Nozzles are adaptable in sizing from 3mm(1/8 inch) to 25mm(1inch).



Stream Engine



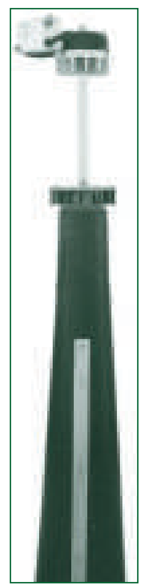
Stream Engine Installation

Typically, these systems operate at 12, 24, or 48 volts, with reconnectable wiring which allows the user to install a standard ***Stream Engine*** at most sites. Custom windings are also available which can produce high voltage (120, 240) at any site.

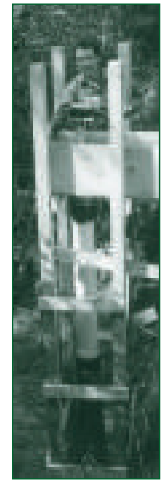
LH1000 OPERATION

The ***LH1000***, like the ***Stream Engine***, is designed to operate in conjunction with battery-based power systems, in order to store electrical power for use at times when consumption exceeds generation. Power is stored during periods of low demand. When AC loads are desired, extra "**balance of system**" (see below) components are required to convert stored DC to residential AC power.

To gain enough **head** to operate the ***LH1000***, water is channeled into a sluiceway. The turbine is mounted in a 18cm (7") opening in the sluice bottom, with the draft tube extending to the tailwater below. The water turns the propeller, creating shaft power. This, in turn, powers the generator, producing electricity.



LH1000

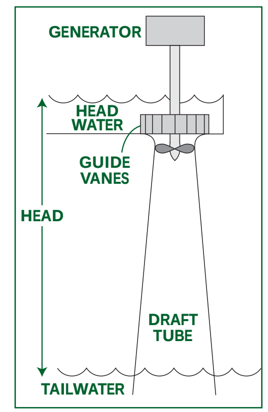


LH1000 Installation

The ***LH1000*** typically operates at 12, 24, 48, or 120 volts. It can be specially wound to operate at 240 volts, when necessary. Employing the same adjustable, permanent magnet generator as the ***Stream Engine***, the ***LH1000*** has reconnectable wiring for use at a wide range of sites.

POWER OUTPUT & SITE ASSESSMENT

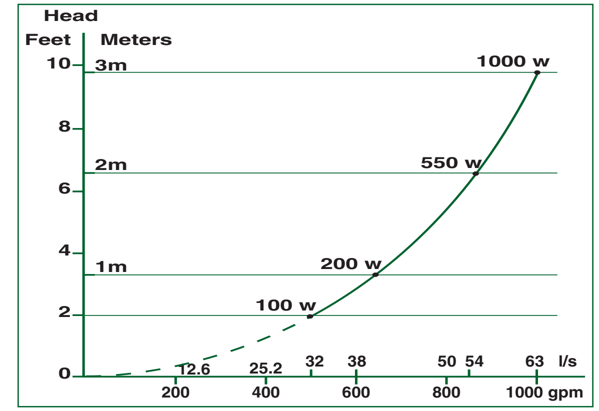
To determine the power available at a site, **head** and **flow** measurements must be taken. **Flow** is the rate at which water moves, measured in liters per second (l/s) or gallons per minute (gpm). This can be measured by channeling the water into a pipeline, then into a container of a known volume, noting the time it takes to do so. A weir can be used to measure flows in larger streams. **Head** can be measured by using a transit, by siting along a level, or by using a pressure gauge at the end of the pipeline. An altimeter can also be used, so long as it is accurate, and sufficiently sensitive.



LH1000 Installation

Stream Engine Output (Watts Continuous)

Head Metres (Feet)	Flow Litres/Sec (Gallons/Min) 0.63 (10)	1.3 (20)	2.5 (40)	4.7 (75)	6.3 (100)	9.5 (150)
3 (10)			50	90	120	
6 (20)		40	100	180	230	350
15 (50)	45	100	220	400	550	800
30 (100)	80	200	500	940	1100	
60 (200)	150	400	900	1500		

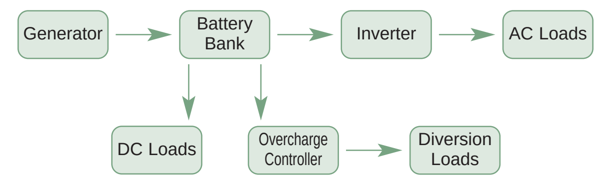


LH1000 Output (Watts Continuous)

It is important to keep in mind that output can only be accurately determined if **head** and **flow** measurements are made correctly, so care should be taken during this process. Two other important factors in a site assessment are **system voltage**, and **transmission distance**. The voltage and distance the power must travel can affect the efficiency and cost of your transmission lines.

"BALANCE OF SYSTEM" & OTHER COMPONENTS

Energy Systems and Design offers system design services. Also available are "**balance of system**" components including batteries, inverters, and charge controllers.



A Typical "Stand-Alone" RE System

Batteries

Batteries are an integral part of the self-sufficient energy system. Lead-acid, deep-cycle batteries are usually used in hydro systems. Deep-cycle batteries are designed to withstand repeated charge and discharge cycles typical in renewable energy systems. Ideally, lead-acid batteries should not be discharged more than about half their capacity. Alkaline batteries, such as nickel-iron and nickel-cadmium, can withstand complete discharge with no ill effects.

Inverters

A battery bank does not enable users to live with all of the conveniences of modern living, as most appliances use high voltage AC (alternating current), while batteries can supply only DC (direct current). Inverters are used to convert DC into AC so that stored battery power may be used, as needed, by appliances and other loads. Modern inverters are available in almost every size, from small, recreational to industrial types, and are designed for user friendliness, durability, and reliability.

Charge Controllers

When the load demand is less than the generator output, power is available to charge the batteries. When the batteries are charged to capacity, the power is diverted to a secondary, "diversion" load, such as hot water heaters. The diversion of the generated power is accomplished by using a **charge controller**. Many types are available to perform this function.

MICRO-HYDROELECTRIC COMPONENTS

Turbine Wheels

Turgo- This rugged bronze turbine wheel is adaptable to a wide range of sites from 2m (6 feet) of head and up. This wheel can handle large flows though it has only a 10cm (4-inch) pitch diameter; it can accommodate nozzles up to 1" (25mm).

Bronze Turgo Wheel
10cm/4" pitch diameter

The turgo wheel fits a Ford or Delco alternator, with a 17mm shaft and a 1.25mm thread pitch (20 tpi.). Its approximate weight is 2.5kg (5.5 lbs), and is supplied balanced and machined.

Pelton- This popular, plastic pelton wheel is useful in higher head/lower flow situations and where outputs will not be excessive. With a 10cm pitch diameter (4 inch), it is ideal for small, do-it-yourself applications, and has been used in the "L'il Otto" micro-hydroelectric systems for years. The peltons are supplied with a 13mm (1/2") bore.

Polyurethane Pelton Wheel
10cm/4" pitch diameter

Permanent Magnet Alternators

The **Energy Systems and Design** permanent magnet alternator has been designed specifically for micro-hydroelectric applications. With an output of 500watts/1000rpm, it is over 80% efficient at full load. Operating without brushes, and with its windings encapsulated in epoxy, maintenance is minimal, and usually limited to bearing replacement.

The rotor is adjustable so as to enable the user to vary the field strength, and match the output to the load. With a variety of wiring configurations, the permanent magnet alternator is ideal for most sites. It has a 17mm shaft and a 1.25mm thread pitch. Sealed ball bearings are used to give reliable performance and provide for easy procurement of spares.

The **Energy Systems and Design** permanent magnet alternator is available in a **series design** (outputs up to 30 amps) and a **parallel design** (outputs up to 60 amps). A **high voltage design** is useful for long distance transmissions (120 or 240 volt), and can be used with ***ES & D*** **transformer panels** to step power down to battery voltages (contact us for details).

Transformer panels are built inside an aluminum junction box, containing a transformer, a rectifier, wiring lugs for connecting the wiring to the loads, and a precision shunt for output amperage measurement, using the supplied digital multimeter.

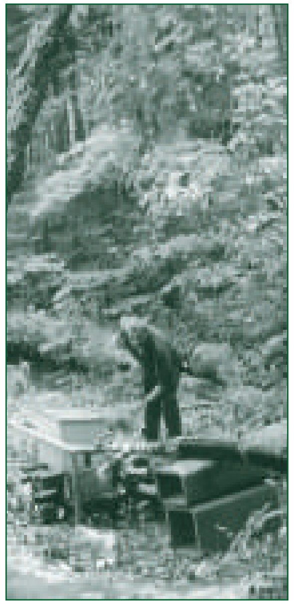
Universal Nozzles

Energy Systems and Design has developed a new type of nozzle. It is conical in shape, with gradations marked on it which correlate to a range of nozzle sizes, 3mm (1/8 inch) to 25mm (1 inch). The nozzle is cut to the appropriate size and the end is sanded to a smooth finish.

Turbine Housings

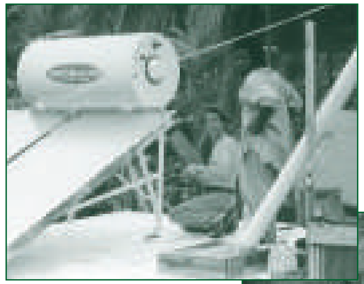
Turbine housings are made of cast aluminum, and powder coated white for lasting protection. The side walls are angled to accommodate the nozzles, in conjunction with the use of the turgo wheel. Turbine housings are available unmachined or prepared to user specifications.

INSTALLATION SERVICES



Boiestown, NB, Canada

Energy Systems & Design offers design and installation services to international communities at competitive rates. Our team of technicians designs and prepares your system at our facility in Canada, and then completes the installation at your site. We are prepared to handle any system, from solar hot water systems to photovoltaic, wind and microhydro. Contact us for details.



Morant Bay, St. Thomas Parish, Jamaica

Boiestown, NB, Canada

APPENDIX

a/ Power available at any given site can be assessed using the formula:

head (feet) x **flow**(gpm) /10= **Watts**
e.g., 100 feet x 30 gpm /10= 300 **Watts**
or
head (m) x **flow** (l/s) x 5 = **Watts**
e.g., 30 m x 2 l/s x 5= 300 **Watts**

b/ Before considering the purchase of a **Stream Engine** or **LH1000**, perform the above estimate. If it is determined that your site is viable, contact your dealer to discuss **pipelines**, **transmission distance**, and **system voltage**. Power from the **Stream Engine** or **LH1000** is limited according to the available **head**. See "Power Output and Site Assessment" for power charts.

c/ The length, diameter, and type of **pipeline** must be determined in order to predict losses due to friction.

d/ Many factors affect **system voltage** including output and **transmission distance**. Power is usually generated at battery voltage, but where transmission distances are too great for low voltage transmission (12, 24, or 48 V), higher voltages can be generated and transformers can be effectively used to step down to battery voltage.

"Innovative Micro-Hydro Systems Since 1980"

How it works

Stream Engine

The Stream Engine and the LH1000 are designed for use in battery-based power systems, with electricity generated at a steady rate, and stored in batteries for use at higher rates than is generated. During times of low demand power is stored. An inverter is used when AC power is desired.

Water from a stream is channeled into a pipeline to gain enough head (the vertical distance the water falls) to power the system. The Stream Engine operates at heads of about 2 metres (6 feet) and upward. The water passes through a nozzle, where it accelerates, strikes the turbine wheel, and turns the generator shaft. Up to 4 nozzles can be installed on one machine. The LH1000 operates at heads up to 3 metres (10 feet). The water passes through a guide vane assembly and then turns the propeller which is connected to the generator, then exits through a draft tube which is a tapered pipe which is immersed in the tailwater.

Typically, these systems operate at 12, 24, or 48 volts, with reconnectable wiring which allows the user to install a standard Stream Engine at most sites. Custom windings are also available which can produce high voltage (120, 240) at any site.

Stream Engine
(Bottom View)

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Power Output & Site Assessment

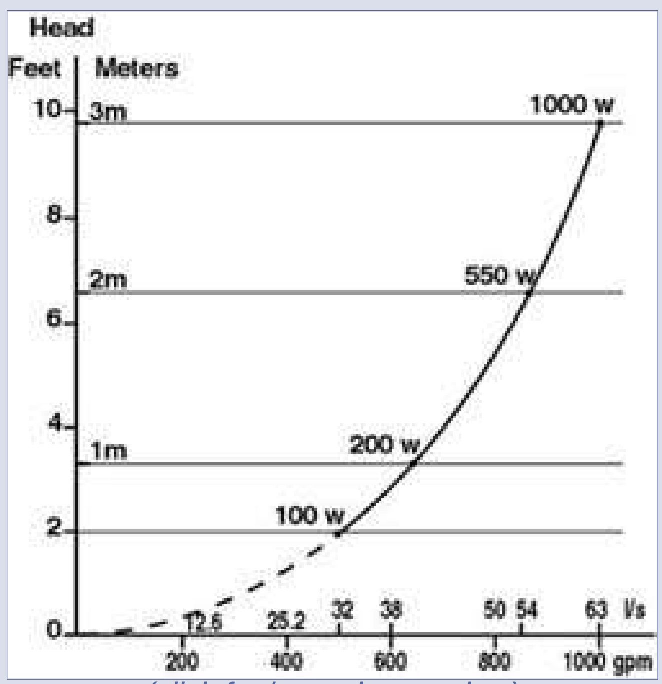
Stream Engine Installation:
8 meter (25 foot) head,
450 Watt output

To determine the power available at a site, head and flow measurements must be taken. Flow is the rate at which water moves, measured in liters per minute (l/m) or gallons per minute (gpm). This can be measured by channeling the water into a pipeline, then into a container of a known volume, noting the time it takes to do so. Head can be measured by using a transit, by siting along a level, or by using a pressure gauge at the end of the pipeline. It is important to keep in mind that output can only be accurately determined if head and flow measurements are made correctly, so care should be taken during this process.

Stream Engine Output (Watts Continuous)

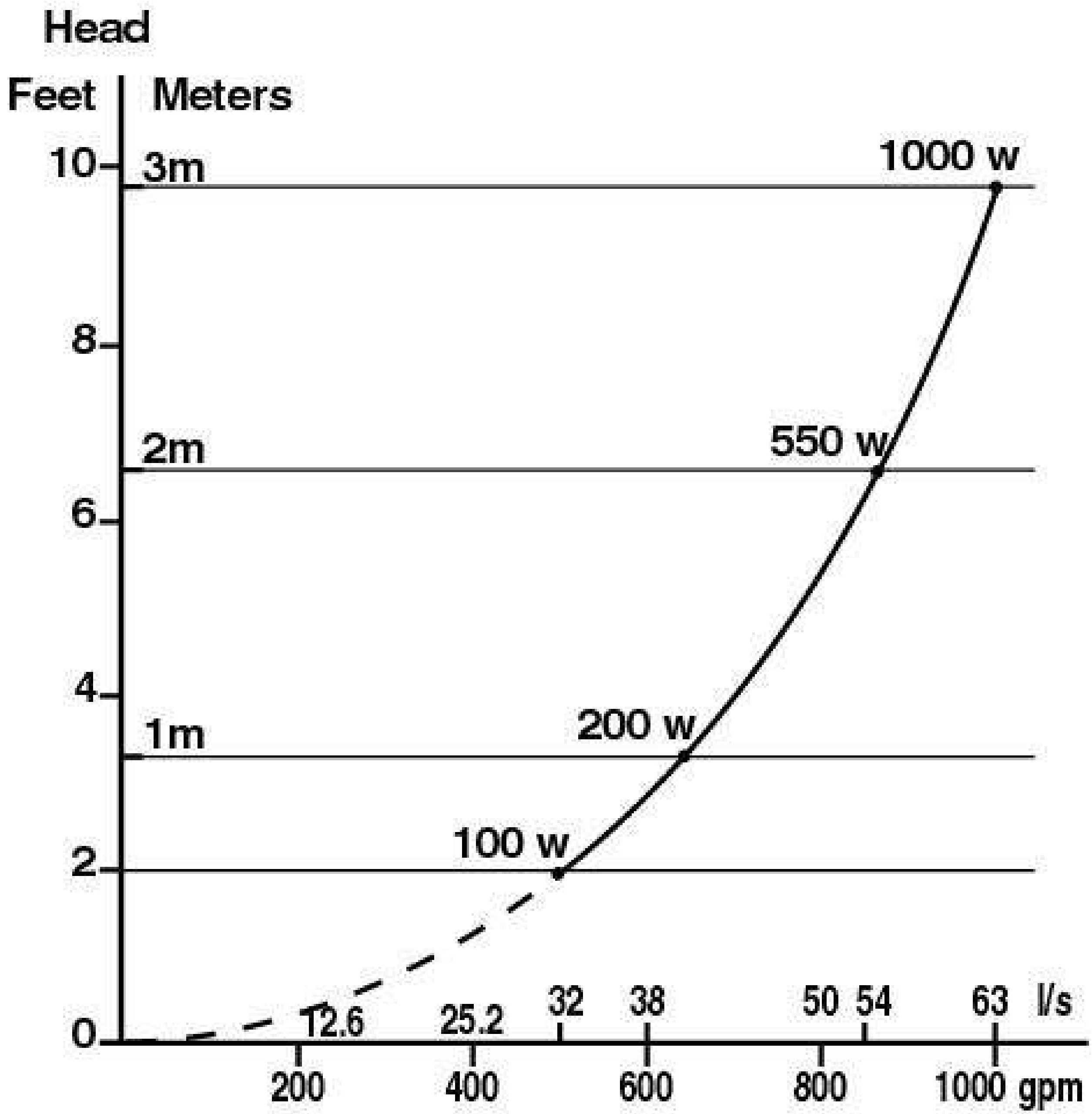
FLOW Litres/Min (GALLONS/MIN)					
Head Metres (Feet)	40 (10)	80 (20)	150 (40)	300 (75)	400 (100)
3 (10)		20	50	90	120
6 (20)	15	40	100	180	230
15(50)	45	110	230	450	600
30 (100)	80	200	500	940	1100
60(200)	150	400	900	1600	

LH1000 Output (Watts Continuous)



(click for larger image view)

www.microhydropower.com

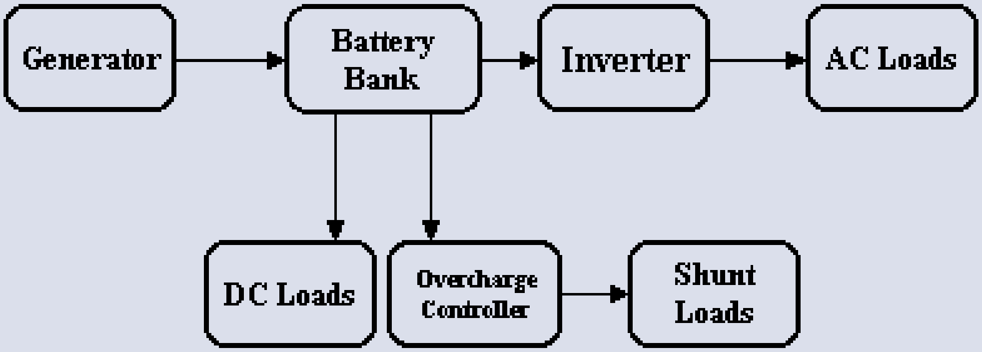

Head
Feet
Meters
10
3m
1000 w
8
2m
550 w
6
4
1m
200 w
2
100 w
0
12.6
25.2
32
38
50
54
63
l/s
200
400
600
800
1000 gpm

"Innovative Micro-Hydro Systems Since 1980"

"Balance of System" & Other Components

Bronze Turgo Wheel (Bottom View) -- 10cm (4") Pitch Diameter

Energy Systems and Design offers system design services.
Also available are "balance of system" components including batteries, inverters, and charge controllers.



Batteries

Batteries are an integral part of the self-sufficient energy system. Lead-acid deep-cycle batteries are usually used in hydro systems. Deep-cycle batteries are designed to withstand the repeated charge and discharge typical in renewable energy systems. Ideally, lead-acid batteries should not be discharged more than about half their capacity. Alkaline batteries, such as nickel-iron and nickel-cadmium, can withstand complete discharge with no ill effects.

Inverters

A battery bank does not enable users to live with all of the conveniences of modern living, as most appliances use high voltage AC (alternating current) while batteries can supply only DC (direct current). Inverters are used to convert DC into AC so that stored battery power may be used as needed by appliances and other loads. Modern inverters are available in almost every size, from small recreational to industrial types, and are designed for user friendliness, durability, and reliability.

Charge Controllers

When the load demand is less than the generator output, power is available to charge the batteries. When the batteries are charged to capacity, the power is diverted to a secondary load, like a hot water heater. The diversion of the generated power is accomplished by using a charge controller. Many types are available to perform this function.

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Components


Universal Nozzles

MICRO-HYDROELECTRIC COMPONENTS

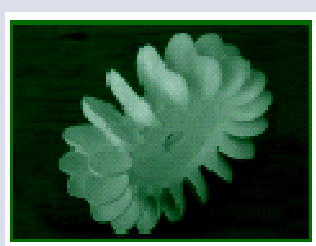
Turbine Wheels

Turgo - This rugged bronze turbine wheel is adaptable to a wide range of sites from 2 metres (6 feet) of head and up. This wheel can handle large flows though it has only a 10 centimetre (4 inch) pitch diameter. The turgo wheel fits a Ford or Delco alternator, with a 17mm shaft and a 1.25mm thread pitch (20 tpi.). Its approximate weight is 2.5 kg (5.5 lbs), and is supplied balanced and machined.

Pelton - This popular, plastic pelton wheel is useful in higher head, lower flow situations where outputs will not be excessive. With a 10cm pitch diameter (4 inch), it is ideal for small, do-it-yourself applications, and has been used in the "L'il Otto" micro-hydroelectric systems for years. The peltons are supplied with a 13mm (1/2") bore.


Bronze Turgo Wheel (Top View) 10 cm (4") diameter


Bronze Turgo Wheel (Bottom View) -- 10cm (4") Pitch Diameter


Urethane Pelton Wheel -- 10cm (4") Pitch Diameter

Permanent Magnet Alternators

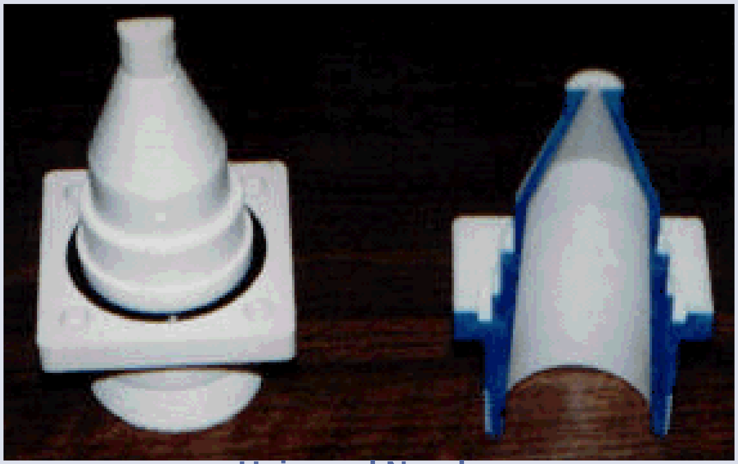
The Energy Systems and Design permanent magnet alternator has been designed specifically for micro-hydroelectric applications. With an output of 500watts/1000rpm, it is over 80% efficient at full load. Operating without brushes, and with its windings encapsulated in epoxy, maintenance is minimal, and usually limited to bearing replacement.

The rotor is adjustable so as to enable the user to adjust the field strength. With a variety of wiring configurations, the permanent magnet alternator is ideal for most sites. It has a 17mm shaft and a 1.25mm thread pitch. Sealed ball bearings are used to give reliable performance and provide for easy procurement of spares.

The Energy Systems and Design permanent magnet alternator is available in a series design (outputs up to 30 amps), a parallel design (outputs up to 60 amps), and a high voltage design useful for long distance transmissions (120 or 240 volt). They may be purchased separately, or with an aluminum junction box containing a terminal block for wiring, a rectifier, wiring lugs for connecting the wiring to the loads, and a shunt. A digital multimeter is supplied to measure current output.

Universal Nozzles

Energy Systems and Design has developed a new nozzle. It is conical in shape, with gradations marked on it which correlate to a range of nozzle sizes, 3mm (1/8 inch) to 25mm (1 inch). The nozzle is cut to the appropriate size and the end is sanded to a smooth finish.



Universal Nozzles

Turbine Housings

Turbine housings are made of cast aluminum, and powder coated white for lasting protection. The side walls are at an angle to accommodate the nozzles, in conjunction with the use of the turgo wheel. Turbine housings are available unmachined or prepared to user specifications.

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Appendix

1. Approximate power available at any given site can be assessed using the formula:

head (feet) x flow (gpm) / 8 -- Watts
e.g., 100 feet x 30 gpm / 8 = 375 Watts

or

head (m) x flow (l/m) / 10 = Watts
e.g., 30 m x 120 l/m / 10 = 360 Watts

2. Before considering the purchase of a Stream Engine, perform the above estimate. If it is determined that your site is viable, contact your dealer to discuss pipelines, transmission distance, and system voltage. Power from the Stream Engine is limited according to the available head.
At about 7.5 metre (25 feet), output is limited to 500 watts, 15 metre (50 feet) to 750 watts, and at a 30 metre (100 feet) head, 1000 watts can be generated, given adequate flow.

3. The length, diameter, and type of pipeline must be determined in order to predict losses due to friction.

4. Many factors affect system voltage including output and transmission distance. Power is usually generated at battery voltage, but where transmission distances are too great for low voltage transmission (12, 24, or 48 V), higher voltages can be generated and transformers can be effectively used to step down to battery voltage.

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Downloads

Pipeline & Machine (Photo byJo Pach)

ES&D's download page

Get Acrobat Reader

MANUAL 1	***The Stream Engine*** ***Personal Hydropower Owner's Manual*** • HTML • PDF (575k) • PDF (Spanish) (407k)
MANUAL 2	***The LH 1000 Low Head Propeller Turbine*** ***Personal Hydropower Owner's Manual*** • HTML (web page) • PDF (623k) • PDF (Spanish) (737k)
E-Brochure (PDF)	***Download ES&D BROCHURE.pdf***
Installation Diagrams	• Stream Engine - PDF • LH1000 - PDF
General Info	• LH1000
Dealer Info Form	• PDF • PDF (Spanish)

Manuals may take a few minutes to load due to size. Please be patient.

www.microhydropower.com

The Stream Engine Personal Hydropower Owner's Manual

Testing a Machine

Energy Systems & Design
P.O. Box 4557
Sussex, NB
Canada E4E 5L7

MANUAL I

The Stream Engine Personal Hydropower Owner's Manual

Made in Canada

Table of Contents

www.microhydropower.com

MANUAL I

The Stream Engine Personal Hydropower Owner's Manual

INTRODUCTION

This manual describes The Stream Engine, which is manufactured by Energy Systems and Design. The installer must have some knowledge of plumbing and electrical systems, and the user of the system should also.

These machines are small, but can generate some very high voltages. Even 12-volt machines can produce high voltages under certain conditions. Practice all due safety. Electricity cannot be seen and can be lethal.

Electricity is garnered from the potential energy in moving water from a high point to a lower one. This distance is called "head" and is measured in units of distance (feet, meters) or in units of pressure (pounds per square inch, kilo-pascals). "Flow" is measured in units of volume (gallons per minute - gpm, or liters per second - l/s), and is the second portion of the power equation. The power available is related to the product of the head and the flow.

The Stream Engine is designed to operate over a wide range of heads and flows. This is achieved with the use of a Turgo runner, or wheel. Nozzle diameters of 1/8 to 1 inch are available, and up to four nozzles can be used on one machine, to utilize heads as low as four feet and as high as hundreds.

The Stream Engine uses a permanent magnet type alternator. This design eliminates the need for brushes and the maintenance that accompany them while increasing efficiency. The Stream Engine's output can be optimized by simply adjusting the rotor clearance.

---

www.microhydropower.com

MANUAL I

The Stream Engine Personal Hydropower Owner's Manual

SITE EVALUATION

Certain information must be determined concerning your site, in order to use its potential for maximum output. Head and flow must first be determined. The other factors are: pipeline length, transmission distance, and the system voltage. These factors determine how much power can be expected.

Power is generated at a constant rate by the Stream Engine and stored in batteries as direct current (DC). Power is supplied, as needed, by the batteries, which store energy during periods of low consumption for use in periods where consumption exceeds the generation rate.

Appliances can be used that operate directly from batteries, or 120 volt alternating current (AC) power can be supplied through an inverter, converting DC to AC power.

Sites may vary, so carefully consider flow and head when choosing yours.

Maximum head can be achieved by placing the Stream Engine at as low an elevation as possible, the machine can become submerged (or washed away!).

---

www.microhydropower.com

MANUAL I

The Stream Engine Personal Hydropower Owner's Manual

HEAD MEASUREMENT

Head may be measured using various techniques. A garden hose or length of pipe can be submerged with one end upstream and the other end downstream. Anchor the upstream end with rocks or have an assistant hold it; water should flow out the low end, especially if the pipeline is pre-filled. Once water is flowing, raise the downstream end until it stops. Do this slowly since the water tends to oscillate. When the flow has stabilized, measure the distance sown to the level of water in the stream with a tape measure. This will give a very accurate measurement of that stream section. Mark the spot and then repeat the procedure until the entire distance is covered.

Another technique is to use a surveyor's transit. This method can also be approximated using a carpenter's level using a measuring stick or a "story pole." This technique is also done in a series of steps to arrive at the overall head. A variation on this method is the use of altimeters. Casio makes a wristwatch with a built-in altimeter.

FLOW MEASUREMENT

The easiest method to measure small flows is to channel the water into a pipe using a temporary dam and to fill a container of known volume. Measuring the time to fill the container enables you to calculate the flow rate.

The weir method is more versatile and may prove useful for higher flows. This technique uses a rectangular opening cut in a board or piece of sheet metal set into the brook like a dam. The water is channeled into the weir and the depth is measured from the top of a stake that is level with the edge of the weir and several feet upstream.

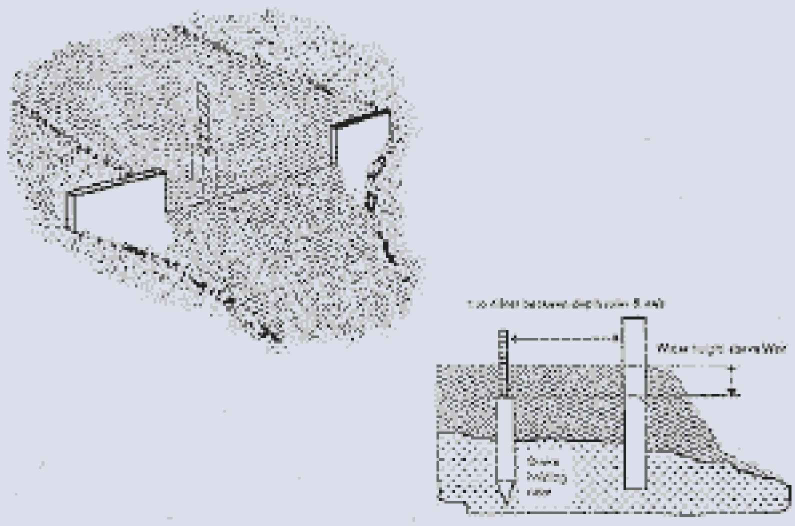
WEIR MEASUREMENT TABLE

Table shows water flow in gallons/minute (gpm) that will flow over a weir one inch wide and from 1/8 to 10-7/8 inches deep.

Inches		1/8	1/4	3/8	1/2	5/8	3/4	7/8
0	0.0	0.1	0.4	0.7	1.0	1.4	1.9	2.4
1	3.0	3.5	4.1	4.8	5.5	6.1	6.9	7.6
2	8.5	9.2	10.1	10.9	11.8	12.7	13.6	14.6
3	15.5	16.5	17.5	18.6	19.5	20.6	21.7	22.8

4	23.9	25.1	26.2	27.4	28.5	29.7	31.0	32.2
5	33.4	34.7	36.0	37.3	38.5	39.9	41.2	42.6
6	43.9	45.3	46.8	48.2	49.5	51.0	52.4	53.9
7	55.4	56.8	58.3	59.9	61.4	63.0	64.6	66.0
8	67.7	69.3	70.8	72.5	74.1	75.8	77.4	79.1
9	80.8	82.4	84.2	85.9	87.6	89.3	91.0	92.8
10	94.5	96.3	98.1	99.9	101.7	103.6	105.4	107.3

Example of how to use weir table:
Suppose depth of water above stake is 9 3/8 inches. Find 9 in the left-hand column and 3/8 in the top column. The value where they intersect is 85.9 gpm. That's only for a 1-inch weir, however. You multiply this value by the width of your weir in inches to obtain water flow.



Click on image for larger view

Measuring the flow at different times of the year helps you estimate maximum and minimum usable flows. If the water source is seasonally limited, you may have to depend on some other source of power during dry times (solar, wind). Keep in mind that a reasonable amount of water must be left in the stream (Don't take it all, that water supports life forms).

When head and flow are determined, the expected power output can be determined from the following chart. Keep in mind that chart values represent generated output and that actual power delivered to the batteries will be reduced by transmission lines, power converters, and other equipment required by the system. All systems should be carefully planned to maximize power output.

---

www.microhydropower.com

MANUAL I

The Stream Engine Personal Hydropower Owner's Manual

INTAKE, PIPELINE, AND TAILRACE

All hydro systems require a pipeline. Even systems operating directly from a dam require at least a short plumbing run. It is important to use the correct type and size of pipe to minimize restrictions in the flow to the nozzle(s). When possible, pipelines should be buried; this stabilizes the line and prevents animals from chewing it.

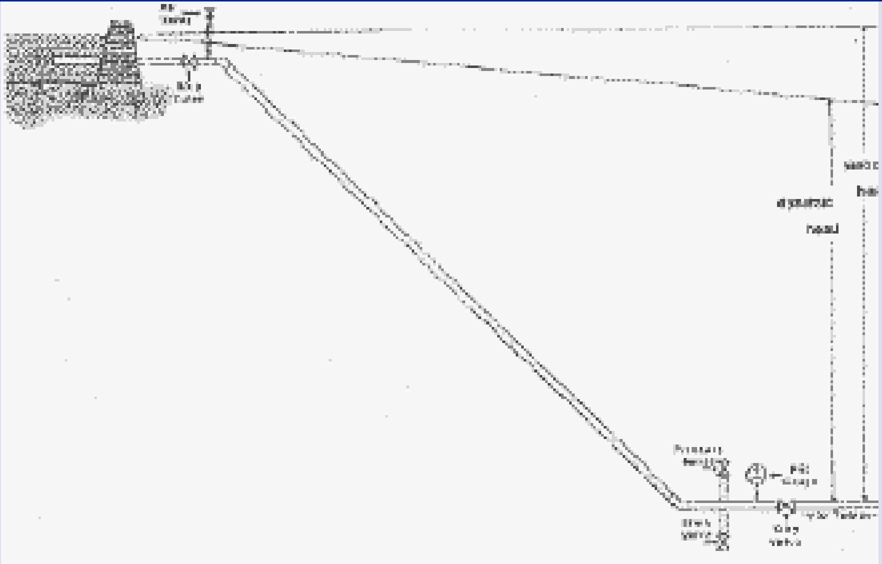
At the inlet of the pipe, a filter should be installed. A screened box can be used with the pipe entering one side, or add a section of pipe drilled lull of range holes wrapped with screen or small holes and used without screen. Make sure that the filter openings are smaller than the smallest nozzle used.

The intake must be above the streambed so as not to suck in silt and should be deep enough so as not to suck in air. The intake structure should be placed to one side of the main flow of the stream so that the force of the flowing water and its debris bypasses it.

If the whole pipeline doesn't run continuously downhill, at least the first section should, so the water can begin flowing. A bypass valve may be necessary.

For pipelines running over dams, the downstream side may be filled by hand. Once filled, the stop valve at the turbine can be opened to start the flow. If full pressure is not developed, a hand-powered vacuum pump can be used to remove air trapped at the high point.

At the turbine end of the pipeline a bypass valve may be necessary to allow water to run through the pipe without affecting the turbine, purging the line of air or increasing flow to prevent freezing.



Click on image for larger view

A stop valve should be installed upstream of the nozzle. This valve should be at least 1-1/2 inches if nozzles larger than Y2 inch are used. A pressure gauge should be installed upstream of the stop valve so both the static head (no water flowing) and the dynamic head (water flowing) can be read.

The stop valve on any major pipeline should always be closed slowly to prevent water hammer (a large column of water coming to an abrupt stop). This can easily destroy your pipeline and for this reason, you may wish to install a pressure relief valve just upstream of the stop valve.

Nozzles can be installed or changed from under the turbine, or from the above, by removing the nozzle flange by unscrewing its four bolts. The use of flexible pipe makes it easier to remove the flanges from the nozzles.
DO NOT OVER-TIGHTEN THE NOZZLES

The turbine housing can be mounted on two boards to suspend it above the stream. It is recommended to have the Stream Engine in a small enclosure or under some cover to keep it dry and provide a place for auxiliary equipment.

Mounting the machine in concrete is also possible (you may wish to try a temporary wood mounting first). The opening under the housing to catch the water should be at least the size of the turbine housing opening, and preferably a little larger. Make certain the tailrace (exit channel) provides enough flow for the exiting water. The housing opening is 9-1/2 inches square, the bolt holes are on an 11-inch square, and the housing is 12 inches square.

In cold climates, it may be necessary to build a "trap" into the exit. This prevents outside air from entering the housing and causing freeze-ups.

---

www.microhydropower.com

MANUAL I

The Stream Engine Personal Hydropower Owner's Manual

BATTERIES, INVERTERS & CONTROLLERS

System Voltage

A small system with a short transmission distance is usually designed to operate at 12 volts. Larger systems can also be 12 volts, but if higher power is desired of the transmission distance is long, then a system of 24 volts or higher may be preferable. This is especially true if all loads are inverter-powered. In a 12-volt system, operating at a low power level, it may be advantageous to operate all loads directly from batteries. Many 12-volt appliances and small inverters are available. In 24-volt systems, it may also be preferable to operate the loads directly (although not as many appliances are available).

In higher power systems, it is usually better to use an inverter to convert battery voltage to regular 120 VAC power. This has been made feasible with the advent of reliable high power inverters. Thousands of home power systems are in operation with only AC loads.

Sizing Battery Capacity

A typical hydro system should have about two days of battery storage capacity. This will generally keep lead-acid cells operating in the middle of their charge range where they are the most efficient and long-lived. Alkaline batteries like the nickel-iron and the nickel-cadmium types can have a lower capacity since they can be more fully discharged without harm.

Batteries should be located outside of living space, or adequate ventilation should be provided, as a rising charge level tends to produce both hydrogen gas andcorrosive fumes. Also, the water consumption increases; distilled water should be used to maintain the water level.

Charge Control

A hydro system requires that a load be present so that the power has somewhere to go. Otherwise, system voltage can rise to very high levels. This situation provides an opportunity to do something with the excess power (i.e., a modest dump load can be used for water heating).

As the batteries become fully charged, their voltage rises. At some point, the charging process should stop and the power be diverted to the dump load (there is a fair bit of guesswork involved here). The voltage set-point should be about 13.5 to 14.5 for a 12-volt system depending on the charge rate. The higher the charge rate, the higher the voltage can go. If batteries are often in a state of charge, the voltage limit should be on the low end of the range.

Some examples of good charge controllers are the TRACE C-30, C-40 and the ENERMAXER. Both switch power to a dump load when their set point is reached. The C-30 has "on" and "oft" settings and uses a relay to switch the load either fully on or fully off. The ENERMAXER has one set point and uses solid state switches to dump the power gradually at the one voltage. Dump loads are usually resistive, such as heaters, but can be anything that is compatible with the system.

A voltmeter or a watt-hour meter can be used to monitor battery charge level. Battery voltage is roughly a function of the charge level, and varies according to the load level and charge rate. As you gain experience, the battery voltage can be used to assess the charge level more accurately.

---

www.microhydropower.com

MANUAL I

The Stream Engine Personal Hydropower Owner's Manual

WIRING AND LOAD CENTER

Every system requires some wiring to connect the various components. Load centers are available as a complete package that easily facilitates the connection of loads and power source(s). All circuits in the system should use wire of adequate size and have fuses or breakers of sufficient capacity to carry the expected load current. Even the Stream Engine must be fused since it can suffer from a short or similar fault just like anything else in the system.

Inside the junction box on the side of the machine are two terminal blocks for the battery wiring. The negative terminal is bolted to the box and the positive terminal is bolted to the plastic plate. Your transmission wire ends are inserted into these two connectors (after being stripped of insulation) and then tightened.

The ammeter installed on the box will give a readout of the hydro output and is comparable to the speedometer of a car. A voltmeter connected to the batteries will roughly indicate the charge level, as described in Charge Level above, and is comparable to the gas gauge.

DESIGN EXAMPLE

This example shows how to proceed with a complete installation. The parameters of the example site are:

-120 feet of head over a distance of 1000 feet
-a flow of 30 gpm (most of the time)
-100 feet distance from the house to the hydro machine
-12 volt system

The first thing we do is determine the pipeline size. Although maximum power is produced from a given size pipe when the flow loss is 1/3 of the static head, more power can be obtained from the same flow with a larger pipe, which has lower losses. Therefore, pipe size must be optimized based on economics. As head decreases, efficiency of the system decreases, and it is important to keep the head losses low.

The pipe flow charts show us that two-inch diameter polyethylene pipe has a head loss of 1.77 feet of head per 100 feet of pipe at a flow rate of 30 gpm. This is 17.7 feet of loss for 1000 feet of pipe.

Using two-inch PVC gives us a loss of 1.17 feet of head per 100 feet of pipe or 11.7 feet for 1000 feet.

Polyethylene comes in continuous coils because it is flexible (and more freeze resistant). PVC comes in shorter lengths and has to be glued together or purchased with gaskets (for larger sizes). Let's say we select polyethylene.

The maximum output occurs with a flow of about 45 gpm since that gives us a head loss of 3.75 feet per 100 feet of pipe, or 37.5 feet of loss for our 1000 feet of pipe. This is 37.5' loss/120' head = 31% loss.

A flow of 30 gpm gives a net head of 102.3 feet (120' - 17.7'). The losses caused by the various pipe fittings and intake screen will further decrease the dynamic head, so 100 feet is a good working figure for the net head.

At this head and flow condition, the output of the machine is equal to about 300 watts.

Since we require 12 volts and the transmission distance is short, we can generate and transmit 12 volts using the Stream Engine. This Stream Engine could also be used for higher voltages like 24 and 48, and power could be transmitted longer distances.

Looking at the nozzle flow chart, we see that a 3/8" nozzle will produce a flow of 27.6 gpm at a 100' head. This is very close to the design point but will produce slightly less output than if we had exactly 30 gpm. A 7/16" nozzle would produce slightly greater flow and output. We need to go 100' with 300 watts at our site. This will be about 20 amps at 15 volts at the generator. Note that there will be some voltage drop in the line and 12-volt batteries require somewhat higher voltages than nominal to become charged. So the 20 amps must pass through 200' of wire for the round trip. Resistance losses should be kept as low as economics permit, just like the pipeline losses.

Let's say we wish to have around a 10% loss. This is 30 watts out of the original 300. The formula for resistive loss is I2R = watts when I = Intensity (current in amps) and R = Resistance in ohms.

(20 amps)2 x R (ohms) = 30 watts
400 amps x R (ohms) = 30 watts
R = 30 watts/400 amps
R = 0.075 ohms

This is the wire resistance that will produce a 10% loss. The wire loss chart shows loss per 1000', so:
1000'/200' x 0.075 ohms = 0.375 ohms per 1000'.

The chart shows 6 ga. Wire has a resistance of 0.40 ohms per 1000', so:
200'/1000' x 0.40 ohms = 0.08 ohms. This is close to the desired level.
20 amps x 20 amps x 0.08 ohms = 32 watts of loss.

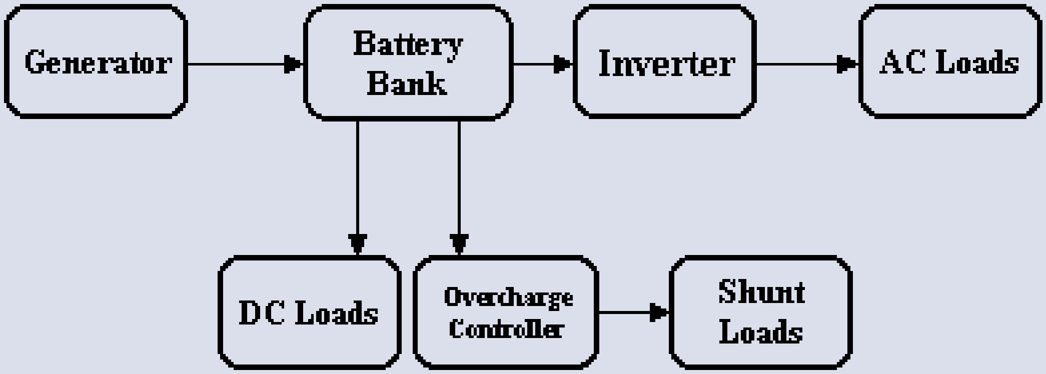
Increasing the wire size further reduces the losses. Voltage drop in the wire is equal to: IR = 20 amps x 0.08 ohms = 1.6 volts

So if the battery voltage is 13.4 the generator will be operating at 15.0 volts. Keep in mind that it is always the batteries that determine the system voltage. That is, all voltages in the system rise and fall according to the battery's state of charge.

At the site, we would be generating 20 amps continuously. If we use lead acid batteries and wish to have two days of storage capacity, then: 20 amps x 24 hrs x 2 days = 960 amp. Hrs. Capacity

We would probably use an inverter and load controller with the system. The diagram for such a system would look like this:

Below: Diagram of a typical battery-based system:



---

www.microhydropower.com

MANUAL I

The Stream Engine Personal Hydropower Owner's Manual

OUTPUT ADJUSTMENT

For the machine to produce the highest output, the rotor height should be adjusted. This involves is raising and lowering the rotor to increase the magnetic flux level. This is necessary to match the r output of the turbine with that of the generator.

After the machine is installed, perform an initial run to establish a power output level. This can be determined using an ammeter to measure current or a digital meter to measure voltage. A good idea is to keep a logbook to note any output changes in relation to settings. After everything is hooked up, start the machine by opening the stop valve. Run it long enough for the output level to stabilize and note the current (or voltage). Then shut the stop valve.

The machine comes with the rotor set very close to the stator (the stationary part of the machine). To increase this distance and reduce the magnetic flux level, you must turn the larger bolt (3/4" head) on the top of the rotor while holding it stationary. This is done by inserting the 1/4" pin supplied in one of the holes in the edge of the rotor. Then the smaller (7/16" head) bolt is loosened. Now you can turn the larger bolt, which will force the rotor up. Each full turn of the bolt will move the rotor vertically 0.050" or 1.25 mm. If raising the rotor causes the current (or the voltage) to increase, then continue to do so until there is no longer an increase. If a point is reached where a decrease occurs, then the rotor should be lowered. This is done by loosening the larger bolt and then tightening the smaller one. Turning the smaller bolt causes the rotor to move vertically the same distance per turn as the larger bolt does. When you have found the best position (no increase in current or voltage), make sure the larger bolt is turned until it is tight. Now the smaller bolt should be tightened securely to lock everything in place. No further adjustments should be required unless nozzle sizes are changed.

When adjusting the rotor downward, it may reach the point where it will contact the stator. If this occurs, always adjust it upwards by at least a 1/4 turn of the larger bolt. Operating the machine with the rotor any closer than this will not result in any power increase but may damage the machine.

**** Always turn the rotor by hand before starting the machine to check for rubbing****. Remove the pin in the rotor edge before starting the machine.

Optimum nozzle size can be found using a similar technique. First, install the nozzle insert that approximates a match to your conditions. Then try both a smaller and a larger one and pursue the direction of maximum power. Note that if you use a nozzle larger than your flow can support, air will be sucked into your pipeline.

NOZZLE FLOW CHART
FLOW RATE IN U.S. GALLONS PER MINUTE

Head Feet	Pressure PSI	Nozzle Diameter, inches											Turbine RPM
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1.0	
5	2.2					6.18	8.40	11.0	17.1	24.7	33.6	43.9	460
10	4.3			3.88	6.05	8.75	11.6	15.6	24.2	35.0	47.6	62.1	650
15	6.5		2.68	4.76	7.40	10.7	14.6	19.0	29.7	42.8	58.2	76.0	800
20	8.7	1.37	3.09	5.49	8.56	12.4	16.8	22.0	34.3	49.4	67.3	87.8	925
30	13.0	1.68	3.78	6.72	10.5	15.1	20.6	26.9	42.0	60.5	82.4	107	1140
40	17.3	1.94	4.37	7.76	12.1	17.5	23.8	31.1	48.5	69.9	95.1	124	1310
50	21.7	2.17	4.88	8.68	13.6	19.5	26.6	34.7	54.3	78.1	106	139	1470
60	26.0	2.38	5.35	9.51	14.8	21.4	29.1	38.0	59.4	85.6	117	152	1600
80	34.6	2.75	6.18	11.0	17.1	24.7	33.6	43.9	68.6	98.8	135	176	1850
100	43.3	3.07	6.91	12.3	19.2	27.6	37.6	49.1	76.7	111	150	196	2070
120	52.0	3.36	7.56	13.4	21.0	30.3	41.2	53.8	84.1	121	165	215	2270
150	65.0	3.76	8.95	15.0	23.5	33.8	46.0	60.1	93.9	135	184	241	2540
200	86.6	4.34	9.77	17.4	27.1	39.1	53.2	69.4	109	156	213	278	2930
250	108	4.86	10.9	19.9	30.3	43.6	59.4	77.6	121	175	238	311	3270
300	130	5.32	12.0	21.3	33.2	47.8	65.1	85.1	133	191	261	340	3591
400	173	6.14	13.8	24.5	38.3	55.2	75.2	98.2	154	221	301	393	4140

www.microhydropower.com

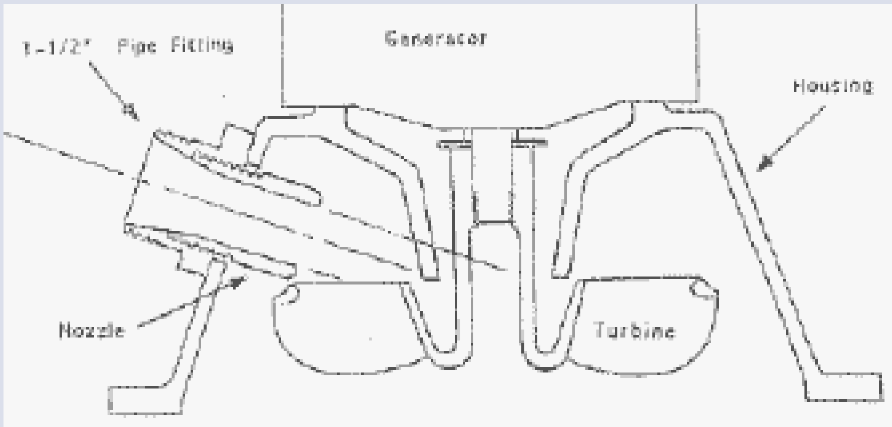
MANUAL I

The Stream Engine Personal Hydropower Owner's Manual

SERVICE & ASSEMBLY

In order to remove the generator you must first remove the turbine wheel. The machine's wheel is unscrewed from the shaft by holding the rotor using the 1/4" diameter rod inserted into one of the holes in the edge of the rotor. The turbine wheel is assembled with a washer and then a spacer on top. The shaft is made with standard right hand threads for the turbine wheel so it will unscrew in a counter-clockwise direction when looking at the shaft (with the machine upside down). Then you can remove the four bolts (with 5/32" allen hex heads).

You should replace bearings as soon as you notice any looseness. If they are too loose, severe damage to both the rotor and the stator can result. This machine uses three 6203 ball bearings with non-contact seals. These are press fit into the alternator housing and must be installed and removed using a press of adequate capacity and a proper sized mandrel.



Click on image for larger view

COPPER WIRE RESISTENCE

Wire Gauge	Diameter Inches	Ohms per 1000'	Ohms per Mile
0000	0.460	0.05	0.26
000	0.410	0.06	0.33
00	0.364	0.08	0.42
0	0.324	0.10	0.52
2	0.258	0.16	0.84
4	0.204	0.25	1.34

6	0.162	0.40	2.13
8	0.128	0.64	3.38
10	0.102	1.02	5.38
12	0.081	1.62	8.56
14	0.064	2.58	13.6
16	0.051	4.10	21.6
18	0.040	6.52	34.4

PIPE FRICTION LOSS

Polyethylene SDR - Pressure Rated Pipe
Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM								
	0.5	0.75	1	1.25	1.5	2	2.5	3
1	1.13	0.28	0.09	0.02				
2	4.05	1.04	0.32	0.09	0.04			
3	8.60	2.19	0.67	0.19	0.09	0.02		
4	14.6	3.73	1.15	0.30	0.14	0.05		
5	22.1	5.61	1.75	0.46	0.21	0.07		
6	31.0	7.89	2.44	0.65	0.30	0.09	0.05	
7	41.2	10.5	3.24	0.85	0.42	0.12	0.06	
8	53.1	13.4	4.14	1.08	0.51	0.16	0.07	
9		16.7	5.15	1.36	0.65	0.18	0.08	
10		20.3	6.28	1.66	0.78	0.23	0.09	0.02
12		28.5	8.79	2.32	1.11	0.32	0.14	0.05
14		37.9	11.7	3.10	1.45	0.44	0.18	0.07
16			15.0	3.93	1.87	0.55	0.23	0.08
18			18.6	4.90	2.32	0.69	0.30	0.09
20			22.6	5.96	2.81	0.83	0.35	0.12
22			27.0	7.11	3.36	1.00	0.42	0.37
24			31.7	8.35	3.96	1.17	0.49	0.16
26			36.8	9.68	4.58	1.36	0.58	0.21
28				11.1	5.25	1.56	0.67	0.23
30				12.6	5.96	1.77	0.74	0.25
35				16.8	7.94	2.35	1.00	0.35
40				21.5	10.2	3.02	1.27	0.44

45	26.8	12.7	3.75	1.59	0.55
50	32.5	15.4	4.55	1.91	0.67
55		18.3	5.43	1.96	0.81
60		21.5	6.40	2.70	0.94
65		23.8	7.41	3.13	1.08
70		28.7	8.49	3.59	1.24
75		32.6	9.67	4.07	1.40
80			10.9	4.58	1.59
85			12.2	5.13	1.77
90			13.5	5.71	1.98
95			15.0	6.31	2.19
100			16.5	6.92	2.42
150			34.5	14.7	5.11
200				25.0	8.70
300					18.4

PIPE FRICTION LOSS - PVC Class 160 PSI Plastic Pipe

Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM	**Pipe Diameter, Inches**									
	1	**1.25**	**1.5**	**2**	**2.5**	**3**	**4**	**5**	**6**	**8**	**10**
1	0.05	0.02									
2	0.14	0.05	0.02								
3	0.32	0.09	0.04								
4	0.53	0.16	0.09	0.02							
5	0.80	0.25	0.12	0.04							
6	1.13	0.35	0.18	0.07	0.02						
7	1.52	0.46	0.23	0.08	0.02						
8	1.93	0.58	0.30	0.10	0.04						
9	2.42	0.71	0.37	0.12	0.05						
10	2.92	0.87	0.46	0.16	0.07	0.02					
11	3.50	1.04	0.53	0.18	0.07	0.02					

12	4.09	1.22	0.64	0.20	0.09	0.02					
14	5.45	1.63	0.85	0.28	0.12	0.04					
16	7.00	2.09	1.08	0.37	0.14	0.04					
18	8.69	2.60	1.33	0.46	0.18	0.07					
20	10.6	3.15	1.63	0.55	0.21	0.09	0.02				
22	12.6	3.77	1.96	0.67	0.25	0.09	0.02				
24	14.8	4.42	2.32	0.78	0.30	0.12	0.04				
26	17.2	5.13	2.65	0.90	0.35	0.14	0.05				
28	19.7	5.89	3.04	1.04	0.41	0.16	0.05				
30	22.4	6.70	3.45	1.17	0.43	0.18	0.05				
35		8.90	4.64	1.56	0.62	0.23	0.07				
40		11.4	5.89	1.98	0.78	0.30	0.09	0.02			
45		14.2	7.34	2.48	0.97	0.37	0.12	0.04			
50		17.2	8.92	3.01	1.20	0.46	0.14	0.04			
55		20.5	10.6	3.59	1.43	0.55	0.16	0.05			
60		24.1	12.5	4.21	1.66	0.64	0.18	0.07	0.02		
70			16.6	5.61	2.21	0.85	0.25	0.09	0.03		
80			21.3	7.18	2.83	1.08	0.32	0.12	0.04		
90				8.92	3.52	1.36	0.39	0.14	0.07		
100				10.9	4.28	1.66	0.48	0.18	0.07	0.02	
150				23.2	9.06	3.50	1.04	0.37	0.16	0.05	
200					15.5	5.96	1.75	0.62	0.28	0.07	0.02
250					23.4	9.05	2.65	0.94	0.42	0.12	0.05
300						12.6	3.73	1.34	0.58	0.16	0.05
350						16.8	4.95	1.78	0.76	0.21	0.07
400						21.5	6.33	2.25	0.97	0.28	0.10
450							7.87	2.81	1.20	0.32	0.12
500							9.55	3.41	1.45	0.42	0.14
550							11.4	4.07	1.75	0.48	0.16
600							13.4	4.78	2.05	0.58	0.18

650		15.5	5.54	2.37	0.67	0.23
700		17.8	6.37	2.71	0.76	0.25
750		20.3	7.22	3.10	0.86	0.30
800			8.14	3.50	0.97	0.32
850			9.11	3.89	1.08	0.37
900			10.1	4.32	1.20	0.42
950			10.8	4.79	1.34	0.46
1000			12.3	5.27	1.45	0.51

POWER OUTPUT IN WATTS (CONTINUOUS)

Net Head, Feet	Flow Rate in U.S. Gallons per Minute										
	5	10	15	20	30	40	50	75	100	150	200	300
5				5	8	10	15	20	30	40		
10			7	12	18	23	30	45	60	80	100	
15	5	10	15	20	30	40	50	75	100	125	150	200
20	8	16	25	32	50	65	85	125	170	210	275	350
30	12	30	45	60	90	120	150	225	300	400	500	700
40	16	40	60	80	120	160	200	300	400	500	600	
50	20	50	75	100	150	200	250	375	500	600		
75	30	75	110	150	225	300	375	560	700			
100	40	100	150	200	300	400	500	650				
150	60	150	225	300	400	550	650					
200	80	200	300	400	550	700						
300	120	240	360	480	720							
400	160	320	480	640								

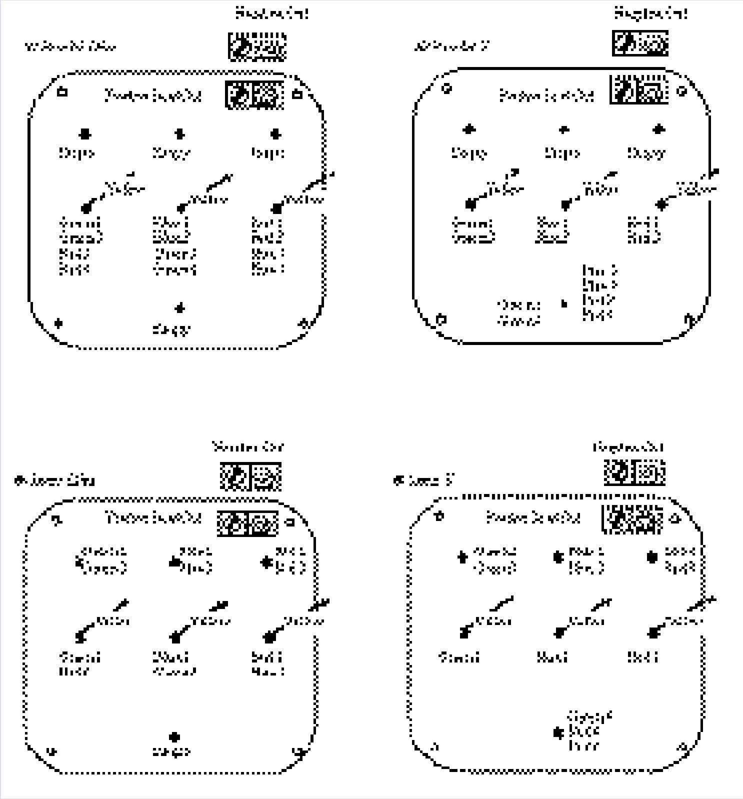
www.microhydropower.com

MANUAL I

The Stream Engine Personal Hydropower Owner's Manual

WIRING DIAGRAMS

These diagrams represent the four possible combinations of output wiring. They are in order of potential. If you find your air gap adjustment to be at a minimum and wish to try for more power, then try using the next higher combination. If you find the air gap is very large, try the next lower one. Note that there is only a small change in potential between #2 to #3.



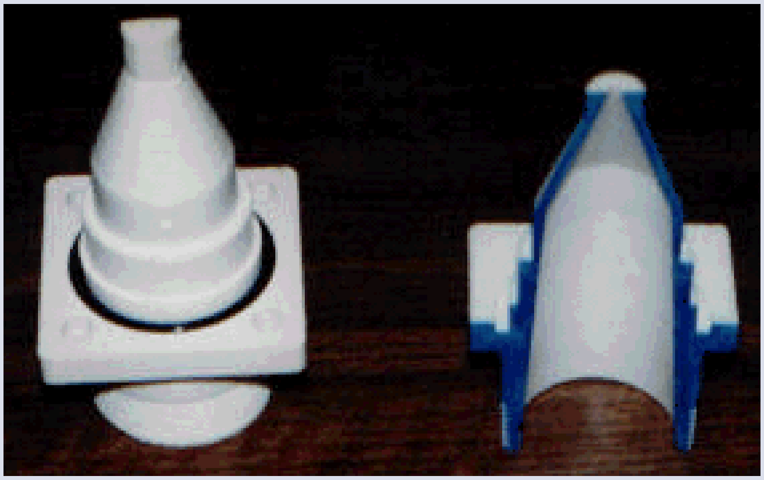
Click for close up view

www.microhydropower.com

MANUAL I

The Stream Engine Personal Hydropower Owner's Manual

THE NEW UNIVERSAL NOZZLE



Energy Systems and Design has introduced a new type of nozzle for its hydro-electric generators. This makes it possible to create any size nozzle jet that might be required by simply cutting the nozzle to the appropriate length. Cutting can be done with a hacksaw, or any other fine toothed saw. The end of the nozzle should then be finished with a piece of sandpaper. This is best done by placing the sandpaper on a flat surface and moving the nozzle against it. Markings are on the nozzle to assist in cutting to the correct size. The numbers are in millimeters and correspond to inches as follows:

mm	3	4.5	6	8	10	13	16	19	22	25
inches	1/8	3/16	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1

Odd sizes can also be produced. The opening of the nozzle is about 6% larger than the actual jet of water that exits from it. Another possibility is to keep making the opening larger until the desired flow is obtained. An o-ring is provided in order to seal the face. This prevents water leaks to the outside of the machine.

For the smallest nozzle sizes, the nozzle may have to be installed with the numbered side facing upward, so that the end will not contact the turbine wheel.

www.microhydropower.com

MANUAL I

The Stream Engine Personal Hydropower Owner's Manual

NEW CURRENT MEASUREMENT TECHNIQUE

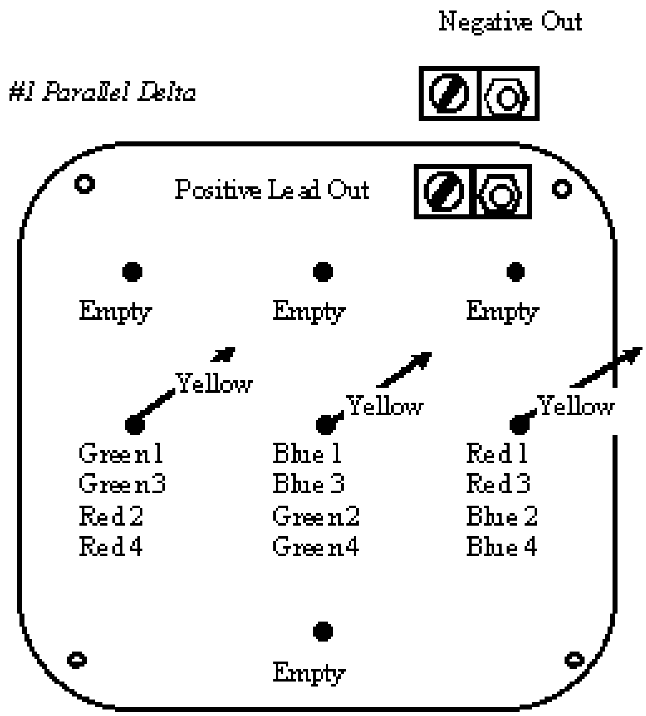
Previously, all Stream Engines were equipped with analogue ammeters. This enabled the current to be measured while adjusting the rotor air gap for maximum output. Now, a built-in shunt (precision resistance) is installed in the junction box which allows the current to be measured digitally. This is done with the supplied DMM (digital multi meter).

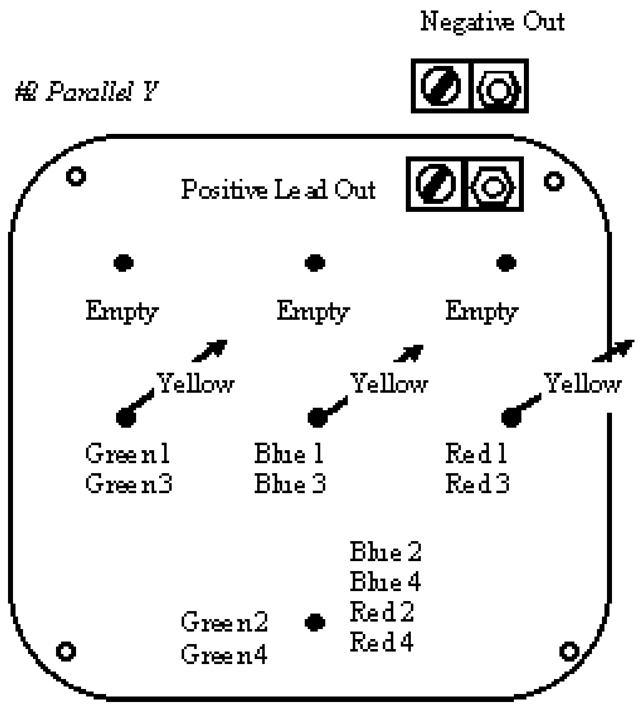
To measure the current produced by the generator, set the DMM scale to "DC milli-volts" or "200 m" at the nine o'clock position. Plug the leads into their corresponding color-coded jacks on the shunt in the junction box. This will give current readings from 0.1 amps to 99.9 amps.

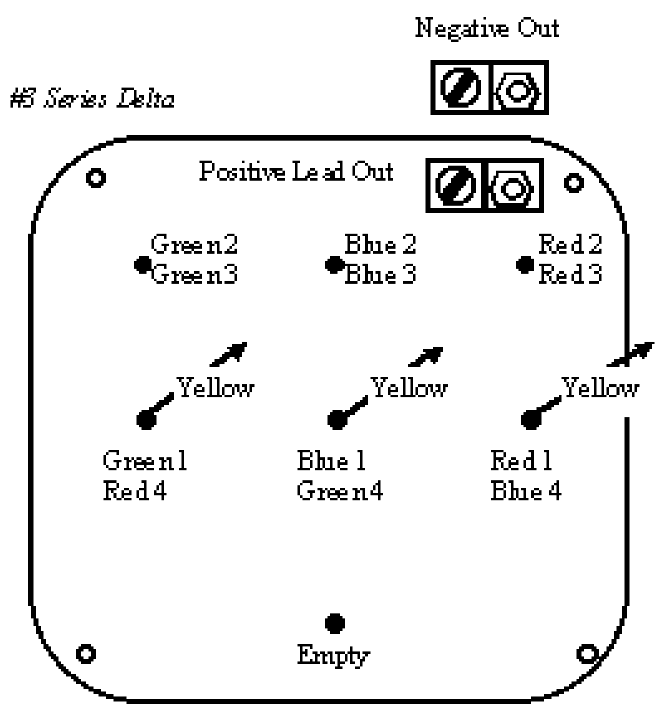
Of course, the DMM can be used for other tasks with your renewable energy system.

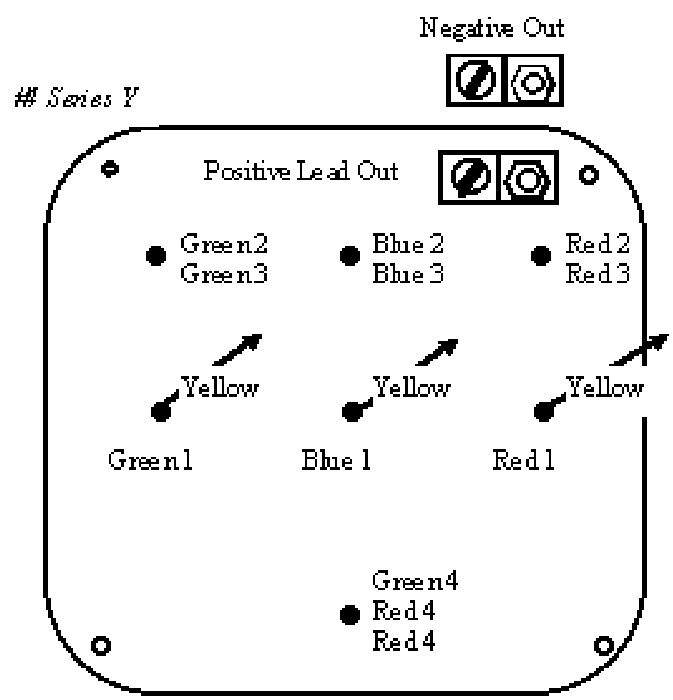
Stream Engine showing multi-meter used to measure output current.

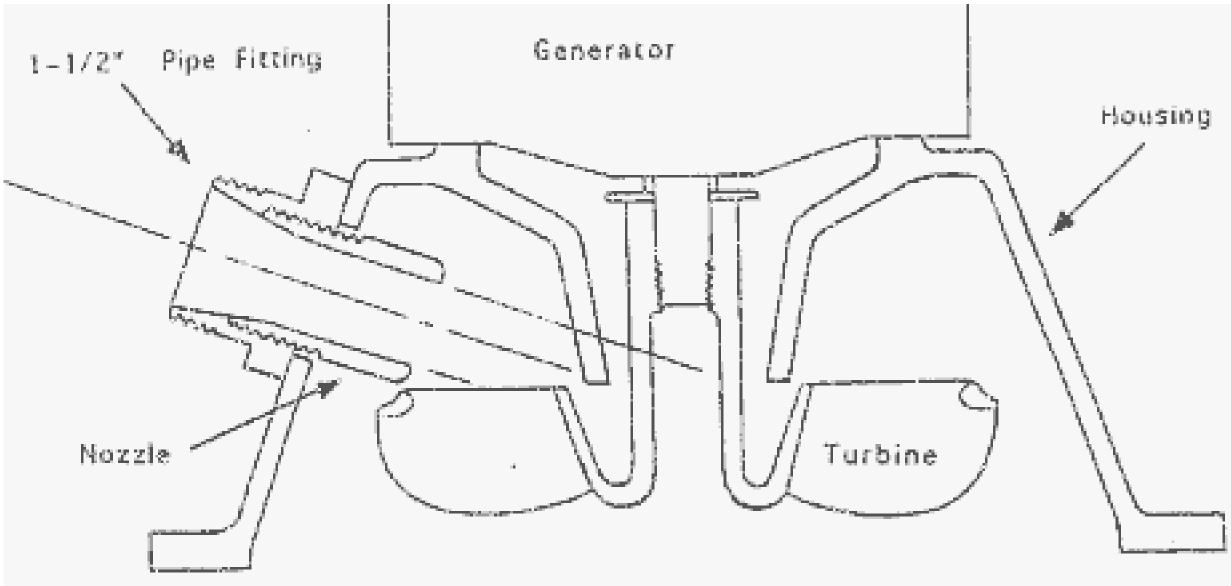
www.microhydropower.com

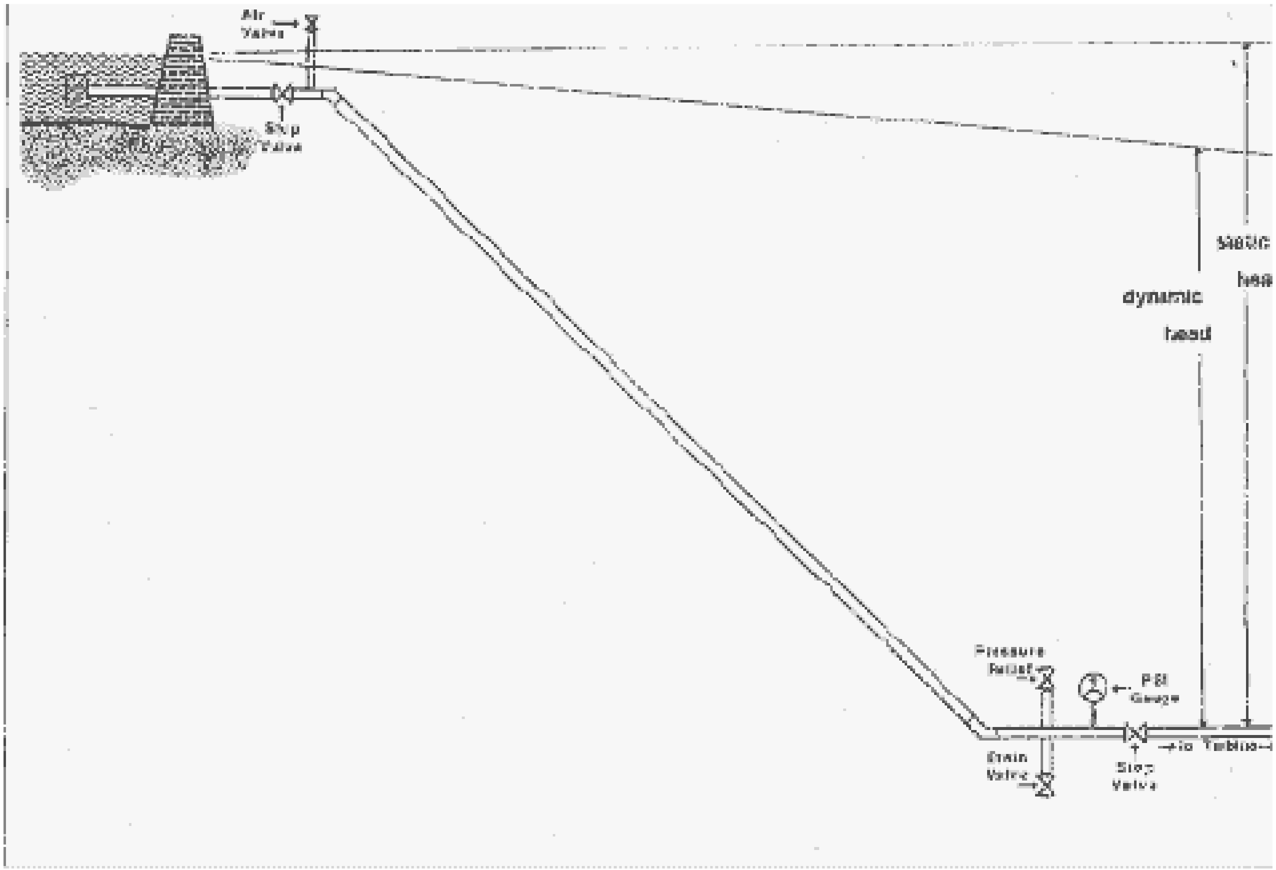

#1 Parallel Delta
Negative Out
Positive Lead Out
Empty
Empty
Empty
Yellow
Yellow
Yellow
Green1
Green3
Red 2
Red 4
Blue 1
Blue 3
Green2
Green4
Red 1
Red 3
Blue 2
Blue 4
Empty

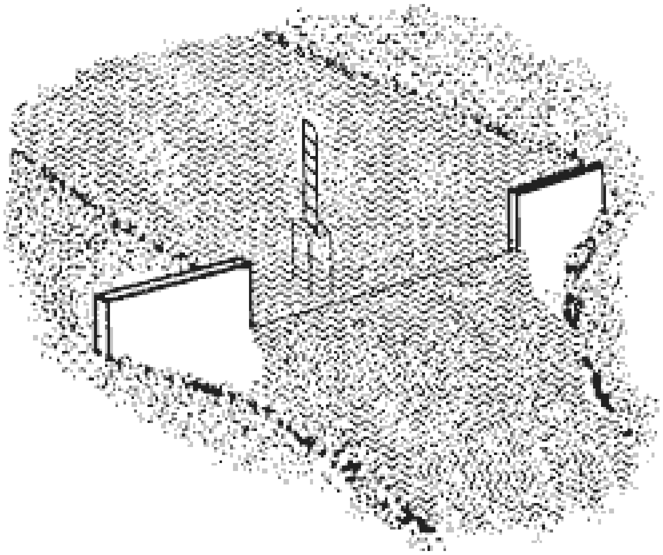

#2 Parallel Y
Negative Out
Positive Lead Out
Empty
Empty
Empty
Yellow
Yellow
Yellow
Green1
Green3
Blue 1
Blue 3
Red 1
Red 3
Blue 2
Blue 4
Red 2
Red 4
Green2
Green4

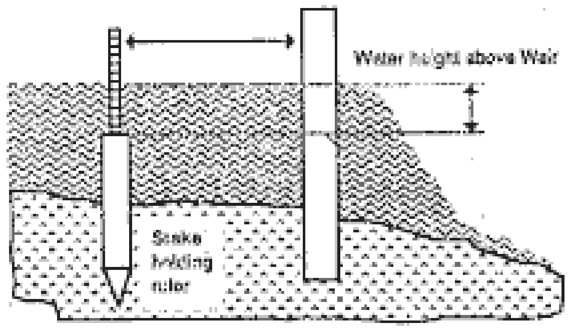

#3 Series Delta
Negative Out
Positive Lead Out
Green2
Green3
Blue 2
Blue 3
Red 2
Red 3
Yellow
Yellow
Yellow
Green1
Red 4
Blue 1
Green4
Red 1
Blue 4
Empty


#4 Series Y
Negative Out
Positive Lead Out
Green2
Green3
Blue 2
Blue 3
Red 2
Red 3
Yellow
Yellow
Yellow
Green1
Blue 1
Red 1
Green4
Red 4
Red 4


1-1/2" Pipe Fitting
Generator
Housing
Nozzle
Turbine


Air Valve
Stop Valve
dynamic head
Pressure Relief
PSI Gauge
Drain Valve
Stop Valve




1 to 4 feet between depth ruler & weir
Water height above Weir
Stake holding ruler

The Stream Engine

Personal Hydropower

Owner's Manual

<u>PLEASE READ CAREFULLY</u>

Made in Canada
by
Energy Systems and Design Ltd.
P.O. Box 4557
Sussex, NB
Canada E4E 5L7

Tel: (506) 433-3151
Fax: (506) 433-6151
Email: support@microhydropower.com
Website: www.microhydropower.com

Congratulations on your purchase of a new *Stream Engine*! With a thorough installation and a little routine maintenance, your Stream Engine will provide you with years of trouble-free operation. This manual will help you to install your Stream Engine as well as assist you in trouble-shooting and problem solving. Of course, you may contact Energy Systems & Design Ltd. if you run into trouble.

May your RE adventures prove successful!

PLEASE READ CAREFULLY

It is very important to keep the alternator rotor from contacting the stator (the stationary part under the rotor). If this occurs, serious damage may result.

Whenever you are operating the machine with a small air gap (distance between alternator rotor and stator) you should check the gap whenever an adjustment is made!

Do this by inserting a business card (0.010" or 0.25mm thick) in the gap when the rotor is stationary. Check all the way around the rotor. This is also a way to check for bearing wear on a monthly basis. If you **cannot** insert the card into the gap, either all or in part, it is necessary to adjust the rotor upward (see *Output Adjustment* in this manual).

When making air gap adjustments, make sure the larger bolt is tightened (clockwise) against the shaft and the smaller bolt is also tightened (clockwise); so as to lock both parts in place.

Table of Contents

INTRODUCTION

This manual describes **The Stream Engine**, which is manufactured by Energy Systems and Design Ltd. The installer must have some knowledge of plumbing and electrical systems, and the user of the system should also. These machines are small, but can generate some very high voltages. Even 12-volt machines can produce high voltages under certain conditions. Practice all due safety. Electricity cannot be seen and can be lethal.

It is important to consult with local officials before conducting any watercourse alteration. ES&D advises following all local laws and ordinances regarding watercourses.

Electricity is produced from the potential energy in moving water from a high point to a lower one. This distance is called "head" and is measured in units of distance (feet, meters) or in units of pressure (pounds per square inch, kilo-Pascals). "Flow" is measured in units of volume (gallons per minute - gpm, or liters per second - l/s), and is the second portion of the power equation. The power available is related to the head and the flow.

The Stream Engine is designed to operate over a wide range of heads and flows. This is achieved with the use of a Turgo runner, or wheel. Nozzle diameters of 1/8 to 1 inch are available, and up to four nozzles can be used on one machine, to utilize heads as low as four feet and as high as hundreds.

The Stream Engine uses a permanent magnet type alternator. This design eliminates the need for brushes and the maintenance that accompany them while increasing efficiency. The Stream Engine's output can be optimized by simply adjusting the rotor clearance.

SITE EVALUATION

Certain information must be determined concerning your site, in order to use its potential for maximum output. Head and flow must first be determined. Other factors are: pipeline length, transmission distance, and the system voltage. These factors determine how much power can be expected.

Power is generated at a constant rate by the Stream Engine and stored in batteries as direct current (DC). Power is supplied, as needed, by the batteries, which store energy during periods of low consumption for use in periods where consumption exceeds the generation rate. Appliances can be used that operate directly from batteries, or 120 volt alternating current (AC) power can be supplied through an inverter, converting DC to AC power.

Sites may vary, so carefully consider flow and head when choosing yours. Remember, maximum head can be achieved by placing the Stream Engine at as low an elevation as possible, but going too low may cause the machine to become submerged (or washed away!).

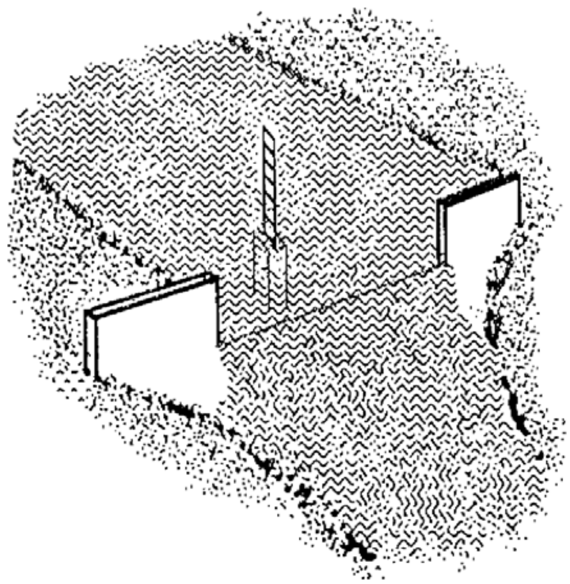
HEAD MEASUREMENT

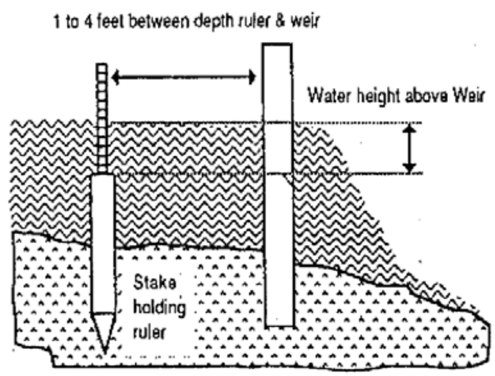
Head may be measured using various techniques. A garden hose or length of pipe can be submerged with one end upstream and the other end downstream. Anchor the upstream end with rocks or have an assistant hold it; water should flow out the low end, especially if the pipeline is pre-filled. Once water is flowing, raise the downstream end until it stops. Do this slowly since the water tends to oscillate. When the flow has stabilized, measure the distance sown to the level of water in the stream with a tape measure. This will give a very accurate measurement of that stream section. Mark the spot and then repeat the procedure until the entire distance is covered.

Another technique is to use a surveyor's transit. This method can also be approximated using a carpenter's level using a measuring stick or a "story pole." This technique is also done in a series of steps to arrive at the overall head. A variation on this method is the use of altimeters. Casio makes a wristwatch with a built-in altimeter.

FLOW MEASUREMENT

The easiest method to measure small flows is to channel the water into a pipe using a temporary dam and to fill a container of known volume. Measuring the time to fill the container enables you to calculate the flow rate.





The weir method is more versatile and may prove useful for higher flows. This technique uses a rectangular opening cut in a board or piece of sheet metal set into the brook like a dam. The water is channeled into the weir and the depth is measured from the top of a stake that is level with the edge of the weir and several feet upstream.

Measuring the flow at different times of the year helps you estimate maximum and minimum usable flows. If the water source is seasonally limited, you may have to depend on some other source of power during dry times (solar, wind). Keep in mind that a reasonable amount of water must be left in the stream (Don't take it all, that water supports life forms).

When head and flow are determined, the expected power output can be determined from the following chart. Keep in mind that chart values represent *generated* output and that actual power delivered to the batteries will be reduced by transmission lines, power converters, and other equipment required by the system. All systems should be carefully planned to maximize power output.

WEIR MEASUREMENT TABLE

Table shows water flow in gallons/minute (gpm) that will flow over a weir one inch wide and from 1/8 to 10-7/8 inches deep.

Inches		1/8	1/4	3/8	1/2	5/8	3/4	7/8
0	0.0	0.1	0.4	0.7	1.0	1.4	1.9	2.4
1	3.0	3.5	4.1	4.8	5.5	6.1	6.9	7.6
2	8.5	9.2	10.1	10.9	11.8	12.7	13.6	14.6
3	15.5	16.5	17.5	18.6	19.5	20.6	21.7	22.8
4	23.9	25.1	26.2	27.4	28.5	29.7	31.0	32.2
5	33.4	34.7	36.0	37.3	38.5	39.9	41.2	42.6
6	43.9	45.3	46.8	48.2	49.5	51.0	52.4	53.9
7	55.4	56.8	58.3	59.9	61.4	63.0	64.6	66.0
8	67.7	69.3	70.8	72.5	74.1	75.8	77.4	79.1
9	80.8	82.4	84.2	85.9	87.6	89.3	91.0	92.8
10	94.5	96.3	98.1	99.9	101.7	103.6	105.4	107.3

Example of how to use weir table:
Suppose depth of water above stake is 9 3/8 inches. Find 9 in the left-hand column and 3/8 in the top column. The value where they intersect is 85.9 gpm. That's only for a 1-inch weir, however. You multiply this value by the width of your weir in inches to obtain water flow.

INTAKE, PIPELINE, AND TAILRACE

All hydro systems require a pipeline. Even systems operating directly from a dam require at least a short plumbing run. It is important to use the correct type and size of pipe to minimize restrictions in the flow to the nozzle(s). When possible, pipelines should be buried; this stabilizes the line and prevents animals from chewing it.

At the inlet of the pipe, a filter should be installed. A screened box can be used with the pipe entering one side, or add a section of pipe drilled full of holes wrapped with screen or small holes and used without screen. Make sure that the filter openings are smaller than the smallest nozzle used.

The intake must be above the streambed so as not to suck in silt and should be deep enough so as not to suck in air. The intake structure should be placed to one side of the main flow of the stream so that the force of the flowing water and its debris bypasses it. Routinely clean the intake of any leaves or other debris.

If the whole pipeline doesn't run continuously downhill, at least the first section should, so the water can begin flowing. A bypass valve may be necessary. This should be installed at a low point in the pipe.

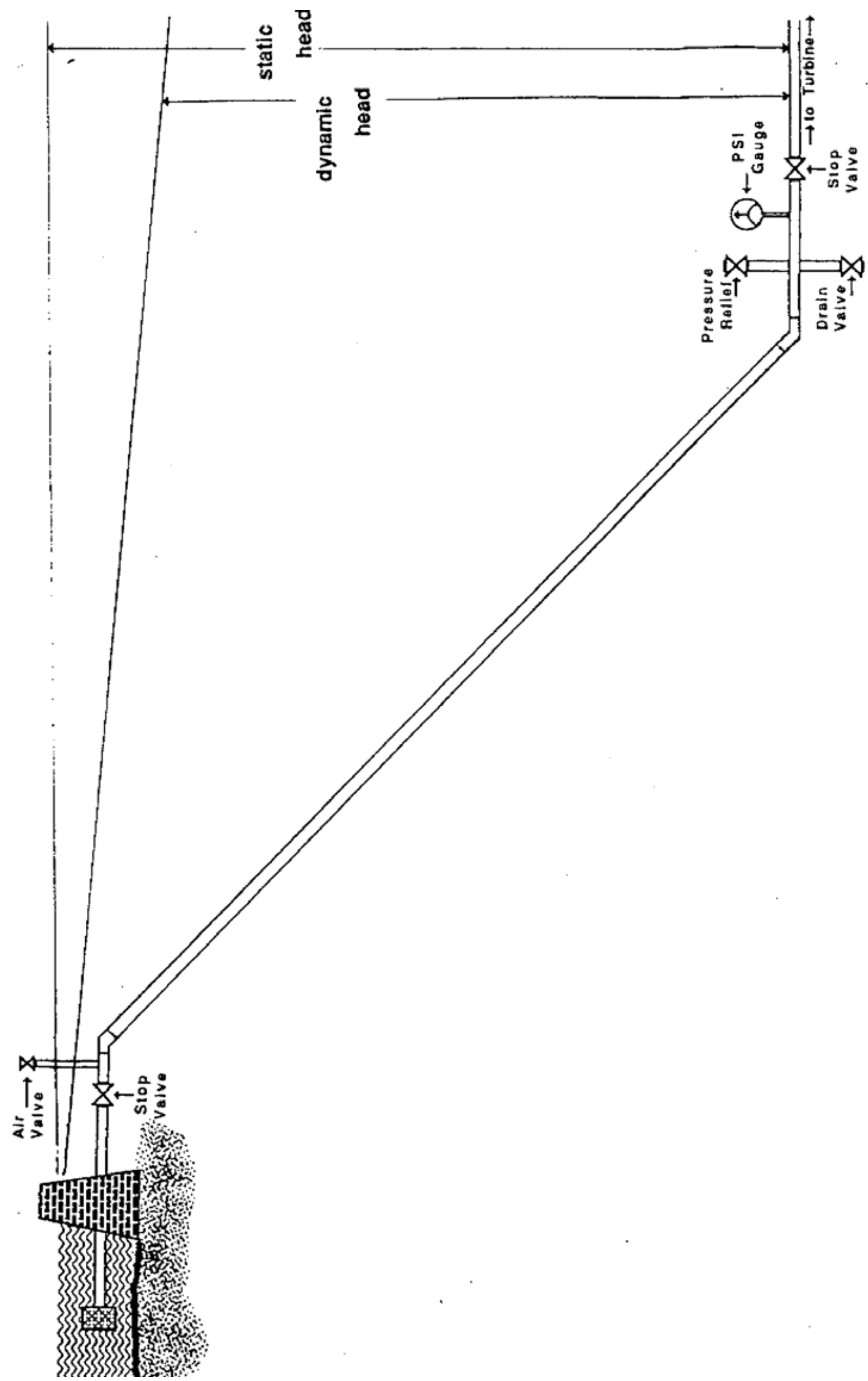
For pipelines running over dams, the downstream side may be filled by hand. Once filled, the stop valve at the turbine can be opened to start the flow. If full pressure is not developed, a hand-powered vacuum pump can be used to remove air trapped at the high point.

At the turbine end of the pipeline a bypass valve may be necessary to allow water to run through the pipe without affecting the turbine, purging the line of air or increasing flow to prevent freezing.

A stop valve should be installed upstream of the nozzle. A pressure gauge should be installed upstream of the stop valve so both the static head (no water flowing) and the dynamic head (water flowing) can be read.

The stop valve on a pipeline should always be closed slowly to prevent water hammer (the column of water in the pipe coming to an abrupt stop). This can easily destroy your pipeline and for this reason, you may wish to install a pressure relief valve just upstream of the stop valve. This can also occur if debris clogs the nozzle.

Nozzles can be installed or changed by removing the nozzle by unscrewing its four nuts using a 11 mm (7/16") wrench. The use of flexible pipe makes it easier to remove the plumbing from the nozzles.



The turbine housing can be mounted on two boards to suspend it above the stream. It is recommended to have the Stream Engine in a small enclosure or under some cover to keep it dry and provide a place for auxiliary equipment.

Mounting the machine in concrete is also possible (you may wish to try a temporary wood mounting first). The opening under the housing to catch the water should be at least the size of the turbine housing opening, and preferably a little larger. Make certain the tailrace (exit channel) provides enough flow for the exiting water. The housing opening is 9-1/2 inches square, the bolt holes are on an 11-inch square, and the housing is 12 inches square.

In cold climates, it may be necessary to build a "trap" into the exit. This prevents outside air from entering the housing and causing freeze-ups.

BATTERIES, INVERTERS & CONTROLLERS

System Voltage

A small system with a short transmission distance is usually designed to operate at 12 volts. Larger systems can also be 12 volts, but if higher power is desired or the transmission distance is long, then a system of 24 volts or higher may be preferable. This is especially true if all loads are inverter-powered. In a 12-volt system operating at a low power level, it may be advantageous to operate all loads directly from batteries. Many 12-volt appliances and small inverters are available. In 24-volt systems, it may also be preferable to operate the loads directly (although not as many appliances are available).

In higher power systems, it is usually better to use an inverter to convert battery voltage to regular 120 VAC power. This has been made feasible with the advent of reliable high power inverters. Thousands of home power systems are in operation with only AC loads.

Sizing Battery Capacity

A typical hydro system should have about two days of battery storage capacity. This will generally keep lead-acid cells operating in the middle of their charge range where they are the most efficient and long-lived. Alkaline batteries like the nickel-iron and the nickel-cadmium types can have a lower capacity since they can be more fully discharged without harm.

Batteries should be located outside of living space, or adequate ventilation should be provided, as a rising charge level tends to produce both hydrogen gas and corrosive fumes. Also, the water consumption increases; distilled water should be used to maintain the water level.

Charge Control

A hydro system requires that a load be present so that the power has somewhere to go. Otherwise, system voltage can rise to very high levels. This situation provides an opportunity to do something with the excess power (a dump load can be used for water heating).

As the batteries become fully charged, their voltage rises. At some point, the charging process should stop and the power be diverted to the dump load (there is a fair bit of guesswork involved here). The voltage set-point should be about 13.5 to 14.5 for a 12-volt system depending on the charge rate. The higher the charge rate, the higher the voltage can go. If batteries are often in a state of charge, the voltage limit should be on the low end of the range.

Some examples of good charge controllers are the TRACE C-35, C-40 and the ENERMAXER. Both switch power to a dump load when their set point is reached. The ENERMAXER has one set point and uses solid state switches to dump the power gradually at the one voltage. Dump loads are usually resistive, such as heaters, but can be anything that is compatible with the system.

A voltmeter or a watt-hour meter can be used to monitor battery charge level. Battery voltage is roughly a function of the charge level, and varies according to the load level and charge rate. As you gain experience, the battery voltage can be used to assess the charge level more accurately.

WIRING AND LOAD CENTER

Every system requires some wiring to connect the various components. Load centers are available as a complete package that easily facilitates the connection of loads and power source(s). All circuits in the system should use wire of adequate size and have fuses or breakers of sufficient capacity to carry the expected load current. The Stream Engine must be fused since it can suffer from a short or similar fault just like anything else in the system.

Inside the junction box on the side of the machine are two terminal blocks for the battery wiring. The negative terminal is bolted to the box and the positive terminal is bolted to the plastic plate. Your transmission wire ends are inserted into these two connectors (after being stripped of insulation) and then tightened. Make sure that the battery wiring is correctly connected or the rectifier will be destroyed. Do not operate the machine without being connected to the batteries as very high voltages may be generated.

The multi-meter connected to the shunt terminals (see *new current measurement technique, pg. 17* **)** will measure current output and is comparable to the speedometer of a car. A voltmeter connected to the batteries will roughly indicate the charge level, as described in Charge Level above, and is comparable to the gas gauge.

DESIGN EXAMPLE

This example shows how to proceed with a complete installation. The parameters of the example site are:

-120 feet of head over a distance of 1000 feet
-a flow of 30 gpm (most of the time)
-100 feet distance from the house to the hydro machine
-12 volt system

The first thing we do is determine the pipeline size. Although maximum power is produced from a given size pipe when the flow loss is 1/3 of the static head, more power can be obtained from the same flow with a larger pipe, which has lower losses. Therefore, pipe size must be optimized based on economics. As head decreases, efficiency of the system decreases, and it is important to keep the head losses low.

The pipe flow charts show us that two-inch diameter polyethylene pipe has a head loss of 1.77 feet of head per 100 feet of pipe at a flow rate of 30 gpm. This is 17.7 feet of loss for 1000 feet of pipe.

Using two-inch PVC gives us a loss of 1.17 feet of head per 100 feet of pipe or 11.7 feet for 1000 feet.

Polyethylene comes in continuous coils because it is flexible (and more freeze resistant). PVC comes in shorter lengths and has to be glued together or purchased with gaskets (for larger sizes). Let's say we select polyethylene.

The maximum output occurs with a flow of about 45 gpm since that gives us a head loss of 3.75 feet per 100 feet of pipe, or 37.5 feet of loss for our 1000 feet of pipe. This is 37.5' loss/120' head = 31% loss.
A flow of 30 gpm gives a net head of 102.3 feet (120' - 17.7'). The losses caused by the various pipe fittings and intake screen will further decrease the dynamic head, so 100 feet is a good working figure for the net head.

At this head and flow condition, the output of the machine is equal to about 300 watts.

Since we require 12 volts and the transmission distance is short, we can generate and transmit 12 volts using the Stream Engine. This Stream Engine could also be used for higher voltages like 24 and 48, and power could be transmitted longer distances.

Looking at the nozzle flow chart, we see that a 3/8" nozzle will produce a flow of 27.6 gpm at a 100' head. This is very close to the design point but will produce slightly less output than if we had exactly 30 gpm. A 7/16" nozzle would produce slightly greater flow and output. We need to go 100' with 300 watts at our site. This will be about 20 amps at 15 volts at the generator. Note that there will be some voltage drop in the line and 12-volt batteries require somewhat higher voltages than nominal to become charged. So the 20 amps must pass through 200' of wire for the round trip. Resistance losses should be kept as low as economics permit, just like the pipeline losses.

Let's say we wish to have around a 10% loss. This is 30 watts out of the original 300. The formula for resistive loss is I^2R = watts when I = Intensity (current in amps) and R = Resistance (in ohms).

> (20 amps) x (20 amps) x R (ohms) = 30 watts
> 400 amps x R (ohms) = 30 watts
> R = 30 watts/400 amps
> R = 0.075 ohms

This is the wire resistance that will produce a 10% loss. The wire loss chart shows loss per 1000', so:

> 1000'/200' x 0.075 ohms = 0.375 ohms per 1000'.

The chart shows 6 ga. Wire has a resistance of 0.40 ohms per 1000', so:

> 200'/1000' x 0.40 ohms = 0.08 ohms. This is close to the desired level.
> 20 amps x 20 amps x 0.08 ohms = 32 watts of loss.

Increasing the wire size further reduces the losses. Voltage drop in the wire is equal to:

IR = 20 amps x 0.08 ohms = 1.6 volts

So if the battery voltage is 13.4 the generator will be operating at 15.0 volts. Keep in mind that it is always the batteries that determine the system voltage. That is, all voltages in the system rise and fall according to the battery's state of charge.

At the site, we would be generating 20 amps continuously. If we use lead acid batteries and wish to have two days of storage capacity, then:

20 amps x 24 hrs x 2 days = 960 amp. Hrs. Capacity

We would probably use an inverter and load controller with the system. The diagram for such a system would look like this:

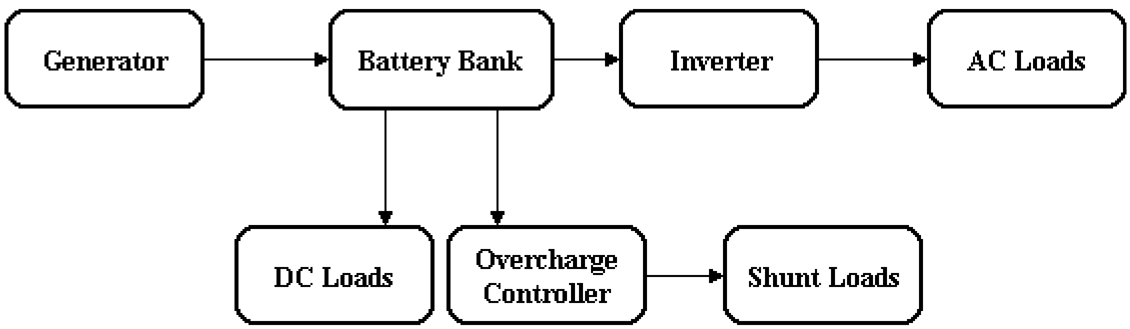


Diagram of a typical battery-based system:

OUTPUT ADJUSTMENT

For the machine to produce the highest output, the rotor height should be adjusted. This involves raising and lowering the rotor to increase the magnetic flux level. This is necessary to match the output of the turbine with that of the generator.

After the machine is installed, perform an initial run to establish a power output level. This can be determined using an ammeter to measure current or a digital meter to measure voltage. A good idea is to keep a logbook to note any output changes in relation to settings. After everything is hooked up, start the machine by opening the stop valve. Run it long enough for the output level to stabilize and note the current (or voltage). Then shut the stop valve.
The machine comes with the rotor set very close to the stator (the stationary part of the machine). To increase this distance and reduce the magnetic flux level, you must turn the larger bolt 19mm (3/4") head on the top of the rotor while holding it stationary. This is done by inserting the 1/4" pin supplied in one of the holes in the edge of the rotor. Then the smaller 11mm(7/16") head bolt is loosened. Now you can turn the larger bolt, which will force the rotor up. Each full turn of the bolt will move the rotor vertically 1.25 mm (0.050”). If raising the rotor causes the current (or the voltage) to increase, then continue to do so until there is no longer an increase. If a point is reached where a decrease occurs, then the rotor should be lowered. This is done by loosening the larger bolt and then tightening the smaller one. Turning the smaller bolt causes the rotor to move vertically the same distance per turn as the larger bolt does. When you have found the best position (no increase in current or voltage), make sure the larger bolt is turned until it is tight. Now the smaller bolt should be tightened securely to lock everything in place. No further adjustments should be required unless nozzle sizes are changed.

When adjusting the rotor downward, it may reach the point where it will contact the stator. If this occurs, always adjust it upwards by at least a 1/4 turn of the larger bolt. Operating the machine with the rotor closer than this may damage the machine.

**** Always turn the rotor by hand before starting the machine to check for rubbing**.**
Remove the pin in the rotor edge before starting the machine.

Optimum nozzle size can be found using a similar technique.

Energy Systems and Design has introduced a new type of nozzle for its hydro-electric generators. This makes it possible to create any size nozzle jet that might be required by simply cutting the nozzle to the appropriate length. Cutting can be done with a hacksaw, or any other fine toothed saw. The end of the nozzle should then be finished with a piece of sandpaper. This is best done by placing the sandpaper on a flat surface and moving the nozzle against it. Markings are on the nozzle to assist in cutting to the correct size. The numbers are in millimeters and correspond to inches as follows:

mm	3	4.5	6	8	10	13	16	19	22	25
inches	1/8	3/16	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1

Odd sizes can also be produced. The opening of the nozzle is about 6% larger than the actual jet of water that exits from it. Another possibility is to make the opening larger until the desired flow is obtained. An O-ring is provided in order to seal the face. This prevents water leaks to the outside of the machine.

For the smallest nozzle sizes, the nozzle may have to be installed with the numbered side facing upward, so that the end will not contact the turbine wheel.

High Voltage models Only

When operating a Stream Engine using transformers, it will require a different technique in order to optimize the output. This can be done at the turbine by adjusting for maximum voltage rather than maximum current. AC voltage can be measured across any two of the output terminals. These terminals are the same on the terminal board as for low-voltage DC systems. Make rotor air gap adjustments according to the instructions earlier in this manual. An on/off switch is supplied for the incoming AC power. In normal use the switch is usually left on.

NOZZLE FLOW CHART FLOW RATE IN U.S. GALLONS PER MINUTE

Head Feet	Pressure PSI	Nozzle Diameter, inches											Turbine RPM
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1.0	
5	**2.2**					6.18	8.40	11.0	17.1	24.7	33.6	43.9	**460**
10	**4.3**			3.88	6.05	8.75	11.6	15.6	24.2	35.0	47.6	62.1	**650**
15	**6.5**		2.68	4.76	7.40	10.7	14.6	19.0	29.7	42.8	58.2	76.0	**800**
20	**8.7**	1.37	3.09	5.49	8.56	12.4	16.8	22.0	34.3	49.4	67.3	87.8	**925**
30	**13.0**	1.68	3.78	6.72	10.5	15.1	20.6	26.9	42.0	60.5	82.4	107	**1140**
40	**17.3**	1.94	4.37	7.76	12.1	17.5	23.8	31.1	48.5	69.9	95.1	124	**1310**
50	**21.7**	2.17	4.88	8.68	13.6	19.5	26.6	34.7	54.3	78.1	106	139	**1470**
60	**26.0**	2.38	5.35	9.51	14.8	21.4	29.1	38.0	59.4	85.6	117	152	**1600**
80	**34.6**	2.75	6.18	11.0	17.1	24.7	33.6	43.9	68.6	98.8	135	176	**1850**
100	**43.3**	3.07	6.91	12.3	19.2	27.6	37.6	49.1	76.7	111	150	196	**2070**
120	**52.0**	3.36	7.56	13.4	21.0	30.3	41.2	53.8	84.1	121	165	215	**2270**
150	**65.0**	3.76	8.95	15.0	23.5	33.8	46.0	60.1	93.9	135	184	241	**2540**
200	**86.6**	4.34	9.77	17.4	27.1	39.1	53.2	69.4	109	156	213	278	**2930**
250	**108**	4.86	10.9	19.9	30.3	43.6	59.4	77.6	121	175	238	311	**3270**
300	**130**	5.32	12.0	21.3	33.2	47.8	65.1	85.1	133	191	261	340	**3591**
400	**173**	6.14	13.8	24.5	38.3	55.2	75.2	98.2	154	221	301	393	**4140**

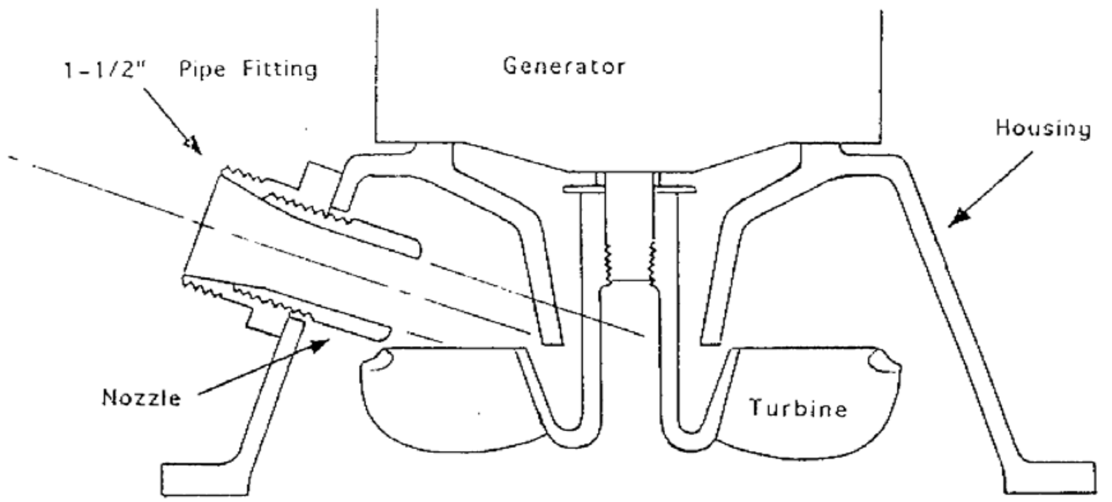
BEARINGS, SERVICE & ASSEMBLY

In order to remove the generator you must first remove the turbine wheel. The machine's wheel is unscrewed from the shaft by holding the rotor using the 1/4" diameter rod inserted into one of the holes in the edge of the rotor. The turbine wheel is assembled with a washer and then a spacer on top. The shaft is made with standard right hand threads for the turbine wheel so it will unscrew in a counter-clockwise direction when looking at the shaft (with the machine upside down). Then you can remove the four bolts with 4mm (5/32") hex drive.

You should replace bearings as soon as you notice any looseness. If they are too loose, severe damage to both the rotor and the stator can result. This machine uses three 6203 ball bearings with contact seals. On earlier machines these are press fit into the alternator housing and must be installed and removed using a press of adequate capacity and a proper sized mandrel. Presently the bearings in the machine are a loose fit in the housing bore and can be replaced by hand IF there is not too much rust.

To replace bearings:

1. Using the rotor pin to hold the shaft, unthread the runner from the generator shaft.
2. Remove rotor. To remove rotor and shaft raise the rotor as described in *output adjustment* until the magnetic attraction is low enough to separate the rotor/shaft assembly from the housing and stator.
3. Unscrew 4 bolts and washers retaining bearings.
4. With the Stream Engine sitting inverted, using your thumbs, push out the bearings from the sleeve or tap the bearings out. This may require a press in some situations.
5. Clean bearing sleeve and insert new 6203LLU bearings.
6. Reassemble.



Copper Wire Resistance Chart

Wire Gauge	Diameter Inches	Ohms per 1000'	Ohms per Mile
0000	0.460	0.05	0.26
000	0.410	0.06	0.33
00	0.364	0.08	0.42
0	0.324	0.10	0.52
2	0.258	0.16	0.84
4	0.204	0.25	1.34
6	0.162	0.40	2.13
8	0.128	0.64	3.38
10	0.102	1.02	5.38
12	0.081	1.62	8.56
14	0.064	2.58	13.6
16	0.051	4.10	21.6
18	0.040	6.52	34.4

PIPE FRICTION LOSS - PVC Class 160 PSI Plastic Pipe

Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM	*Pipe Diameter, Inches*										
	1	**1.25**	**1.5**	**2**	**2.5**	**3**	**4**	**5**	**6**	**8**	**10**
1	0.05	0.02									
2	0.14	0.05	0.02								
3	0.32	0.09	0.04								
4	0.53	0.16	0.09	0.02							
5	0.80	0.25	0.12	0.04							
6	1.13	0.35	0.18	0.07	0.02						
7	1.52	0.46	0.23	0.08	0.02						
8	1.93	0.58	0.30	0.10	0.04						
9	2.42	0.71	0.37	0.12	0.05						
10	2.92	0.87	0.46	0.16	0.07	0.02					
11	3.50	1.04	0.53	0.18	0.07	0.02					
12	4.09	1.22	0.64	0.20	0.09	0.02					
14	5.45	1.63	0.85	0.28	0.12	0.04					
16	7.00	2.09	1.08	0.37	0.14	0.04					
18	8.69	2.60	1.33	0.46	0.18	0.07					
20	10.6	3.15	1.63	0.55	0.21	0.09	0.02				
22	12.6	3.77	1.96	0.67	0.25	0.10	0.02				
24	14.8	4.42	2.32	0.78	0.30	0.12	0.04				
26	17.2	5.13	2.65	0.90	0.35	0.14	0.05				
28	19.7	5.89	3.04	1.04	0.41	0.16	0.05				
30	22.4	6.70	3.45	1.17	0.43	0.18	0.05				
35		8.90	4.64	1.56	0.62	0.23	0.07				
40		11.4	5.89	1.98	0.78	0.30	0.09	0.02			
45		14.2	7.34	2.48	0.97	0.37	0.12	0.04			
50		17.2	8.92	3.01	1.20	0.46	0.14	0.04			
55		20.5	10.6	3.59	1.43	0.55	0.16	0.05			
60		24.1	12.5	4.21	1.66	0.64	0.18	0.07	0.02		
70			16.6	5.61	2.21	0.85	0.25	0.09	0.03		
80			21.3	7.18	2.83	1.08	0.32	0.12	0.04		
90				8.92	3.52	1.36	0.39	0.14	0.07		
100				10.9	4.28	1.66	0.48	0.18	0.07	0.02	
150				23.2	9.06	3.50	1.04	0.37	0.16	0.05	
200					15.5	5.96	1.75	0.62	0.28	0.07	0.02
250					23.4	9.05	2.65	0.94	0.42	0.12	0.05
300						12.6	3.73	1.34	0.58	0.16	0.05
350						16.8	4.95	1.78	0.76	0.21	0.07
400						21.5	6.33	2.25	0.97	0.28	0.10
450							7.87	2.81	1.20	0.32	0.12
500							9.55	3.41	1.45	0.42	0.14
550							11.4	4.07	1.75	0.48	0.16
600							13.4	4.78	2.05	0.58	0.18
650							15.5	5.54	2.37	0.67	0.23
700							17.8	6.37	2.71	0.76	0.25
750							20.3	7.22	3.10	0.86	0.30
800								8.14	3.50	0.97	0.32
850								9.11	3.89	1.08	0.37
900								10.1	4.32	1.20	0.42
950								10.8	4.79	1.34	0.46
1000								12.3	5.27	1.45	0.51

PIPE FRICTION LOSS Polyethylene SDR - Pressure Rated Pipe

Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM	Pipe Diameter, Inches							
	0.5	0.75	1	1.25	1.5	2	2.5	3
1	1.13	0.28	0.09	0.02				
2	4.05	1.04	0.32	0.09	0.04			
3	8.60	2.19	0.67	0.19	0.09	0.02		
4	14.6	3.73	1.15	0.30	0.14	0.05		
5	22.1	5.61	1.75	0.46	0.21	0.07		
6	31.0	7.89	2.44	0.65	0.30	0.09	0.05	
7	41.2	10.5	3.24	0.85	0.42	0.12	0.06	
8	53.1	13.4	4.14	1.08	0.51	0.16	0.07	
9		16.7	5.15	1.36	0.65	0.18	0.08	
10		20.3	6.28	1.66	0.78	0.23	0.09	0.02
12		28.5	8.79	2.32	1.11	0.32	0.14	0.05
14		37.9	11.7	3.10	1.45	0.44	0.18	0.07
16			15.0	3.93	1.87	0.55	0.23	0.08
18			18.6	4.90	2.32	0.69	0.30	0.09
20			22.6	5.96	2.81	0.83	0.35	0.12
22			27.0	7.11	3.36	1.00	0.42	0.14
24			31.7	8.35	3.96	1.17	0.49	0.16
26			36.8	9.68	4.58	1.36	0.58	0.21
28				11.1	5.25	1.56	0.67	0.23
30				12.6	5.96	1.77	0.74	0.25
35				16.8	7.94	2.35	1.00	0.35
40				21.5	10.2	3.02	1.27	0.44
45				26.8	12.7	3.75	1.59	0.55
50				32.5	15.4	4.55	1.91	0.67
55					18.3	5.43	1.96	0.81
60					21.5	6.40	2.70	0.94
65					23.8	7.41	3.13	1.08
70					28.7	8.49	3.59	1.24
75					32.6	9.67	4.07	1.40
80						10.9	4.58	1.59
85						12.2	5.13	1.77
90						13.5	5.71	1.98
95						15.0	6.31	2.19
100						16.5	6.92	2.42
150						34.5	14.7	5.11
200							25.0	8.70
300								18.4

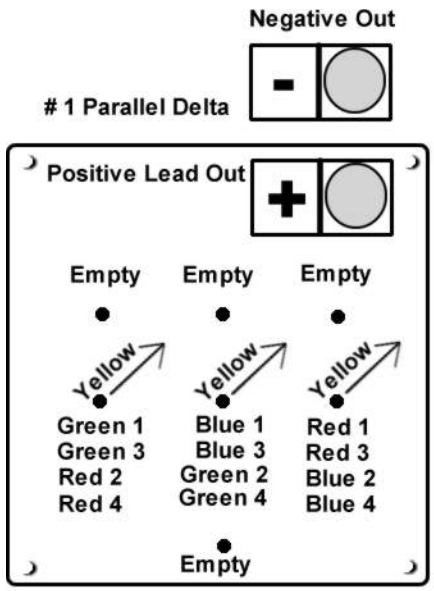
Stream Engine Output in Watts (Continuous)

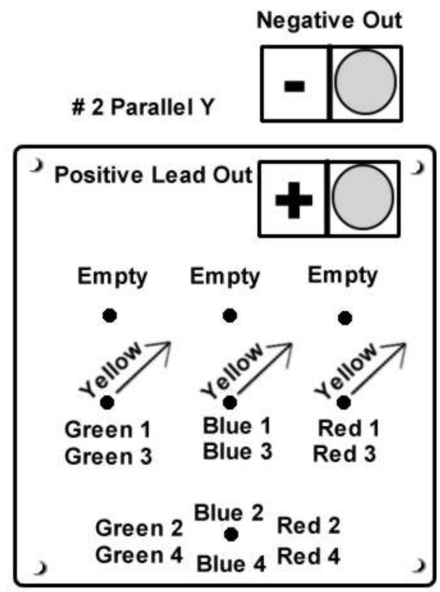
Net Head		Flow Rate Liters/sec (Gallons/min)						
Meters	Feet	0.67 (10)	1.33 (20)	2.50 (40)	5.00 (75)	6.67 (100)	7.50 (112)	9.50 (150)
3	10	-	20	50	90	120	130	150
6	20	15	40	100	180	230	250	350
15	49	45	110	230	450	600	650	800
30	98	80	200	500	940	1100	*	*
60	197	150	400	900	1500	*	*	*
90	295	200	550	1200	*	*	*	*
120	394	300	700	1500	*	*	*	*
150	492	400	850	1900	*	*	*	*

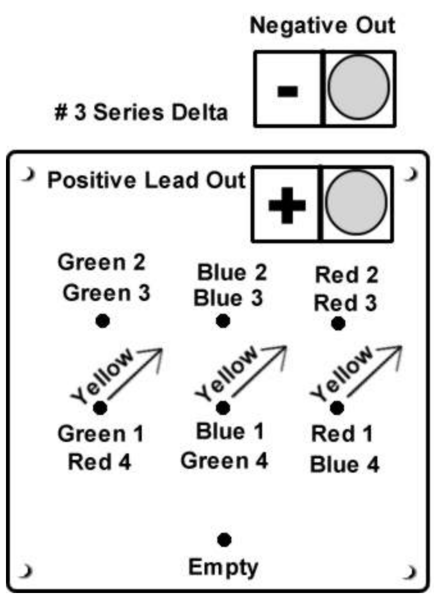
* Due to lower efficiency at higher flows, it becomes worthwhile to utilize two Stream Engines.

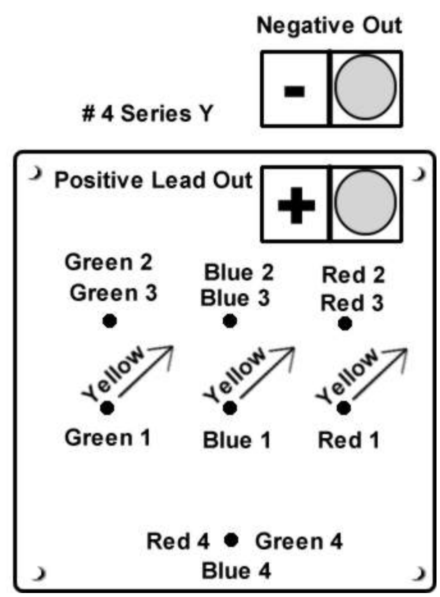
WIRING DIAGRAMS

These diagrams represent the four possible combinations of output wiring. They are in order of potential. If you find your air gap adjustment to be at a minimum and wish to try for more power, then try using the next higher combination. If you find the air gap is very large, try the next lower one. Note that there is only a small change in potential between #2 to #3.









WIRING SCHEMES

12 VOLTS	*24 VOLTS*	*48 VOLTS*
Parallel Delta All Heads	**Series Delta** *up to 60'/18 m*	**Series Y** *up to 60'/ 18m*
	Parallel Delta *30'/ 9m and up*	**Series Delta** *30'/9m to 250'/75m*
		Parallel Delta *140'/43m and up*

Note: At a given site, more than one scheme may work. But one will work best.

Parallel wye configuration is not mentioned because it is very similar to series delta. It differs by about 15 %. If you have a site where series delta is used and you think the output could be greater, try it. Remember to adjust the rotor for highest output when changing the wiring.

NEW CURRENT MEASUREMENT TECHNIQUE

Previously, all Stream Engines were equipped with analogue ammeters. Now, a built-in shunt (precision resistance) is installed in the junction box which allows the current to be measured digitally. This is done with the supplied DMM (digital multi meter). To measure the current produced by the generator, set the DMM scale to "DC mili-volts" or "200 m" at the nine o'clock position. Do not use the amps scale. Plug the negative in bottom hole, and positive in middle hole. Plug the leads into their corresponding color-coded jacks on the shunt in the junction box. This will give current readings from 0.1 amps to 99.9 amps. Of course, the DMM can be used for other tasks with your renewable energy system.

The LH 1000 Low Head Propeller Turbine Personal Hydropower Owner's Manual

LH1000

Energy Systems & Design
P.O. Box 4557
Sussex, NB
Canada E4E 5L7

MANUAL 2

The LH 1000 Low Head Propeller Turbine Personal Hydropower Owner's Manual

Made in Canada

Table of Contents

www.microhydropower.com

MANUAL 2

The LH 1000 Low Head Propeller Turbine Personal Hydropower Owner's Manual

INTRODUCTION

This manual describes the LH 1000, which is manufactured by Energy Systems & Design LTD. The installer must have some knowledge of plumbing and electrical systems, as should the end-user of the system.

These machines are small, but can generate very high voltages. Even 12-volt machines can produce high voltages under certain conditions. Practice all due safety. Electricity cannot be seen and it can be lethal.

Electricity is produced from the potential energy in water moving from a high point to a lower one. This distance is called "head" and is measured in units of distance: meters (or feet) or in units of pressure: kilograms per square centimeter). "Flow" is measured in units of volume: gallons per minute - GPM (or liters per second - l/s), and is the second portion of the power equation: power [watts] = head x flow. The LH1000 is designed to operate over a fixed range of heads and flows, from 0.6-3m (two to ten feet), employing a cast polyurethane propeller and guide vane assembly.

The LH1000 uses a permanent magnet type alternator. This design eliminates the need for brushes and the maintenance that accompanies them, while increasing efficiency. The LH1000's output can be optimized by simply adjusting the rotor's clearance from the stator.

www.microhydropower.com

MANUAL 2

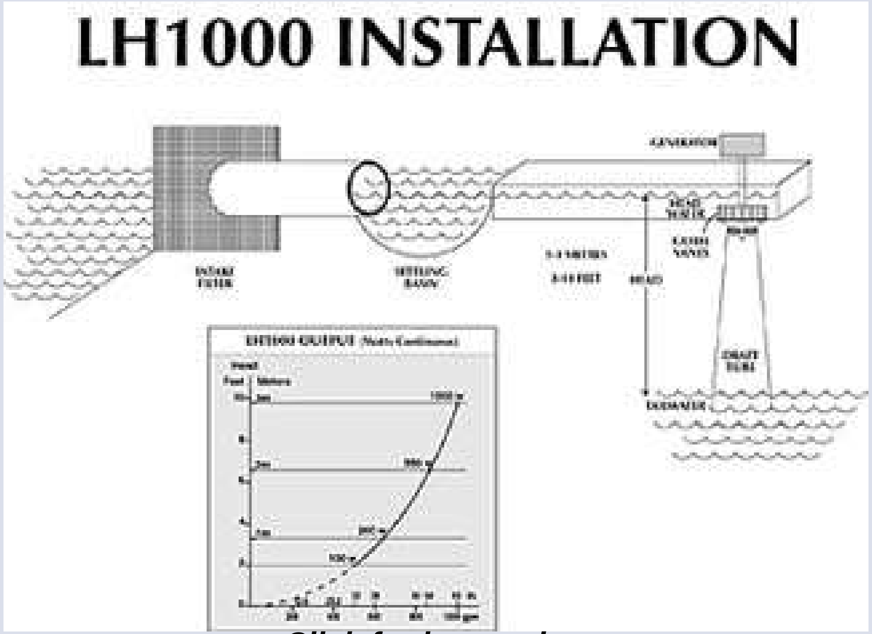
The LH 1000 Low Head Propeller Turbine Personal Hydropower Owner's Manual

SITE EVALUATION

Certain information must be determined concerning your site, in order to use its potential for maximum output. Head and flow must first be determined. The other factors are plumbing specifications, transmission distance, and the system voltage. These factors determine how much power can be expected.

Power is generated at a constant rate by the LH1000 and stored in batteries as direct current (DC). Power is supplied, as needed, by the batteries, which store energy during periods of low consumption for use in periods where consumption exceeds the generation rate. Appliances can be used that operate directly from batteries, or alternating current (AC) power (at regular domestic specifications) can be supplied through an inverter, converting DC to AC power.

Sites may vary, so carefully consider flow and head when choosing yours.



Click for larger view

---

www.microhydropower.com

MANUAL 2

The LH 1000 Low Head Propeller Turbine Personal Hydropower Owner's Manual

HEAD MEASUREMENT

Head may be measured using various techniques. A garden hose or length of pipe can be submerged with one end upstream and the other end downstream. Anchor the upstream end with rocks or have an assistant hold it; water should flow out the low end, especially if the pipeline is pre-filled. Once water is flowing, raise the downstream end until it stops. Do this slowly since the water tends to oscillate. When the flow has stabilized, measure the distance down to the level of water in the stream with a tape measure. This will give a very accurate measurement of that stream section. Mark the spot and then repeat the procedure until the entire distance is covered.

Another technique is to use a surveyor's transit. This method can also be approximated using a carpenter's level using a measuring stick or a "story pole." This technique is also done in a series of steps to arrive at the overall head. Note that with this reaction type machine, the entire head is used. No head is lost as with an impulse machine.

FLOW MEASUREMENT

The weir method can be used for the higher flows used with this machine. This technique uses a rectangular opening cut in a board or piece of sheet metal set into the brook like a dam. The water is channeled into the weir and the depth is measured from the top of a stake that is level with the edge of the weir and several feet upstream.

WEIR MEASUREMENT TABLE

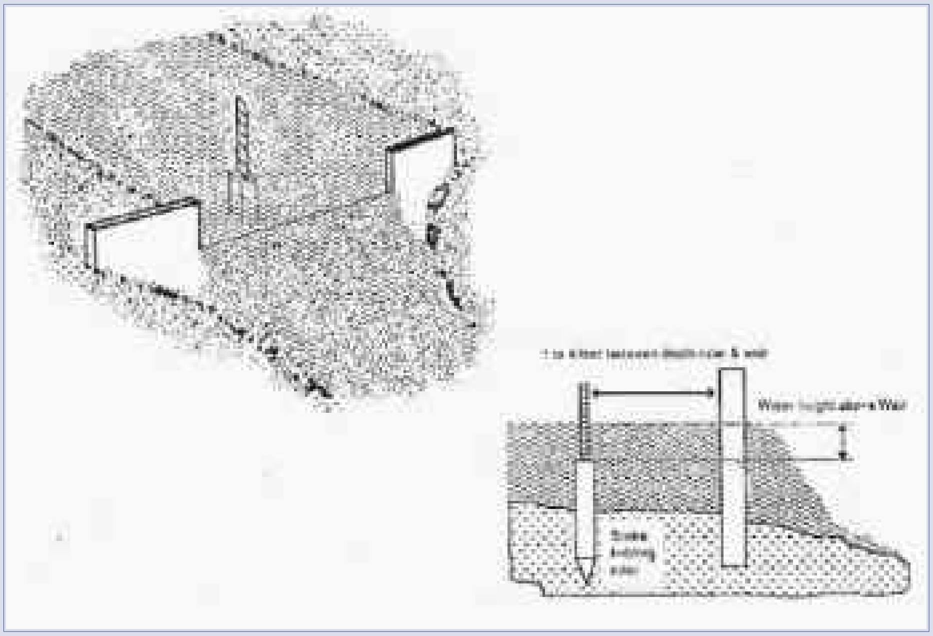
Table shows water flow in gallons/minute (GPM) that will flow over a weir one inch wide and from 1/8 to 10-7/8 inches deep.

Inches		1/8	1/4	3/8	1/2	5/8	¾	7/8
0	0.0	0.1	0.4	0.7	1.0	1.4	1.9	2.4
1	3.0	3.5	4.1	4.8	5.5	6.1	6.	7.6
2	8.5	9.2	10.1	10.9	11.8	12.7	13.6	14.6
3	15.5	16.5	17.5	18.6	19.5	20.6	21.7	22.8
4	23.9	25.1	26.2	27.4	28.5	29.7	31.0	32.2
5	33.4	34.7	36.0	37.3	38.5	39.9	41.2	42.6

6	43.9	45.3	46.8	48.2	49.5	51.0	52.4	53.9
7	55.4	56.8	58.3	59.9	61.4	63.0	64.6	66.0
8	67.7	69.3	70.8	72.5	74.1	75.8	77.4	79.1
9	80.8	82.4	84.2	85.9	87.6	89.3	91.0	92.8
10	94.5	96.3	98.1	99.9	101.7	103.6	105.4	107.3

Example of how to use weir table:
Suppose depth of water above stake is 9 3/8 inches.
Find 9 in the left-hand column and 3/8 in the top column. The value where they intersect is 85.9 gpm. That's only for a 1-inch weir, however. You multiply this value by the width of your weir in inches to obtain water flow.

Click picture for larger view



Measuring the flow at different times of the year helps you estimate maximum and minimum usable flows. If the water source is seasonally limited, you may have to depend on some other source of power during dry times (solar, wind). Keep in mind that a reasonable amount of water must be left in the stream (Don't take it all, that water supports life forms).

When head and flow are determined, the expected power output can be determined from the following chart. Keep in mind that chart values represent generated output and that actual power delivered to the batteries will be reduced by transmission lines, power converters, and other equipment required by the system. All systems should be carefully planned to maximize power output.

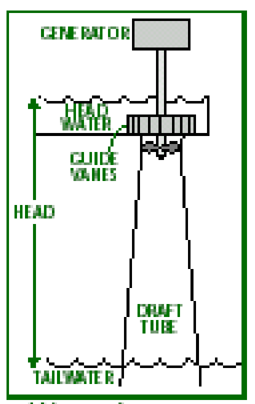
---

www.microhydropower.com

MANUAL 2

The LH 1000 Low Head Propeller Turbine Personal Hydropower Owner's Manual

INTAKE, PIPELINE, AND TAILRACE



LH1000 Installation

All hydro systems require a waterway. Even systems operating directly from a dam require at least a short plumbing run. It is important to use the correct type and size of plumbing to minimize restrictions in the flow. When possible, pipelines should be buried; this stabilizes the line and prevents animals from chewing it.

At the inlet of the plumbing, a filter should be installed. A screened box can be used with the pipe entering one side, or add a section of pipe drilled full of holes wrapped with screen or small holes and used without screen. A mesh size of about 20mm (3/4") and smaller can be used as debris of this size and will pass through the machine. However, it is important to keep sticks out of the intake as they may become jammed in the machine. This may require a smaller mesh size.

A settling basin should be used with this machine. This is a pool of low velocity water that enables the grit to settle so that it will not enter the machine and wear the edge of the propeller and the guide vane housing.

FIND DIAGRAM FOR LOW HEAD INSTALLATION

The turbine can be mounted in the waterway, through a 17-cm (7") hole, with the draft tube extending to the tail waters below. Small tabs with screws are adequate to retain the machine. The draft tube is connected to the machine using rubber sleeves and hose clamps. These are standard plumbing items. PVC pipe of 150mm (6") diameter with a 4mm (0.160") wall thickness is used between the guide vane assembly and the draft tube. Install the rubber sleeve at the lower end of the guide vane tube so as to create a smooth transition from one to the other. It is recommended to have the LH1000 in a small enclosure or under some cover to keep it dry and provide a place for auxiliary equipment. Mounting the machine in concrete is also possible (you may wish to try a temporary wood mounting first).

---

www.microhydropower.com

MANUAL 2

The LH 1000 Low Head Propeller Turbine Personal Hydropower Owner's Manual

BATTERIES, INVERTERS & CONTROLLERS

System Voltage

A small system with a short transmission distance is usually designed to operate at 12 volts. Larger systems can also be 12 volts, but if higher power is desired or the transmission distance is long, then a system of 24 volts or higher may be preferable. This is especially true if all loads are inverter-powered. In a 12-volt system, operating at a low power level, it may be advantageous to operate all loads directly from batteries. Many 12-volt appliances and small inverters are available.

In 24-volt systems, it may also be preferable to operate the loads directly (although not as many appliances are available). In higher power systems, it is usually better to use an inverter to convert battery voltage to regular domestic AC power. This has been made feasible with the advent of reliable high power inverters. Thousands of home power systems are in operation with only AC loads.

Sizing Battery Capacity

A typical hydro system should have about two days of battery storage capacity. This will generally keep lead-acid cells operating in the upper end of their charge range where they are the most efficient and long-lived. Alkaline batteries like the nickel-iron and the nickel-cadmium types can have a lower capacity since they can be more fully discharged without harm.

Batteries should be located outside of living space, or adequate ventilation should be provided, as a rising charge level tends to produce both hydrogen gas and corrosive fumes. Also, distilled water should be added as needed to maintain the electrolyte level.

Charge Control

A hydro system requires that a load be present so that the power has somewhere to go. Otherwise, system voltage can rise to very high levels. This situation provides an opportunity to do something with the excess power (i.e., a diversion load used for water heating).

As the batteries become fully charged, their voltage rises.
At some point, the charging process should stop and the power be diverted to the dump load. The voltage set point should be about 13.5 to 14.5vdc for a 12-volt system depending on the charge rate. The higher the charge rate, the higher the voltage can go. If batteries are often in a high state of charge, the voltage limit should

be on the low end of the range.

A voltmeter or a watt-hour meter can be used to monitor battery charge level. Battery voltage is roughly a function of the charge level, and varies according to the load level and charge rate. There are many commercially available monitors that conveniently display these features to the user, including the state of charge.

---

www.microhydropower.com

MANUAL 2

The LH 1000 Low Head Propeller Turbine Personal Hydropower Owner's Manual

WIRING AND LOAD CENTER

Every system requires some wiring to connect the various components. Load centers are available as a complete package that easily facilitates the connection of loads and power source(s). All circuits in the system should use wire of adequate size and have fuses or breakers of sufficient capacity to carry the expected load current. Even the LH1000 must be fused since it can suffer from a short or similar fault just like anything else in the system.

Inside the "junction box", are two terminal lugs for the battery wiring. The negative terminal lug is bolted to the box and the positive terminal lug is bolted to the clear plastic terminal block. Transmission wire ends are inserted into these two connectors (after being stripped of insulation) and then tightened.

The precision shunt installed in the junction box will give a readout of the hydro output in amperes if the digital multimeter is plugged into the jacks (color coded in the shunt body), and turned to 200m (the 9 o'clock position). A voltmeter connected to the batteries will roughly indicate the charge level, as described in "Charge Level" above, and an ammeter will indicate the output of the machine.

PIPE FRICTION LOSS - PVC Class 160 PSI Plastic Pipe

Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM	Pipe Diameter, Inches										
	1	1.25	1.5	2	2.5	3	4	5	6	8	10
1	0.05	0.02									
2	0.14	0.05	0.02								
3	0.32	0.09	0.04								
4	0.53	0.16	0.09	0.02							
5	0.80	0.25	0.12	0.04							
6	1.13	0.35	0.18	0.07	0.02						
7	1.52	0.46	0.23	0.08	0.02						
8	1.93	0.58	0.30	0.10	0.04						

9	2.42	0.71	0.37	0.12	0.05						
10	2.92	0.87	0.46	0.16	0.07	0.02					
11	3.50	1.04	0.53	0.18	0.07	0.02					
12	4.09	1.22	0.64	0.20	0.09	0.02					
14	5.45	1.63	0.85	0.28	0.12	0.04					
16	7.00	2.09	1.08	0.37	0.14	0.04					
18	8.69	2.60	1.33	0.46	0.18	0.07					
20	10.6	3.15	1.63	0.55	0.21	0.09	0.02				
22	12.6	3.77	1.96	0.67	0.25	0.09	0.02				
24	14.8	4.42	2.32	0.78	0.30	0.12	0.04				
26	17.2	5.13	2.65	0.90	0.35	0.14	0.05				
28	19.7	5.89	3.04	1.04	0.41	0.16	0.05				
30	22.4	6.70	3.45	1.17	0.43	0.18	0.05				
35		8.90	4.64	1.56	0.62	0.23	0.07				
40		11.4	5.89	1.98	0.78	0.30	0.09	0.02			
45		14.2	7.34	2.48	0.97	0.37	0.12	0.04			
50		17.2	8.92	3.01	1.20	0.46	0.14	0.04			
55		20.5	10.6	3.59	1.43	0.55	0.16	0.05			
60		24.1	12.5	4.21	1.66	0.64	0.18	0.07	0.02		
70			16.6	5.61	2.21	0.85	0.25	0.09	0.03		
80			21.3	7.18	2.83	1.08	0.32	0.12	0.04		
90				8.92	3.52	1.36	0.39	0.14	0.07		
100				10.9	4.28	1.66	0.48	0.18	0.07	0.02	
150				23.2	19.0	3.50	1.04	0.37	0.16	0.05	
200					15.5	5.96	1.75	0.62	0.28	0.07	0.02
250					23.4	9.05	2.65	0.94	0.42	0.12	0.05
300						12.6	3.73	1.34	0.58	0.16	0.05
350						16.8	4.95	1.78	0.76	0.21	0.07
400						21.5	6.33	2.25	0.97	0.28	0.10
450							7.87	2.81	1.20	0.32	0.12

500	9.55	3.41	1.45	0.42	0.14
550	11.4	4.07	1.75	0.48	0.16
600	13.4	4.78	2.05	0.58	0.18
650	15.5	5.54	2.37	0.67	0.23
700	17.8	6.37	2.71	0.76	0.25
750	20.3	7.22	3.10	0.86	0.30
800		8.14	3.50	0.97	0.32
850		9.11	3.89	1.08	0.37
900		10.1	4.32	1.20	0.42
950		10.8	4.79	1.34	0.46
1000		12.3	5.27	1.45	0.51

POWER OUTPUT IN WATTS (CONTINUOUS)
PUT IN OUTPUT CHART

DESIGN EXAMPLE

This example shows how to proceed with a complete installation. The parameters of the example site are:

- 6 feet (2m) of head over a distance of 50 feet (15m)
- a flow of at least1000 GPM (63l/s)
- 100 feet distance from the house to the hydro machine
- 12 volt system

The first thing to do is determine the pipe size. Given that there is friction between water and the pipe in which it flows, this friction can be reduced by increasing the size of the pipe to minimize the friction to acceptable limits. Therefore, pipe size must be optimized based on economics and performance.

The pipe flow charts show us that eight-inch (approx. 20cm) diameter PVC pipe has a head loss of 0.97 feet of head per 100 feet (30m) of pipe at a flow rate of 800 GPM (50 l/s). This is about 0.5 feet (15cm) of loss for 50 feet (15m) of pipe. PVC comes in short lengths and is glued together or purchased with gaskets.

The maximum output occurs with a flow of about 800 GPM (50 l/s). Note that with this machine, the flow is determined by the head, as there are no nozzles that can be adjusted that would change the flow.

1 foot loss/100 feet pipe=x feet loss/50 feet pipe
x=0.5 feet (15cm) of head loss

Next, we subtract the head losses from the measured head (often referred to as static, or gross head. Abbreviated: Hg) in order to determine the actual, operating head (often referred to as dynamic, or net head. Abbreviated Hn):

6 feet head (Hg)-0.5 feet head losses =
5.5 feet (1.85m) actual head (Hn)

It is now known that the LH 1000 will be operating at an actual, or dynamic, head of 5.5 feet (1.85m) Hn. By referring back to the output chart, it can be determined that the LH1000 can, realistically, be expected to produce approximately 400w.

COPPER WIRE RESISTANCE

Wire Gauge	Diameter Inches	Ohms per 1000'	Ohms per Mile
0000	0.460	0.05	0.26
000	0.410	0.06	0.33
00	0.364	0.08	0.42
0	0.324	0.10	0.52
2	0.258	0.16	0.84
4	0.204	0.25	1.34
6	0.162	0.40	2.13
8	0.128	0.64	3.38
10	0.102	1.02	5.38
12	0.081	1.62	8.56
14	0.064	2.58	13.6
16	0.051	4.10	21.6
18	0.040	6.52	34.4

Since we require 12 volts and the transmission distance is short, we can generate and transmit 12 volts using the LH1000. This LH1000 could also be used for higher voltages like 24 and 48, and power could be transmitted longer distances. We need to go 100'(30m) with 400 watts at our site. The amperage can be determined using the formula: volts x amperage = watts. So, a 12v system usually operates at an actual voltage of about 15v, therefore: 400/15 = 26.7 amps. The machine will need to be wired parallel delta for this site.

This will be about 26.7 amps at 15 volts at the generator. Note that there will be some voltage drop in the line and 12-volt batteries require somewhat higher voltages than nominal to become charged. So the 26.7 amps must pass through 200'(60m) of wire for the distance to the batteries and back which completes the circuit. As there is friction between water and the pipe that carries it, causing losses, so there is resistance between electricity and the conductor that carries it, and is measured in units called ohms. Resistance losses should be kept as low as economics permit, just like the pipeline losses. Let's assume that a 5% loss is acceptable at this site, resulting in the loss of 25 watts. The formula to calculate resistance losses is I (amps) x I (amps) x R (resistance) = w (watts). We put our known figures into the formula to learn the resistance that we require in a copper conductor to achieve this.

26.7 x 26.7 x R = 25w
711 x R = 25w
R = 0.04 ohms

It has been calculated that a copper conductor with losses of 0.04 ohms over a total distance of 200 feet (60m) will result in an acceptable 5% loss. The Wire Loss Chart shows losses per 1000' (300m) of wire, so:

1000'/200' x 0.04 ohms = 0.2 ohms per 1000'.

The chart shows 2 ga. wire has a resistance of 0.16 ohms per 1000', so:

200'/1000' x 0.16 ohms = 0.032 ohms.

This is close enough to the desired level, that with a little more investigation we can determine whether this will result in acceptable power losses:

26.7 amps x 26.7 amps x 0.032 ohms = 22.8watts of loss.

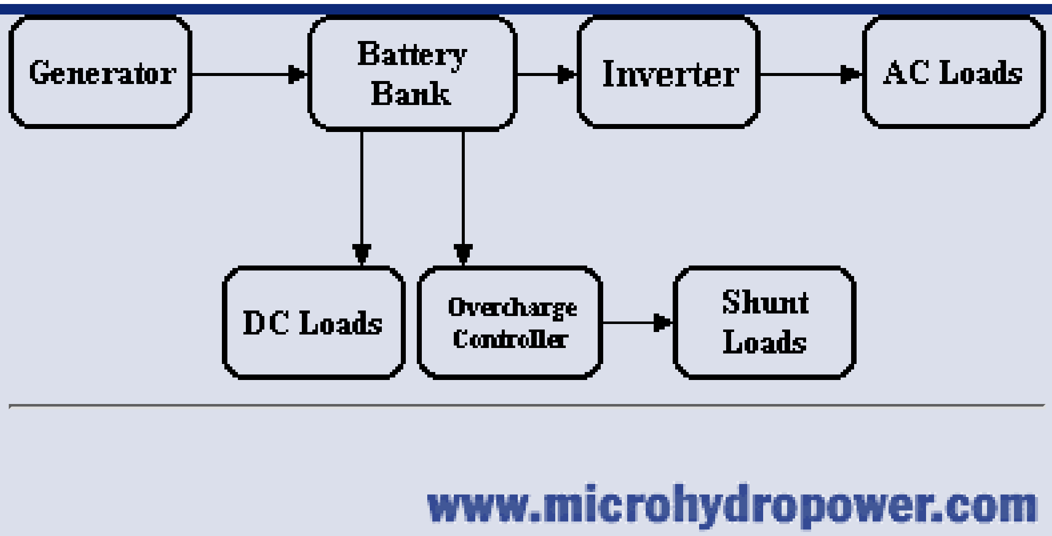
Increasing the wire size can further reduce the losses, but can also increase costs, as larger wire is usually more expensive. Resistance in a length of wire results in power loss that is seen as a voltage drop from one point in the line to another. For example, if your voltage, as measured at the generator, is 15vdc, then it could be assumed that if the voltage were measured along the line to the batteries, it would be lower as you got further from the generator: Voltage drop= I (amps) x R (ohms resistance in your circuit). So:

Voltage drop (v) = 26.7 amps x 0.032 ohms = 0.85 volts

Hence, if your generator voltage is 15vdc, your battery voltage will be 14.15vdc. Keep in mind that it is always the batteries that determine the system voltage, as they are the stabilizing force in your system. All voltages in the system will rise and fall corresponding to the battery voltage, or the battery's state of charge. At the site, we would be generating 26.7 amps continuously. Typically, a battery bank is sized to have two days storage capacity. If we choose lead acid batteries and wish to have two days of storage capacity, then we use the formula: amps x hours x days = amp/hrs capacity. So:

33 amps x 24 hrs x 2 days = 1584 amp. Hrs. Capacity

The Trojan L-16 has a rating of 6vdc and 350 amp/hr. Using these you would require at least eight batteries; there would be four strings paralleled, with each string consisting of two batteries in series to give the 12vdc system voltage we have chosen. This would give 1400 amp/hrs at 12vdc capacity, which is about two days storage. An inverter and charge controller are usually used in the system. The diagram for such a system would look like this:


Generator
Battery Bank
Inverter
AC Loads
DC Loads
Overcharge Controller
Shunt Loads
www.microhydropower.com

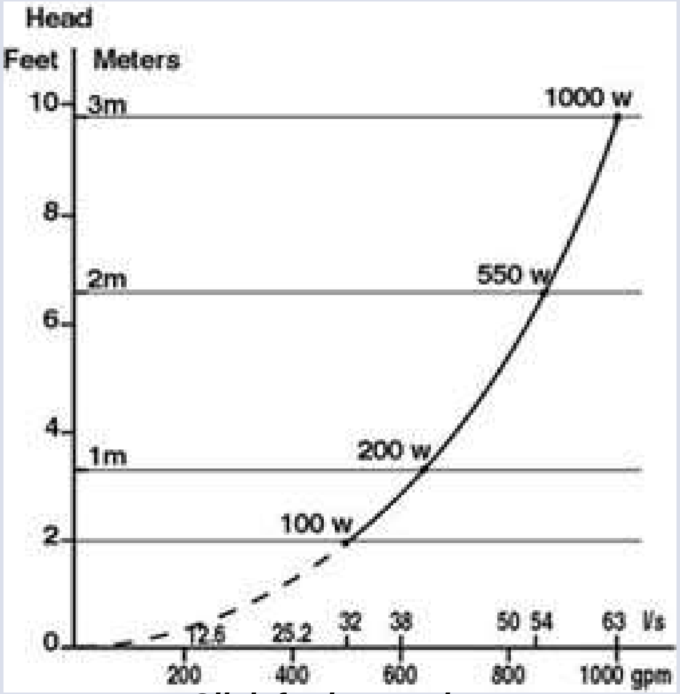
MANUAL 2

The LH 1000 Low Head Propeller Turbine Personal Hydropower Owner's Manual

OUTPUT ADJUSTMENT

For the machine to produce the highest output, the rotor height should be adjusted, so as to match the magnetic power of the rotor to the power of the waterway at the site. Since each site varies from the next, it is important to adjust the rotor for maximum output at your site. This involves raising and lowering the rotor to change or adjust the magnetic flux level until the optimum level is found.

After the machine is installed, perform a trial operation to establish a power output level. This can be determined using a digital multimeter, plugged into the output jacks in the precision shunt found in the junction box. It is recommended to keep a logbook to note any output changes in relation to settings, and to monitor long-term performance. After everything is installed, start the LH1000 by opening the water source. Operate it long enough for the output level to stabilize and note the current (or voltage). Then shut off the water.



Click for larger view

The LH1000 comes with the rotor (the chrome plate) set very close to the stator (the stationary, black body of the generator). To increase this distance, and reduce the magnetic flux level, you first must, while holding the rotor stationary with the 1/4-inch rotor pin placed in the hole in the rotor's edge, loosen the smaller (7/16" head) bolt. Next, hold the rotor stationary with the pin, and tighten the larger bolt, which will force the rotor up. Each full turn of the bolt will move the rotor vertically 0.050" or 1.25 mm. If raising the rotor causes the current (or you may be monitoring the voltage in a high voltage site) to increase, then continue to do so until there is no longer an increase. If a point is reached where a decrease occurs, then the rotor should be lowered. This is done by loosening the larger bolt and then tightening the smaller one. Turning the smaller bolt causes the rotor to move vertically the same distance per turn as the larger bolt does. When you have found the best position (no increase in current or voltage), make sure the larger bolt is turned until it is tight. Now the smaller bolt should be tightened securely to lock everything in place. No further adjustments should be required unless site conditions change.

When adjusting the rotor downward, it may contact the stator. If this occurs, always adjust it upwards by at least a 1/4 turn of the larger bolt. Operating the machine with the rotor any closer than this will not result in any power increase but may damage the machine. ***** Always turn the rotor by hand before starting the machine to check for rubbing and make sure you can always fit a business card in the space between the rotor and stator**.*** Remove the pin from the rotor edge before starting the machine.

---

www.microhydropower.com

MANUAL 2

The LH 1000 Low Head Propeller Turbine Personal Hydropower Owner's Manual

DISASSEMBLY & SERVICE

In order to remove the generator you must first remove the wiring from the terminals on the clear, plastic terminal block in the junction box. Be sure to note their position for later re-installation. An alternative is to remove the junction box from the alternator base by removing the two bolts on the bracket. Then, undo the four allen head bolts that attach the generator to the finned, aluminum base, using the allen wrench supplied with the LH1000. The four bolts are located under the generator base, and thread upward into the generator. Next, unscrew the polyurethane nose cone from the base of the unit, located inside the guide vane assembly, at the end of the shaft in a counter-clockwise or right hand direction. Proceed to remove the propeller by removing the ¾ inch (19mm) brass nut, then the washer, and finally, slide the propeller from the shaft. Now, the generator and shaft assembly may be pulled up, and out of the generator base and shaft housing. The shaft may now be unscrewed so as to remove the long turbine shaft from the generator shaft.

The finned alternator base can be removed from the shaft housing by unscrewing it. The shaft housing can also be unscrewed from the guide vane base. The aluminum guide vane base is attached to the polyurethane guide vane assembly with four 1/4 -20 allen head bolts that may be removed using the provided wrench and a 7/16 (11mm) wrench.

Replace bearings as soon as you notice any looseness and check the air gap thickness for any change. If they are too loose, severe damage to both the rotor and the stator can result. This machine uses three 6203 ball bearings with rubber seals, in the generator, and has a water lubricated bearing located in the guide vane base. These are a slip fit into the alternator housing and the guide vane base.

---

www.microhydropower.com

MANUAL 2

The LH 1000 Low Head Propeller Turbine Personal Hydropower Owner's Manual

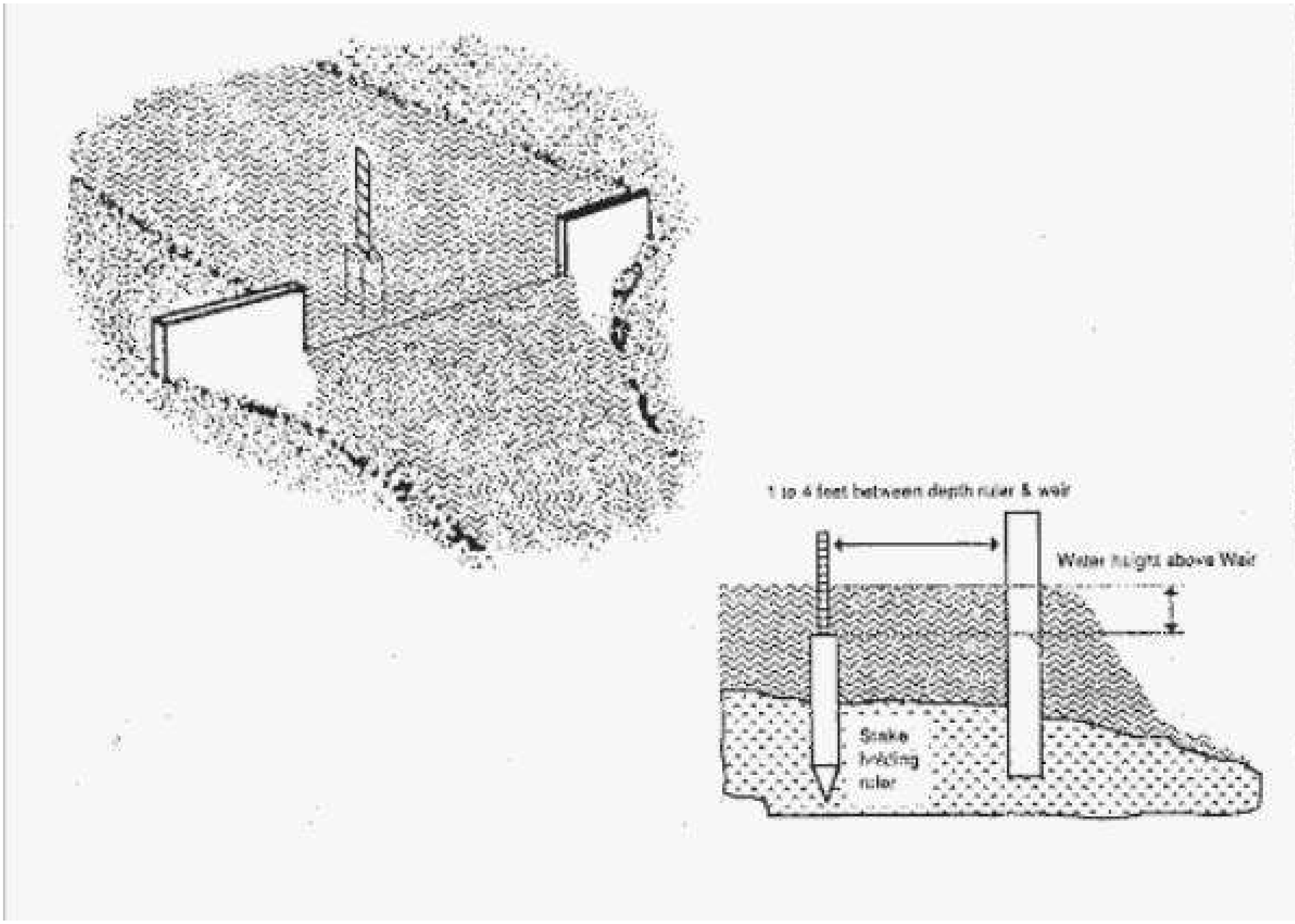
WIRING DIAGRAMS

These diagrams represent the four possible combinations of output wiring. They are in order of potential. If you find your air gap adjustment to be at a minimum and wish to try for more power, then try using the next higher combination. If you find the air gap is very large, try the next lower one. Note that there is only a small change in potential between #2 to #3.

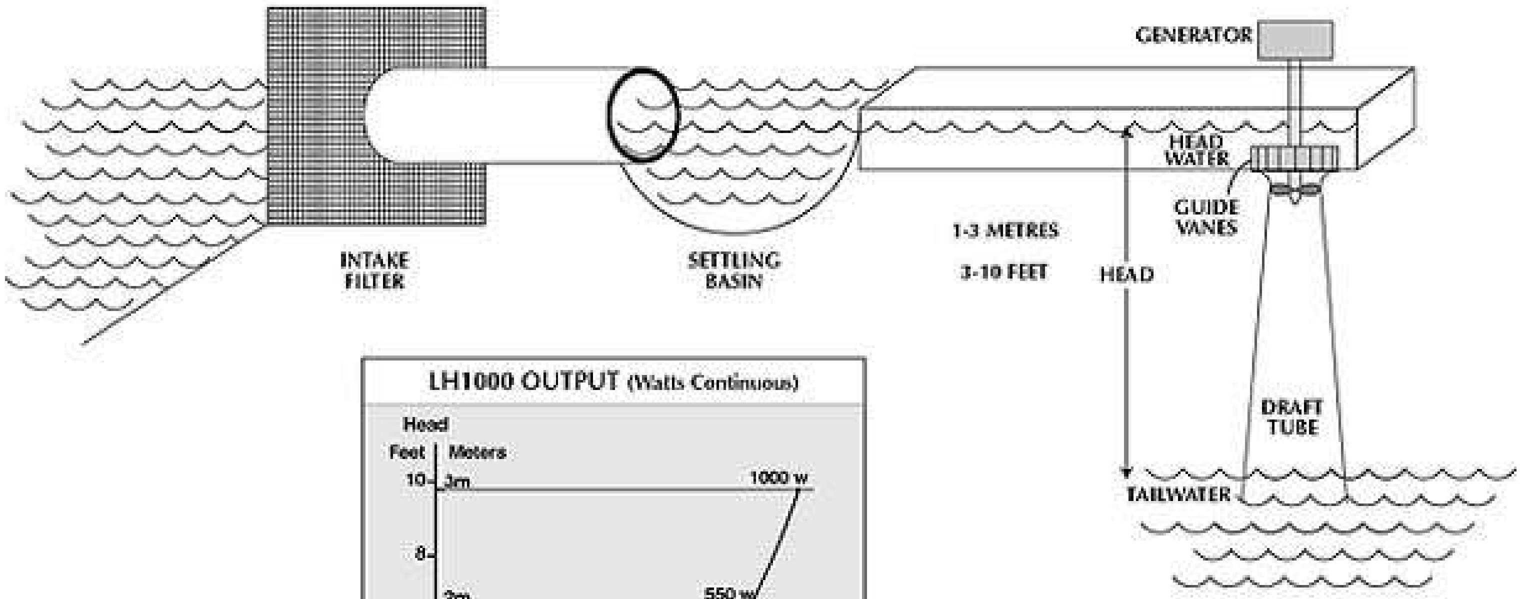
CURRENT MEASUREMENT TECHNIQUE

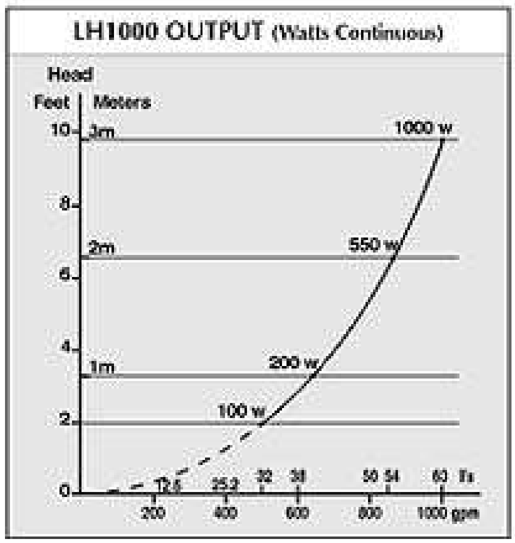
A built-in shunt (precision resistance) is installed in the junction box, which allows the current to be measured digitally. This is done with the supplied DMM (digital multi meter). To measure the current produced by the generator, set the DMM scale to "DC milli-volts" or "200 m" at the nine o'clock position. Plug the leads into their corresponding color-coded jacks on the shunt in the junction box. This will give current readings from 0.1 amps to 199.9 amps. Of course, the DMM can be used for other tasks with your renewable energy system.

www.microhydropower.com


1 to 4 feet between depth ruler & weir
Water height above Weir
Stake
holding
ruler

LH1000 INSTALLATION





The LH1000

Low Head Propeller Turbine

Personal Hydropower

Owner's Manual

PLEASE READ CAREFULLY

Made in Canada
by

Energy Systems and Design Ltd.

P.O. Box 4557

Sussex, NB
Canada E4E 5L7

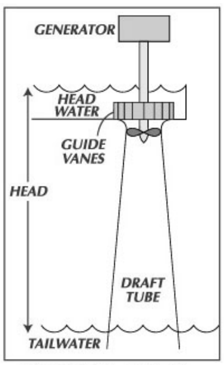
Tel: (506) 433-3151
Fax: (506) 433-6151
Email: support@microhydropower.com
Website: www.microhydropower.com

INTRODUCTION

This manual describes the **LH 1000**, which is manufactured by **Energy Systems & Design LTD**. The installer must have some knowledge of plumbing and electrical systems, as should the end-user of the system.

These machines are small, but can generate very high voltages. Even 12-volt machines can produce high voltages under certain conditions. Practice all due safety. Electricity cannot be seen and it can be lethal.

Electricity is produced from the potential energy in water moving from a high point to a lower one. This distance is called "head" and is measured in units of distance: meters (or feet) or in units of pressure: kilograms per square centimeter). "Flow" is measured in units of volume: gallons per minute – GPM (or liters per second - l/s), and is the second portion of the power equation: power [watts] = head x flow.



LH1000 Installation

The **LH1000** is designed to operate over a fixed range of heads and flows, from 0.6-3m (two to ten feet), employing a cast polyurethane propeller and guide vane assembly. The **LH1000** uses a permanent magnet type alternator. This design eliminates the need for brushes and the maintenance that accompanies them, while increasing efficiency. The **LH1000**'s output can be optimized by simply adjusting the rotor’s clearance from the stator.

SITE EVALUATION

Certain information must be determined concerning your site, in order to use its potential for maximum output. Head and flow must first be determined. The other factors are plumbing specifications, transmission distance, and the system voltage. These factors determine how much power can be expected.

Power is generated at a constant rate by the **LH1000** and stored in batteries as direct current (DC). Power is supplied, as needed, by the batteries, which store energy during periods of low consumption for use in periods where consumption exceeds the generation rate. Appliances can be used that operate directly from batteries, or alternating current (AC) power (at regular domestic specifications) can be supplied through an inverter, converting DC to AC power.

Sites may vary, so carefully consider flow and head when choosing yours.

HEAD MEASUREMENT

Head may be measured using various techniques. A garden hose or length of pipe can be submerged with one end upstream and the other end downstream. Anchor the upstream end with rocks or have an assistant hold it; water should flow out the low end, especially if the pipeline is pre-filled. Once water is flowing, raise the downstream end until it stops. Do this slowly since the water tends to oscillate. When the flow has stabilized, measure the distance down to the level of water in the stream with a tape measure. This will give a very accurate measurement of that stream section. Mark the spot and then repeat the procedure until the entire distance is covered.

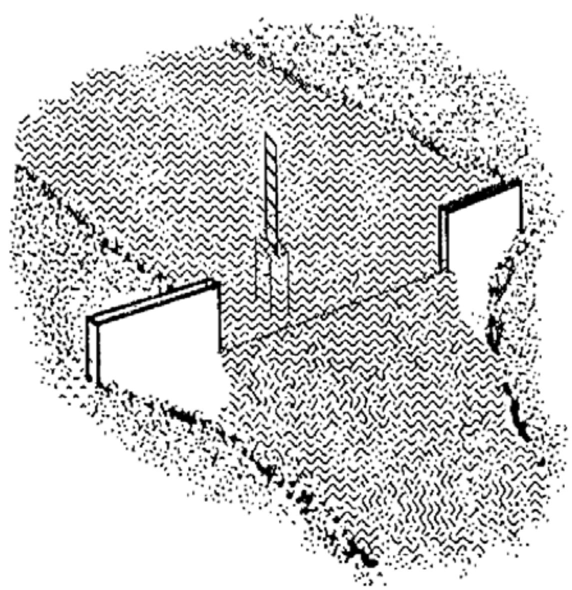
Another technique is to use a surveyor's transit. This method can also be approximated using a carpenter's level using a measuring stick or a "story pole." This technique is also done in a series of steps to arrive at the overall head. Note that with this reaction type machine, the entire head is used. No head is lost as with an impulse machine.

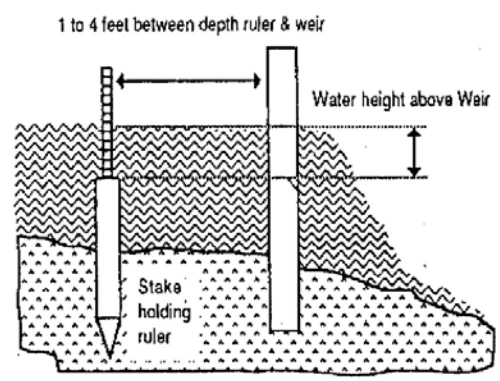
FLOW MEASUREMENT

The weir method can be used for the higher flows used with this machine. This technique uses a rectangular opening cut in a board or piece of sheet metal set into the brook like a dam. The water is channeled into the weir and the depth is measured from the top of a stake that is level with the edge of the weir and several feet upstream.

Measuring the flow at different times of the year helps you estimate maximum and minimum usable flows. If the water source is seasonally limited, you may have to depend on some other source of power during dry times (solar, wind). Keep in mind that a reasonable amount of water must be left in the stream (Don't take it all, that water supports life forms).

When head and flow are determined, the expected power output can be determined from the following chart. Keep in mind that chart values represent generated output and that actual power delivered to the batteries will be reduced by transmission lines, power converters, and other equipment required by the system. All systems should be carefully planned to maximize power output.





WEIR MEASUREMENT TABLE Table shows water flow in gallons/minute (gpm) that will flow over a weir one inch wide and from 1/8 to 10-7/8 inches deep.							
Inches		1/8”	¼”	3/8”	½”	5/8”	¾”	7/8”
0	0.0	0.1	0.4	0.7	1.0	1.4	1.9	2.4
1	3.0	3.5	4.1	4.8	5.5	6.1	6.9	7.6
2	8.5	9.2	10.1	10.9	11.8	12.7	13.6	14.6
3	15.5	16.5	17.5	18.6	19.5	20.6	21.7	22.8
4	23.9	25.1	26.2	27.4	28.5	29.7	31.0	32.2
5	33.4	34.7	36.0	37.3	38.5	39.9	41.2	42.6
6	43.9	45.3	46.8	48.2	49.5	51.0	52.4	53.9
7	55.4	56.8	58.3	59.9	61.4	63.0	64.6	66.0
8	67.7	69.3	70.8	72.5	74.1	75.8	77.4	79.1
9	80.8	82.4	84.2	85.9	87.6	89.3	91.0	92.8
10	94.5	96.3	98.1	99.9	101.7	103.6	105.4	107.3
Example of how to use weir table: Suppose depth of water above stake is 9 3/8 inches. Find 9 in the left-hand column and 3/8 in the top column. The value where they intersect is 85.9 gpm. That's only for a 1-inch weir, however. You multiply this value by the width of your weir in inches to obtain water flow.								

INTAKE, PIPELINE, AND TAILRACE

All hydro systems require a waterway. Even systems operating directly from a dam require at least a short plumbing run. It is important to use the correct type and size of plumbing to minimize restrictions in the flow. When possible, pipelines should be buried; this stabilizes the line and prevents animals from chewing it.

At the inlet of the plumbing, a filter should be installed. A screened box can be used with the pipe entering one side, or add a section of pipe drilled full of holes wrapped with screen or small holes and used without screen. A mesh size of about 20mm (3/4”) and smaller can be used as debris of this size and will pass through the machine. However, it is important to keep sticks out of the intake as they may become jammed in the machine. This may require a smaller mesh size.

A settling basin should be used with this machine. This is a pool of low velocity water that enables the grit to settle so that it will not enter the machine and wear the edge of the propeller and the guide vane housing.

See LH1000 installation illustration at back of manual

The turbine can be mounted in the waterway, through a 17-cm (7”) hole, with the draft tube extending to the tail waters below. Small tabs with screws are adequate to retain the machine. The draft tube is connected to the machine using rubber sleeves and hose clamps. These are standard plumbing items. PVC pipe of 150mm (6") diameter with a 4mm (0.160”) wall thickness is used between the guide vane assembly and the draft tube. Install the rubber sleeve at the lower end of the guide vane tube so as to create a smooth transition from one to the other. It is recommended to have the LH1000 in a small enclosure or under some cover to keep it dry and provide a place for auxiliary equipment. Mounting the machine in concrete is also possible (you may wish to try a temporary wood mounting first).

PIPE FRICTION LOSS - PVC Class 160 PSI Plastic Pipe

Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM	Pipe Diameter, Inches										
	1	1.25	1.5	2	2.5	3	4	5	6	8	10
1	0.05	0.02									
2	0.14	0.05	0.02								
3	0.32	0.09	0.04								
4	0.53	0.16	0.09	0.02							
5	0.80	0.25	0.12	0.04							
6	1.13	0.35	0.18	0.07	0.02						
7	1.52	0.46	0.23	0.08	0.02						
8	1.93	0.58	0.30	0.10	0.04						
9	2.42	0.71	0.37	0.12	0.05						
10	2.92	0.87	0.46	0.16	0.07	0.02					
11	3.50	1.04	0.53	0.18	0.07	0.02					
12	4.09	1.22	0.64	0.20	0.09	0.02					
14	5.45	1.63	0.85	0.28	0.12	0.04					
16	7.00	2.09	1.08	0.37	0.14	0.04					
18	8.69	2.60	1.33	0.46	0.18	0.07					
20	10.6	3.15	1.63	0.55	0.21	0.09	0.02				
22	12.6	3.77	1.96	0.67	0.25	0.09	0.02				
24	14.8	4.42	2.32	0.78	0.30	0.12	0.04				
26	17.2	5.13	2.65	0.90	0.35	0.14	0.05				
28	19.7	5.89	3.04	1.04	0.41	0.16	0.05				
30	22.4	6.70	3.45	1.17	0.43	0.18	0.05				
35		8.90	4.64	1.56	0.62	0.23	0.07				
40		11.4	5.89	1.98	0.78	0.30	0.09	0.02			
45		14.2	7.34	2.48	0.97	0.37	0.12	0.04			
50		17.2	8.92	3.01	1.20	0.46	0.14	0.04			
55		20.5	10.6	3.59	1.43	0.55	0.16	0.05			
60		24.1	12.5	4.21	1.66	0.64	0.18	0.07	0.02		
70			16.6	5.61	2.21	0.85	0.25	0.09	0.03		
80			21.3	7.18	2.83	1.08	0.32	0.12	0.04		
90				8.92	3.52	1.36	0.39	0.14	0.07		
100				10.9	4.28	1.66	0.48	0.18	0.07	0.02	
150				23.2	9.06	3.50	1.04	0.37	0.16	0.05	
200					15.5	5.96	1.75	0.62	0.28	0.07	0.02
250					23.4	9.05	2.65	0.94	0.42	0.12	0.05
300						12.6	3.73	1.34	0.58	0.16	0.05
350						16.8	4.95	1.78	0.76	0.21	0.07
400						21.5	6.33	2.25	0.97	0.28	0.10
450							7.87	2.81	1.20	0.32	0.12
500							9.55	3.41	1.45	0.42	0.14
550							11.4	4.07	1.75	0.48	0.16
600							13.4	4.78	2.05	0.58	0.18
650							15.5	5.54	2.37	0.67	0.23
700							17.8	6.37	2.71	0.76	0.25
750							20.3	7.22	3.10	0.86	0.30
800								8.14	3.50	0.97	0.32
850								9.11	3.89	1.08	0.37
900								10.1	4.32	1.20	0.42
950								10.8	4.79	1.34	0.46
1000								12.3	5.27	1.45	0.51

BATTERIES, INVERTERS & CONTROLLERS

System Voltage

A small system with a short transmission distance is usually designed to operate at 12 volts. Larger systems can also be 12 volts, but if higher power is desired or the transmission distance is long, then a system of 24 volts or higher may be preferable. This is especially true if all loads are inverter-powered. In a 12-volt system, operating at a low power level, it may be advantageous to operate all loads directly from batteries. Many 12-volt appliances and small inverters are available. In 24-volt systems, it may also be preferable to operate the loads directly (although not as many appliances are available).

In higher power systems, it is usually better to use an inverter to convert battery voltage to regular domestic AC power. This has been made feasible with the advent of reliable high power inverters. Thousands of home power systems are in operation with only AC loads.

Sizing Battery Capacity

A typical hydro system should have about two days of battery storage capacity. This will generally keep lead-acid cells operating in the upper end of their charge range where they are the most efficient and long-lived. Alkaline batteries like the nickel-iron and the nickel-cadmium types can have a lower capacity since they can be more fully discharged without harm.

Batteries should be located outside of living space, or adequate ventilation should be provided, as a rising charge level tends to produce both hydrogen gas and corrosive fumes. Also, distilled water should be added as needed to maintain the electrolyte level.

Charge Control

A hydro system requires that a load be present so that the power has somewhere to go. Otherwise, system voltage can rise to very high levels. This situation provides an opportunity to do something with the excess power (i.e., a diversion load used for water heating).

As the batteries become fully charged, their voltage rises. At some point, the charging process should stop and the power be diverted to the dump load. The voltage set point should be about 13.5 to 14.5vdc for a 12-volt system depending on the charge rate. The higher the charge rate, the higher the voltage can go. If batteries are often in a high state of charge, the voltage limit should be on the low end of the range.

A voltmeter or a watt-hour meter can be used to monitor battery charge level. Battery voltage is roughly a function of the charge level, and varies according to the load level and charge rate. There are many commercially available monitors that conveniently display these features to the user, including the state of charge.

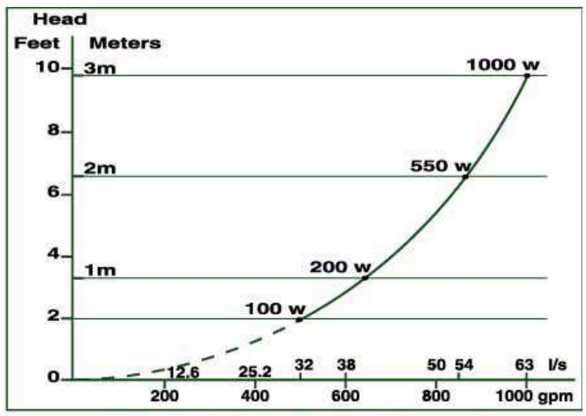
WIRING AND LOAD CENTER

Every system requires some wiring to connect the various components. Load centers are available as a complete package that easily facilitates the connection of loads and power source(s). All circuits in the system should use wire of adequate size and have fuses or breakers of sufficient capacity to carry the expected load current. Even the LH1000 must be fused since it can suffer from a short or similar fault just like anything else in the system.

Inside the “junction box”, are two terminal lugs for the battery cable leads. The negative terminal lug is bolted to the box and the positive terminal lug is bolted to the clear plastic terminal block. Transmission wire ends are inserted into these two connectors (after being stripped of insulation) and then tightened.

The precision shunt installed in the junction box will give a readout of the hydro output in amperes if the digital multimeter is plugged into the jacks (color coded in the shunt body), and turned to 200m (the 9 o’clock position). A voltmeter connected to the batteries will roughly indicate the charge level, as described in “Charge Level” above, and an ammeter will indicate the output of the machine.

LH POWER OUTPUT



LH1000 Output (Watts Continuous)

DESIGN EXAMPLE

This example shows how to proceed with a complete installation. The parameters of the example site are:

-6 feet (2m) of head over a distance of 50 feet (15m)
-a flow of at least1000 GPM (63l/s)
-100 feet distance from the house to the hydro machine
-12 volt system

The first thing to do is determine the pipe size. Given that there is friction between water and the pipe in which it flows, this friction can be reduced by increasing the size of the pipe to minimize the friction to acceptable limits. Therefore, pipe size must be optimized based on economics and performance.

The pipe flow charts show us that eight-inch (approx. 20cm) diameter PVC pipe has a head loss of 0.97 feet of head per 100 feet (30m) of pipe at a flow rate of 800 GPM (50 l/s). This is about 0.5 feet (15cm) of loss for 50 feet (15m) of pipe.
PVC comes in short lengths and is glued together or purchased with gaskets.

The maximum output occurs with a flow of about 800 GPM (50 l/s). Note that with this machine, the flow is determined by the head, as there are no nozzles that can be adjusted that would change the flow.

1 foot loss/100 feet pipe = x feet loss/50 feet pipe
x = 0.5 feet (15cm) of head loss

Next, we subtract the head losses from the measured head (often referred to as static, or gross head. Abbreviated: Hg) in order to determine the actual, operating head (often referred to as dynamic, or net head. Abbreviated Hn):

6 feet head (Hg)-0.5 feet head losses = 5.5 feet (1.85m) actual head (Hn)

It is now known that the **LH 1000** will be operating at an actual, or dynamic, head of 5.5 feet (1.85m) Hn. By referring back to the output chart, it can be determined that the LH1000 can, realistically, be expected to produce approximately 400w.

COPPER WIRE RESISTANCE

Wire Gauge	Diameter Inches	Ohms per 1000'	Ohms per Mile
0000	0.460	0.05	0.26
000	0.410	0.06	0.33
00	0.364	0.08	0.42
0	0.324	0.10	0.52
2	0.258	0.16	0.84
4	0.204	0.25	1.34
6	0.162	0.40	2.13
8	0.128	0.64	3.38
10	0.102	1.02	5.38
12	0.081	1.62	8.56
14	0.064	2.58	13.6
16	0.051	4.10	21.6
18	0.040	6.52	34.4

Since we require 12 volts and the transmission distance is short, we can generate and transmit 12 volts using the **LH1000**. This **LH1000** could also be used for higher voltages like 24 and 48, and power could be transmitted longer distances. We need to go 100'(30m) with 400 watts at our site. The amperage can be determined using the formula: volts x amperage = watts. So, a 12v system usually operates at an actual voltage of about 15v, therefore: 400/15 = 26.7 amps. The machine will need to be wired parallel delta for this site.

This will be about 26.7 amps at 15 volts at the generator. Note that there will be some voltage drop in the line and 12-volt batteries require somewhat higher voltages than nominal to become charged. So the 26.7 amps must pass through 200'(60m) of wire for the distance to the batteries and back which completes the circuit. As there is friction between water and the pipe that carries it, causing losses, so there is resistance between electricity and the conductor that carries it, and is measured in units called ohms. Resistance losses should be kept as low as economics permit, just like the pipeline losses. Let's assume that a 5% loss is acceptable at this site, resulting in the loss of 25 watts.

The formula to calculate resistance losses is I (amps) x I (amps) x R (resistance) = w (watts). We put our known figures into the formula to learn the resistance that we require in a copper conductor to achieve this.

$$26.7 \times 26.7 \times R = 25w$$
$$711 \times R = 25w$$
$$R = 0.04 \text{ ohms}$$

It has been calculated that a copper conductor with losses of 0.04 ohms over a total distance of 200 feet (60m) will result in an acceptable 5% loss. The Wire Loss Chart shows losses per 1000' (300m) of wire, so:

1000'/200' x 0.04 ohms = 0.2 ohms per 1000'.

The chart shows 2 ga. wire has a resistance of 0.16 ohms per 1000', so:

200'/1000' x 0.16 ohms = 0.032 ohms.

This is close enough to the desired level, that with a little more investigation we can determine whether this will result in acceptable power losses:

26.7 amps x 26.7 amps x 0.032 ohms = 22.8watts of loss.

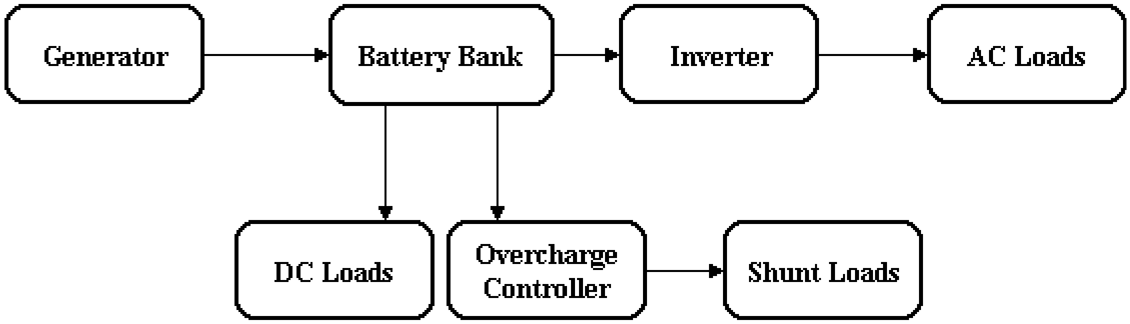
Increasing the wire size can further reduce the losses, but can also increase costs, as larger wire is usually more expensive. Resistance in a length of wire results in power loss that is seen as a voltage drop from one point in the line to another. For example, if your voltage, as measured at the generator, is 15vdc, then it could be assumed that if the voltage were measured along the line to the batteries, it would be lower as you got further from the generator: Voltage drop= I (amps) x R (ohms resistance in your circuit). So:

Voltage drop (v) = 26.7 amps x 0.032 ohms = 0.85 volts

Hence, if your generator voltage is 15vdc, your battery voltage will be 14.15vdc. Keep in mind that it is always the batteries that determine the system voltage, as they are the stabilizing force in your system. All voltages in the system will rise and fall corresponding to the battery voltage, or the battery's state of charge. At the site, we would be generating 26.7 amps continuously. Typically, a battery bank is sized to have two days storage capacity. If we choose lead acid batteries and wish to have two days of storage capacity, then we use the formula: amps x hours x days = amp/hrs capacity. So:

33 amps x 24 hrs x 2 days = 1584 amp. Hrs. Capacity

The Trojan L-16 has a rating of 6vdc and 350 amp/hr. Using these you would require at least eight batteries; there would be four strings paralleled, with each string consisting of two batteries in series to give the 12vdc system voltage we have chosen. This would give 1400 amp/hrs at 12vdc capacity, which is about two days storage. An inverter and charge controller are usually used in the system. The diagram for such a system would look like this:



OUTPUT ADJUSTMENT

For the machine to produce the highest output, the rotor height should be adjusted, so as to match the magnetic power of the rotor to the power of the waterway at the site. Since each site varies from the next, it is important to adjust the rotor for maximum output at your site. This involves raising and lowering the rotor to change or adjust the magnetic flux level until the optimum level is found.

After the machine is installed, perform a trial operation to establish a power output level. This can be determined using a digital multimeter, plugged into the output jacks in the precision shunt found in the junction box. It is recommended to keep a logbook to note any output changes in relation to settings, and to monitor long-term performance. After everything is installed, start the **LH1000** by opening the water source. Operate it long enough for the output level to stabilize and note the current (or voltage). Then shut off the water.

The **LH1000** comes with the rotor (the chrome plate) set very close to the stator (the stationary, black body of the generator). To increase this distance, and reduce the magnetic flux level, you first must, while holding the rotor stationary with the 1/4-inch rotor pin placed in the hole in the rotor's edge, loosen the smaller (7/16" head) bolt. Next, hold the rotor stationary with the pin, and tighten the larger bolt, which will force the rotor up. Each full turn of the bolt will move the rotor vertically 0.050" or 1.25 mm. If raising the rotor causes the current (or you may be monitoring the voltage in a high voltage site) to increase, then continue to do so until there is no longer an increase. If a point is reached where a decrease occurs, then the rotor should be lowered. This is done by loosening the larger bolt and then tightening the smaller one. Turning the smaller bolt causes the rotor to move vertically the same distance per turn as the larger bolt does. When you have found the best position (no increase in current or voltage), make sure the larger bolt is turned until it is tight. Now the smaller bolt should be tightened securely to lock everything in place. No further adjustments should be required unless site conditions change.

When adjusting the rotor downward, it may contact the stator. If this occurs, always adjust it upwards by at least a 1/4 turn of the larger bolt. Operating the machine with the rotor any closer than this will not result in any power increase but may damage the machine.
** Always turn the rotor by hand before starting the machine to check for rubbing and make sure you can always fit a business card in the space between the rotor and stator**. Remove the pin from the rotor edge before starting the machine.

DISASSEMBLY & SERVICE

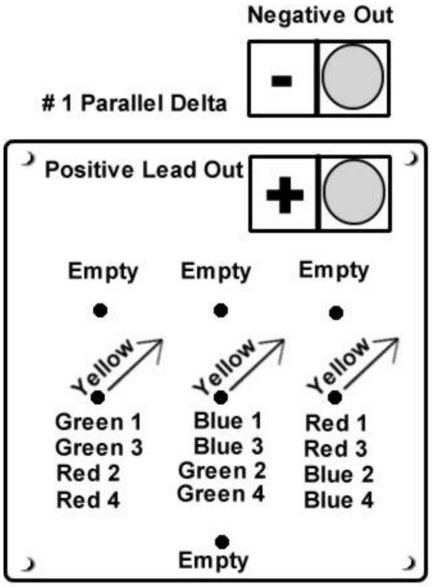
In order to remove the generator you must first remove the wiring from the terminals on the clear, plastic terminal block in the junction box. Be sure to note their position for later re-installation. An alternative is to remove the junction box from the alternator base by removing the two bolts on the bracket. Then, undo the four allen head bolts that attach the generator to the finned, aluminum base, using the allen wrench supplied with the LH1000. The four bolts are located under the generator base, and thread upward into the generator. Next, unscrew the polyurethane nose cone from the base of the unit, located inside the guide vane assembly, at the end of the shaft in a counter-clockwise or right hand direction. Proceed to remove the propeller by removing the ¾ inch (19mm) brass nut, then the washer, and finally, slide the propeller from the shaft. Now, the generator and shaft assembly may be pulled up, and out of the generator base and shaft housing. The shaft may now be unscrewed so as to remove the long turbine shaft from the generator shaft.

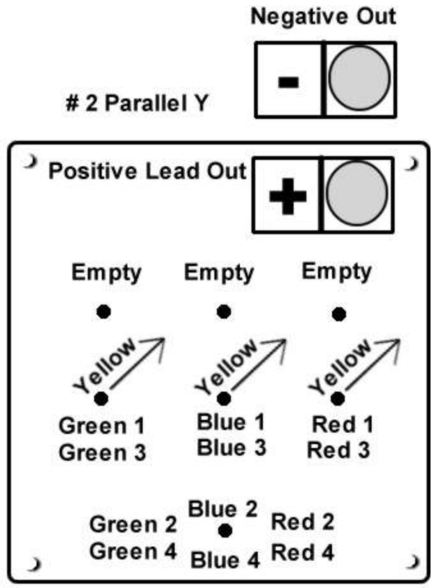
The finned alternator base can be removed from the shaft housing by unscrewing it. The shaft housing can also be unscrewed from the guide vane base. The aluminum guide vane base is attached to the polyurethane guide vane assembly with four 1/4 –20 allen head bolts that may be removed using the provided wrench and a 7/16 (11mm) wrench.

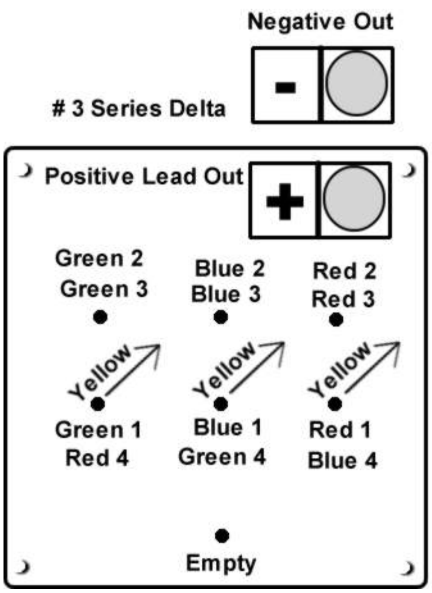
Replace bearings as soon as you notice any looseness and check the air gap thickness for any change. If they are too loose, severe damage to both the rotor and the stator can result. This machine uses three 6203 ball bearings with rubber seals, in the generator, and has a water lubricated bearing located in the guide vane base. These are a slip fit into the alternator housing and the guide vane base. .

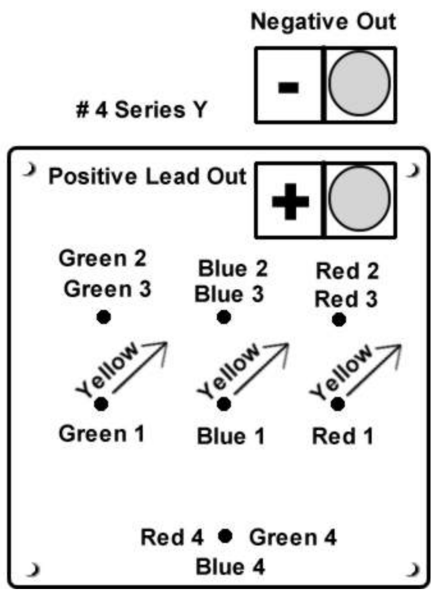
WIRING DIAGRAMS

These diagrams represent the four possible combinations of output wiring. They are in order of potential. If you find your air gap adjustment to be at a minimum and wish to try for more power, then try using the next higher combination. If you find the air gap is very large, try the next lower one. Note that there is only a small change in potential between #2 to #3.





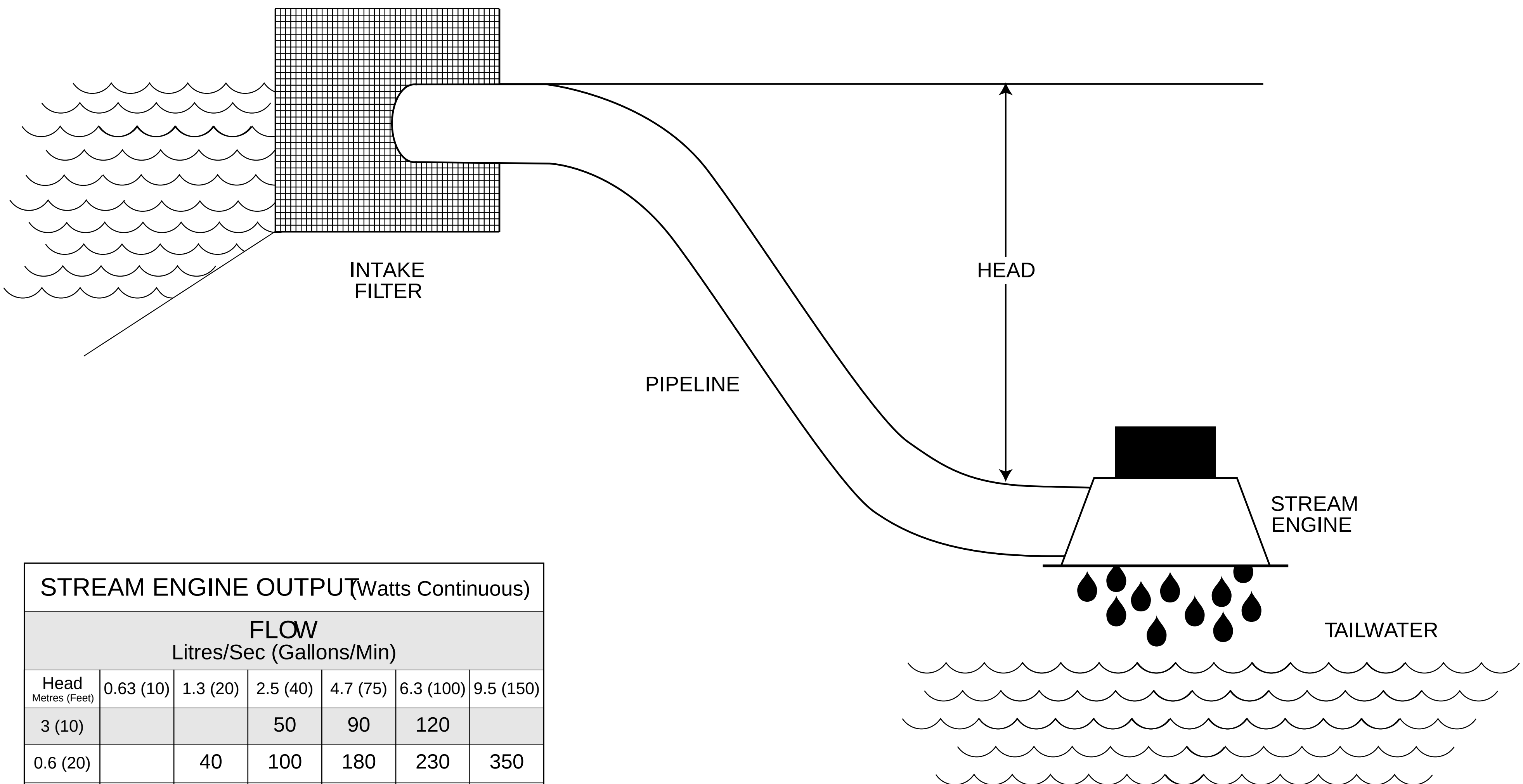




CURRENT MEASUREMENT TECHNIQUE

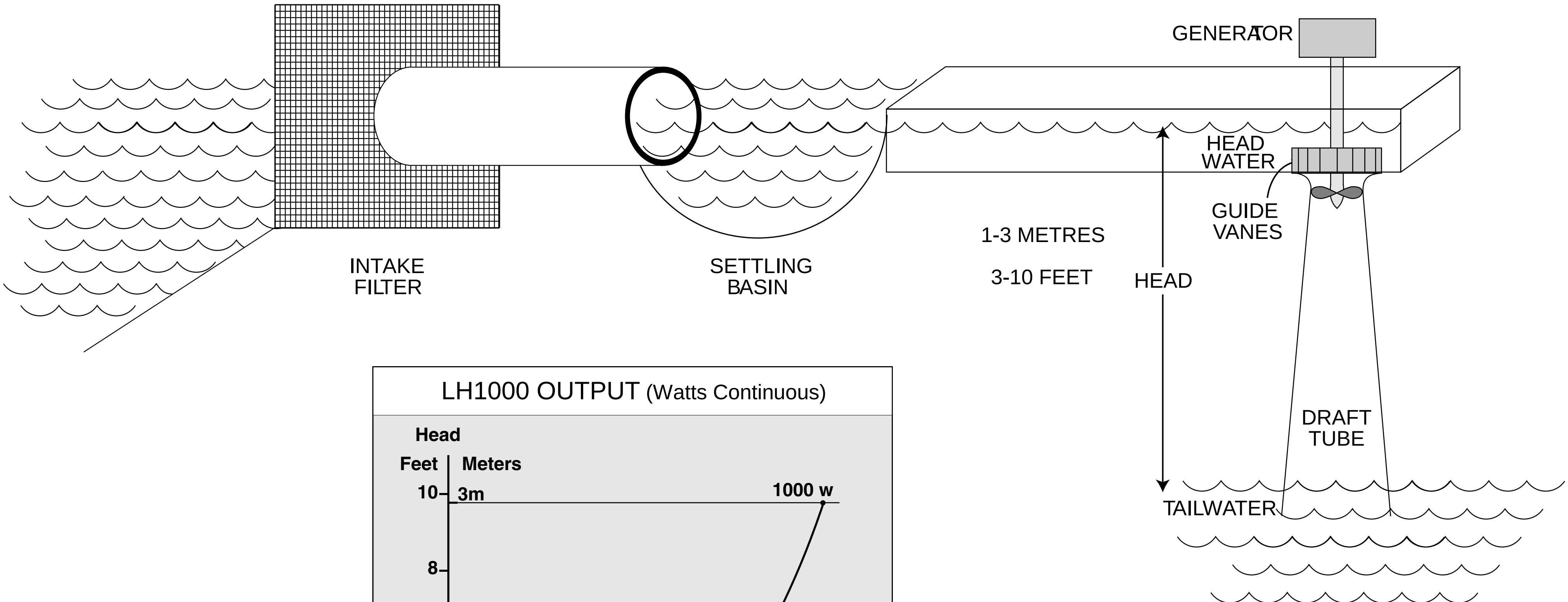
A built-in shunt (precision resistance) is installed in the junction box, which allows the current to be measured digitally. This is done with the supplied DMM (digital multi meter). To measure the current produced by the generator, set the DMM scale to "DC milli-volts" or "200 m" at the nine o'clock position. Plug the leads into their corresponding color-coded jacks on the shunt in the junction box. This will give current readings from 0.1 amps to 199.9 amps. Of course, the DMM can be used for other tasks with your renewable energy system.

STREAM ENGINE INSTALLATION

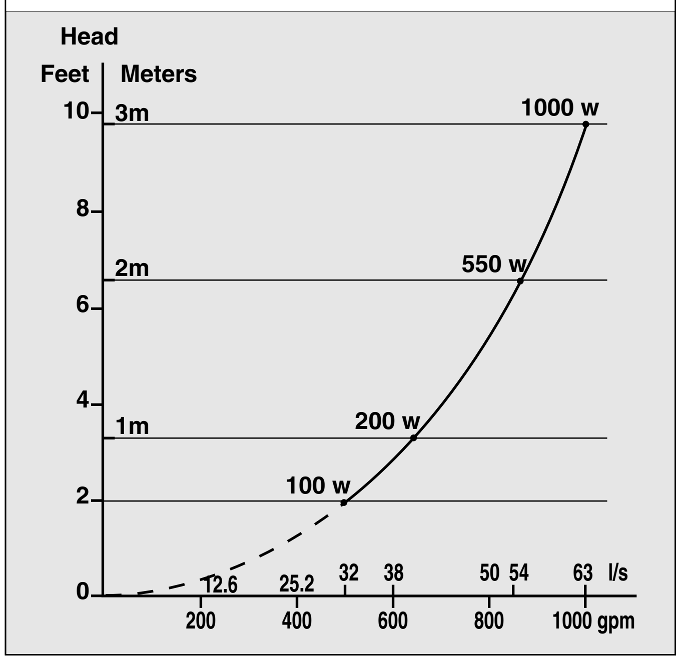


STREAM ENGINE OUTPUT (Watts Continuous)						
	FLOW Litres/Sec (Gallons/Min)					
Head Metres (Feet)	0.63 (10)	1.3 (20)	2.5 (40)	4.7 (75)	6.3 (100)	9.5 (150)
3 (10)			50	90	120	
0.6 (20)		40	100	180	230	350
15 (50)	45	100	220	400	550	800
30 (100)	80	200	500	940	1100	
60 (200)	150	400	900	1500		

LH1000 INSTALLATION

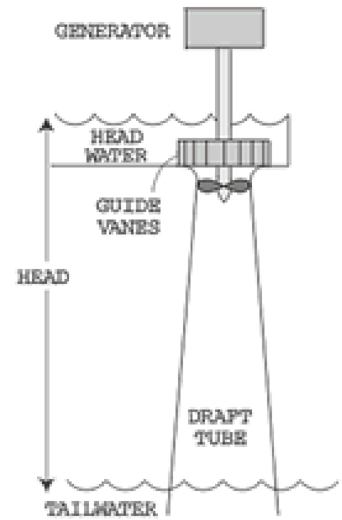


LH1000 OUTPUT (Watts Continuous)



LH1000 - The Low Head Micro-hydro Generator

The *LH1000* is designed to operate in conjunction with battery-based power systems, storing electrical power for use at times when consumption exceeds generation. A load controller maintains batteries, and when fully charged, switches to a diversion load. AC loads require an inverter to convert battery voltage (DC) to residential power (AC).

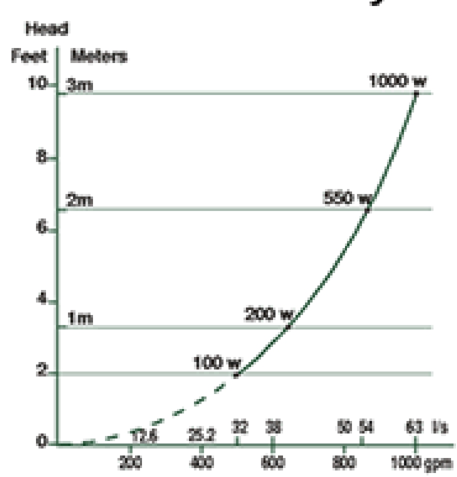


LH 1000 installation

To gain enough head to operate the LH1000, water is channeled into a sluiceway. The turbine is mounted in a 18cm (7") diameter opening in the sluice bottom, with the draft tube extending to the tailwater below. The water turns the propeller, creating shaft power. This, in turn, powers the generator, producing electricity.

The LH1000 typically operates at 12, 24, 48, or 120 volts. It can be specially wound to operate at 240 volts when necessary. Employing an adjustable, pemanent magnet generator and reconnectable wiring, the LH1000 is ideally suited for a wide range of sites.

- Axial Flow Propeller Turbine
- Adjustable Output Permanent Magnet Alternator, with Epoxy Encapuslated Stator
- Non-Corrosive Precision-Made Parts
- Operates on heads of 2-10'
- Explanatory manual and multi-meter incl.
- Straightforward Installation
- 1 Year Warranty



Enery Systems & Design Ltd.
PO Box 4557
Sussex, New Brunswick
Canada E4E 5L7
Tel• + (506) 433-3151
Fax• + (506) 433-6151
hydropow@microhydropower.com
www.microhydropower.com

Energy Systems & Design Ltd. (ES&D)

"Innovative Renewable Energy Systems Since 1980"

Postal Address:
P.O. Box 4557
Sussex, NB.
E4E 5L7 CANADA

Physical Address:
12949 Rte. 114
Penobsquis, NB.
E4G2 X3 CANADA

Email, Internet, Tel/Fax Particulars:
hydropow@nbnet.nb.ca
www.microhydropower.com
T: +1 506 433-3151; / F: +1 506 433-6151

Dealer Information Form

Company Name (legal):____

Limited   Partnership   Sole Proprietor   Date of Incorporation:______________

Are you a manufacturer? ____ If so, what? _________________________________

GST#:______________________   HST#: _______________________

PST#:______________________

Are purchase orders required?   Yes   No

Purchaser Contact: ____

Phone/Email: ____

Accounts Payable Contact: ____

Phone/Email: ____

Receiver Contact: ____

Phone/Email: ____

Billing Address:

Street Address: ____

City: ____________________ Province: __________ Postal Code: ___________

Telephone: ______________ Fax: ______________

Shipping Address (if different from billing address):

Street Address: ____

City: ____________________ Province: __________ Postal Code: ___________

Telephone: ______________ Fax: ______________

Shipping Method (please mark preference)

ES&D Standard Service_______   Your own shipping account_________

Supply shipping account information below

Your Signature: ______________________________ Date: ______________

Name (print): _________________________ Title: ____________________

This is not a credit application. All international orders require pre-payment

"Innovative Micro-Hydro Systems Since 1980"

Articles

Review of the Stream Engine


Running Stream Engine

- Atkinson, Barbara & Paul Cunningham. "Micro Hydro Power in the Nineties". Home Power #44, December 1994 / January 1995. p.24-29.
- Cunningham, Paul. "Hydro Siting". Home Power #8, December 1988 / January 1989. p.17-19.
- "Hydro Systems Using LCBs". Home Power #17, June / July 1990. p.39-40.
- "Induction Generation: an exciting possibility". Home Power #3, February 1988. p.17-19.
- "Long-Distance Power Transmission for Renewable Energy Systems". Renewable Energy World, September 1998. p.72-73.
- "Micro Hydro-Electric Evolution". Renewable Energy World, July 1998. p.60.
- "Small Water Power Siting". Home Power #1, November 1987. p.7-10.
- Cunningham, Paul & Robert G. Fife. "AC/DC: Micro-Hydroelectric Options". Renewable Energy World, November 1998. p.73-75.
- Fife, Robert. "Micro-hydroelectric Installations: A beginner's perspective", Renewable Energy World, March 1999. p.70-73.

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Review of the Steam Engine

Appeared in
Home Power #67
October / November, 1998

Things that Work!: Tested by Home Power

Energy Systems & Design's Stream Engine

Bob-O Schultze KG6MM

Microhydro is the most reliable and cost effective small-scale renewable energy source for charging batteries. It has drawbacks, however-- microhydro is the least charismatic of the renewables. Cleaning the intake to the penstock, especially during fall leaf drop and spring runoff, can be a pain in the neck. Frequent rebuilding of alternators to replace brushes and slip rings that run non-stop is a less-than-wonderful part of the microhydro experience. ES&D's new brushless, permanent magnet (PM) field alternator is a new, exciting, and welcome product for the microhydro user. It should eliminate alternator maintenance for a long time. Now, if they could just build something to clean that darn intake ....

A Quick Hydro History

Using falling water to do work has been around for a long time. How long? Since before Christ was a carpenter, before Buddha was a baby, before Mohammed knew his mom, before well, you get the picture.

Making electricity, from falling water, called hydroelectricity, has been around since the turn of the century. Since that time, there have been many improvements in both the wheels that convert the falling water to a rotary motion, called runners, and in the generators themselves. Most of the generator and runner design work was done long ago. Current manufacturers of microhydro equipment have built on what was already available, adding relatively minor improvements. Hydro system designers need to match the runner correctly to the hydro site and the alternator to the battery system voltage.

Hydro Primer

Every renewable energy site is unique, whether it's for photovoltaic, wind, or hydro. Within the scope of renewables, hydro is the most site specific. You probably can't make the hill any higher, or the water flow any more. In order to assess the site for small hydroelectric capability, there are four questions that need to be answered.

1. What is the head (vertical fall), from intake to hydro plant placement?

2. How many gallons of water per minute (gpm) will you be able to devote to hydro power? Keep in mind that water flow will vary from winter to summer.

3. What is the length, size, and type of pipe from the intake to the hydro plant?

4. What is the distance from the hydro plant site to the batteries?

The ES & D Stream Engine

The Turgo Runner

The Stream Engine is designed to operate over a very wide range of heads and water flows. The ES&D machine uses a Turgo runner to achieve this. The Turgo is a vertically shafted turbine-type runner with the nozzles pointed downward at a 20° angle from horizontal. The great advantage of this type of runner is its ability to digest a lot of water efficiently. This can give us the ability to use more water during peak winter flows. Depending on the head and number of nozzles, up to 300 gpm (1160 liters per minute) can be utilized. Quite an accomplishment for a wheel with a 4.5 inch pitch diameter!

The PM Field Alternator

The ES & D alternator uses sixteen strong magnets embedded in a top plate which is spun by the runner. The twelve stator windings are stationary. Electricity is generated by passing the spinning magnets over the stator windings. The output is determined by the right mixture of rpm, configuration of the stator windings, and the distance between the magnetic field and the stator.

The field to stator distance is adjusted by a bolt within a bolt arrangement, which lowers or raises the spinning magnets. The stator windings can be configured into parallel, series, Delta or Wye wiring. The windings terminate on three studs for easy reconfiguration. The studs are before the rectifier, so it's easy to take the output as a higher voltage three phase ac for long transmission lines.

This may be a little confusing, but either the manufacturer or your system designer will provide the machine with the right configuration for your site. The beauty of this alternator is in its high efficiency and lack of moving parts. Since no electricity is required to energize the field, every watt generated goes towards output. The three ball type #6203 bearings supporting the shaft should last for years. They should be available from all bearing distributors. The machine can be disassembled for bearing replacement in about 15 minutes on a workbench. A bearing press and properly sized mandrel are suggested for removing and replacing the bearings. Any machine shop can do this very quickly.

New Nozzles

Older Stream Engines had the nozzles threaded into the bottom of the 1 1/2 inch nozzle holders. The new nozzle incorporates both the nozzle and the nozzle holder into one molded plastic piece. The new nozzles attach to the housing with four stainless steel Allen-headed screws. An Allen wrench is provided.

The new nozzle tapers all the way down to a 2 mm orifice. To get the right orifice diameter for your site, cut the nozzle back with a hacksaw. There are graduated lines and markings on the nozzle to use as a guide. The cool thing about this arrangement is that the end user can create virtually any nozzle size from 1/8 to 1 inch (3 to 25 mm). Wring the last watt from that water source!

Documentation

The Stream Engine owner's manual is a wealth of information on hydro siting, pipe friction loss, nozzle flow charts, and overall system design. Unfortunately, there are no page numbers and no index. This makes it very hard to find specific information. Still, all of the information you need for a successful set-up is in there--somewhere.

Test Site

The Stream Engine was installed on Camp Creek in Northern California. Camp Creek is a gradually falling watercourse that can range from 20 cubic feet per second during winter runoffs to drying up in the late summer or fall. The total head is 31 feet. The penstock is about 900 feet long. From the top, the pipe consists of 6, 5, and 4 inch PVC. The 4 inch PVC branches to two 3 inch PVC full flow valves. The outlet of each valve is reduced to a 2 inch insert adaptor. Each adaptor is then connected to a 2 inch flexible rubber hose. Each hose is hooked up to a bell reducer, which decreases the diameter of 2 inches even further to 1 1/2. The two bell reducers are connected to the two nozzle holders. From there, it feeds into the hydroplant.

Warts

I'd like to see the nozzle mounting flange a little wider for easier access to the mounting screws. As it is now, almost all of the plumbing needs to come off before a nozzle can be changed.

The metal plate that covers the box containing the stator winding studs, rectifier, and output wire terminals is far from waterproof. Something with a gasket would be welcome.

As with all permanent magnet motor/generators or alternators, the maximum output is limited by the strength of the magnets. The ES&D machine uses very strong magnets but still maxes out at about 850 Watts. This is more power than most watercourses can produce. For those with greater potential, the standard electrically charged field alternator will go nearly twice as high. This is not really a wart; it's just a fact until someone invents stronger magnets.

Operation

Turn the water on. Aside from adjusting the air gap between the magnets and the stator, that's about it. Unlike a regular alternator, there is no need for a diode between the battery and the field windings. Should the alternator stop due to nozzle clogging, the output will just fall off to nothing. There is no chance of the field staying energized and actually discharging the battery.

Adjusting the air gap is a trial and error operation. It involves stopping the machine, holding the rotor with the provided pin, and loosening or tightening the bolt-within-a-bolt. This moves the rotor closer or further away from the stator. It's a case of making an adjustment, spinning the machine up, letting the water flow stabilize, and observing the ammeter. It may take a few tries, but once you find the maximum output setting, it will not vary unless you change nozzles.

Conclusions

This is a very cool machine. It represents a major breakthrough in microhydro design. The probability of going four or five years between maintenance shutdowns is a BIG advantage. Over most of its power curve, it will outperform a standard alternator by 15-30%.

During peak flows at my hydro site, I got 280 W from a Turgo driven alternator fitted with a specially wound stator for low head. With the new ES&D PM field Stream Engine, output increased to 325 W. That's a 15% increase at a less than optimum hydro site. Can I find a use for those extra watts? You betcha!

Energy Systems & Design Engine Test Data

Volts DC	Amps DC	Actual Watts	Theoretical Watts	% Efficiency	Net Head in Feet	Number of Nozzles	Nozzle Size	Gallons per Minute
28.0	11.6	324.8	560.4	58.0%	22	2	7/8"	135
28.0	7.6	212.8	358.1	59.4%	26	1	7/8"	73
28.0	2.7	75.6	141.5	53.4%	30	1	1/2"	25
26.4	3.4	89.8	141.5	63.4%	30	1	1/2"	25

Access:

Author:

Bob-O Schultze, Electron Connection,
PO Box 203, Hornbrook, CA 96044 *
Tel: 530-475-3402
Fax: 530-475-3401
Email: econnect@snowcrest.net
Web: www.electronconnection.com

Manufacturer:

Energy System & Design,
PO Box 1557, Sussex, N.B.
Canada E0E 1PO

Tel: 506-433-3151
Fax: 506-433-6151
Email: hydropow@nbnet.nb.ca

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Staff Publications

Micro Hydro Power in the Nineties

Paul Cunningham & Barbara Atkinson

Micro hydro power was once the world's prominent source of mechanical power for manufacturing.
Micro hydro is making a comeback for electricity generation in homes. Increasing numbers of small hydro systems are being installed in remote sites in North America. There's also a growing market for micro hydro electricity in developing countries. This article is a technical over-view.

Micro hydro power is gradually assuming the decentralized form it once had. Water power predates the use of electricity. At one time hydro power was employed on many sites in Europe and North America. It was primarily used to grind grain where water had a vertical drop of more than a few feet and sufficient flow. Less common, but of no less importance, was the use of hydro to provide shaft power for textile plants, sawmills and other manufacturing operations.

Over time thousands of small mills were replaced by centrally-generated electric power. Many major hydroelectric projects were developed using large dams, generating several megaWatts of power. In many areas, hydro electric power is still used on a small scale and is arguably the most cost-effective form of energy.

Renewable energy sources such as wind and solar are being scaled up from residential to electric utility size. In contrast, hydro power is being scaled down to residential size. The small machines are similar in most ways to the large ones except for their scale.

Siting

A hydro system is much more site-specific than a wind or photovoltaic (PV -- solar electric) system. A sufficient quantity of falling water must be available. The vertical distance the water falls is called head and is usually measured in feet, meters, or units of pressure. The quantity of water is called flow and is measured in gallons per minute (gpm), cubic feet per second (cfs), or liters per second (l/s). More head is usually better because the system uses less water and the equipment can be smaller. The turbine also runs at a higher speed. At very high heads, pipe pressure ratings and pipe joint integrity become problematic. Since power is the product of head and flow, more flow is required at lower head to generate the same power level. More flow is better, even if not all of it is used, since more water can remain in the stream for environmental benefits.

A simple equation estimates output power for a system with 53% efficiency, which is representative of most micro hydro systems:

Net Head* (feet) x Flow (US gpm) / 10: Output (Watts)

* Net head is the pressure available after subtracting losses from pipe friction. Most hydro systems are limited in output capacity by stream conditions. That is, they cannot be expanded indefinitely like a wind or PV system. This means that the sizing procedure may be based on site conditions rather than power needs. The size and/or type of system components may vary greatly from site to site. System capacity may be dictated by specific circumstances (e.g., water dries up in the summer). If insufficient potential is available to generate the power necessary to operate the average load, you must use appliances that are more energy efficient and/or add other forms of generation equipment to the system. Hybrid wind/PV/hydro systems are very successful and the energy sources complement each other.

The systems described here are called "run of river"; i.e. water not stored behind a dam (see HP#8). Only an impoundment of sufficient size to direct the water into the pipeline is required. Power is generated at a constant rate; if not used, it is stored in batteries or sent to a shunt load. Therefore, there is little environmental impact since minimal water is used. There is also much less regulatory complication.

System Types

If electric heating loads are excluded, 300-400 Watts of continuous output can power a typical North American house. This includes a refrigerator / freezer, washing machine, lights, entertainment and communication equipment, all of standard efficiency. With energy efficient appliances and lights and careful use management, it is possible to reduce the average demand to about 200 Watts continuous.

Power can be supplied by a micro hydro system in two ways. In a battery-based system, power is generated at a level equal to the average demand and stored in batteries. Batteries can supply power as needed at levels much higher than that generated and during times of low demand, the excess can be stored. If enough energy is available from the water, an AC-direct system can generate power as alternating current (AC). This system typically requires a much higher power level than the battery-based system.

Battery-Based Systems

Most home power systems are battery-based. They require far less water than AC systems and are usually less expensive. Because the energy is stored in batteries, the generator can be shut down for servicing without interrupting the power delivered to the loads. Since only the average load needs to be generated in this type of system, the pipeline, turbine, generator and other components can be much smaller than those in an AC system.

Very reliable inverters are available to convert DC battery power into AC output (120 volt, 60 Hz). These are used to power most or all home appliances. This makes it possible to have a system that is nearly indistinguishable from a house using utility power.

The input voltage to the batteries in a battery-based system commonly ranges from 12 to 48 Volts DC. If the transmission distance is not great then 12 Volts is often high enough. A 24 Volt system is used if the power level or transmission distance is greater. If all of the loads are inverter-powered, the battery voltage is independent of the inverter output voltage and voltages of 48 or 120 may be used to overcome long transmission distances. Although batteries and inverters can be specified for these voltages, it is common to convert the high voltage back down to 12 or 24 Volts (battery voltage) using transformers or solid state converters. Articles on this subject appeared in Home Power # 17 and #28. Wind or solar power sources can assist in power production because batteries are used. Also, DC loads (appliances or lights designed for DC) can be operated directly from the batteries. DC versions of many appliances are available, although they often cost more and are harder to find, and in some cases, quality and performance vary.

AC-Direct Systems

This is the system type used by utilities. It can also be used on a home power scale under the right conditions. In an AC system, there is no battery storage. This means that the generator must be capable of supplying the instantaneous demand, including the peak load. The most difficult load is the short-duration power surge drawn by an induction motor found in refrigerators, freezers, washing machines, some power tools and other appliances. Even though the running load of an induction motor may be only a few hundred Watts, the starting load may be 3 to 7 times this level or several kilowatts. Since other appliances may also be operating at the same time, a minimum power level of 2 to 3 kilowatts may be required for an AC system, depending on the nature of the loads.

In a typical AC system, an electronic controller keeps voltage and frequency within certain limits. The hydro's output is monitored and any unused power is transferred to a "shunt" load, such as a hot water heater. The controller acts like an automatic dimmer switch that monitors the generator output frequency cycle by cycle and diverts power to the shunt load(s) in order to maintain a constant speed or load balance on the generator. There is almost always enough excess power from this type of system to heat domestic hot water and provide some, if not all, of a home's space heating. Examples of AC-direct systems are described in Home Power #25 and #33.

System Components

An intake collects the water and a pipeline delivers it to the turbine, The turbine converts the water's energy into mechanical shaft power. The turbine drives the generator which converts shaft power into electricity. In an AC system, this power goes directly to the loads. In a battery-based system, the power is stored in batteries, which feed the loads as needed. Controllers may be required to regulate the system.

Pipeline

Most hydro systems require a pipeline to feed water to the turbine. The exception is a propeller machine with an open intake. The water should pass first through a simple filter to block debris that may clog or damage the machine. The intake should be placed off to the side of the main water flow to protect it from the direct force of the water and debris during high flows.

It is important to use a pipeline of sufficiently large diameter to minimize friction losses from the moving water. When possible, the pipeline should be buried. This stabilizes the pipe and prevents critters from chewing it. Pipelines are usually made from PVC or polyethylene although metal or concrete pipes can also be used. The article on hydro system siting in Home Power #8 describes pipe sizing.

Turbines

Although traditional waterwheels of various types have been used for centuries, they aren't usually suitable for generating electricity: They are heavy, large and turn at low speeds. They require complex gearing to reach speeds to run an electric generator. They also have icing problems in cold climates. Water turbines rotate at higher speeds, are lighter and more compact. Turbines are more appropriate for electricity generation and are usually more efficient.

There are two basic kinds of turbines: impulse and reaction.

Impulse machines use a nozzle at the end of the pipeline that converts the water under pressure into a fast moving jet. This jet is then directed at the turbine wheel (also called the runner), which is designed to convert as much of the jet's kinetic energy as possible into shaft power. Common impulse turbines are pelton, turgo and cross-flow.

In reaction turbines the energy of the water is converted from pressure to velocity within the guide vanes and the turbine wheel itself. Some lawn sprinklers are reaction turbines. They spin themselves around as a reaction to the action of the water squirting from the nozzles in the arms of the rotor. Examples of reaction turbines are propeller and Francis turbines.

Turbine Applications

In the family of impulse machines, the pelton is used for the lowest flows and highest heads. The cross-flow is used where flows are highest and heads are lowest. The turgo is used for intermediate conditions. Propeller (reaction) turbines can operate on as little as two feet of head. A turgo requires at least four feet and a pelton needs at least ten feet. These are only rough guidelines with overlap in applications.

The cross-flow (impulse) turbine is the only machine that readily lends itself to user construction. They can be made in modular widths and variable nozzles can be used.

Most developed sites now use impulse turbines. These turbines are very simple and relatively cheap. As the stream flow varies, water flow to the turbine can be easily controlled by changing nozzle sizes or by using adjustable nozzles. In contrast, most small reaction turbines cannot be adjusted to accommodate variable water flow. Those that are adjustable are very expensive because of the movable guide vanes and blades they require. If sufficient water is not available for lull operation of a reaction machine, performance suffers greatly.

An advantage of reaction machines is that they can use the full head available at a site. An impulse turbine must be mounted above the tailwater level and the effective head is measured down to the nozzle level. For the reaction turbine, the full available head is measured between the two water levels while the turbine can be mounted well above the level of the exiting water. This is possible because the "draft-tube" used with the machine recovers some of the pressure head after the water exits the turbine. This cone-shaped tube converts the velocity of the flowing water into pressure as it is decelerated by the draft tube's increasing cross section. This creates suction on the underside of the runner.

Centrifugal pumps are sometimes used as practical substitutes for reaction turbines with good results. They can have high efficiency and are readily available (both new and used) at prices much lower than actual reaction turbines. However, it may be difficult to select the correct pump because data on its performance as a turbine are usually not available or are not straightforward.

One reason more reaction turbines are not in use is the lack of available machines in small sizes. There are many potential sites with 2 to, 10 feet of head and high flow that are not served by the market. An excellent article describing very low-head propeller machines appeared in Home Power #23.

Generators

Most battery-based systems use an automotive alternator. If selected carefully, and rewound when appropriate, the alternator can achieve very good performance. A rheostat can be installed in the field circuit to maximize the output. Rewound alternators can be used even in the 100-200 Volt range.

For higher voltages (100-400 Volts), an induction motor with the appropriate capacitance for excitation can be used as a generator. This will operate in a small battery charging system as well as in larger AC direct systems of several kilowatts. An article describing induction generation appeared in HP #3.

Another type of generator used with micro hydro systems is the DC motor. Usually permanent magnet types are preferable. However, these have serious maintenance problems because the entire output passes through their carbon commutators and brushes.

Batteries

Lead-acid deep-cycle batteries are usually used in hydro systems. Deep-cycle batteries are designed to withstand repeated charge and discharge cycles typical in RE systems. In contrast, automotive (starting) batteries can tolerate only a fraction of these discharge cycles. A micro hydro system requires only one to two days storage. In contrast, PV or wind systems may require many days' storage capacity because the sun or wind may be unavailable for extended periods. Because the batteries in a hydro system rarely remain in a discharged state, they have a much longer life than those in other RE systems. Ideally, lead-acid batteries should not be discharged more than about half of their capacity. Alkaline batteries, such as nickel-iron and nickel-cadmium, can withstand complete discharge with no ill effects.

Controllers

Hydro systems with lead-acid batteries require protection from overcharge and over-discharge. Overcharge controllers redirect the power to an auxiliary or shunt load when the battery voltage reaches a certain level. This protects the generator from overspeed and overvoltage conditions. Overdischarge control involves disconnecting the load from the batteries when voltage falls below a certain level. Many inverters have this low-voltage shutoff capability.

An ammeter in the hydro output circuit measures the current. A voltmeter reading battery voltage roughly indicates the state of charge. More sophisticated instruments are available, including amp-hour meters, which indicate charge level more accurately.

Conclusions

Despite the careful design needed to produce the best performance, a micro hydro system isn't complicated. The system is not difficult to operate and maintain. Its lifespan is measured in decades. Micro hydro power is almost always more cost-effective than any other form of renewable power.

Who should buy a micro hydro system? In North America, micro hydro is cost-effective for any off-grid site that has a suitable water resource, and even for some that are on-grid. Homeowners without utility power have three options: purchasing a renewable energy system, extending the utility transmission line, or buying a gasoline or diesel generator. Transmission line extension can be expensive because its cost depends on distance and terrain. Even the initial cost of a hydro system may be lower. A gasoline generator may be cheaper to purchase but is expensive to operate and maintain. The life-cycle cost of the hydro system (3-25 ¢/kWh) is much lower than that of a generator (60-95 p/kWh). Once the hydro system is paid for, there's no monthly electricity bill and minimal maintenance costs. Since utility rates tend to rise, the value of the power increases, making your investment "inflation-proof."

Notes to budding renewable energy enthusiasts: the future has potential if you use your head. There are many opportunities in this field for creative people with talents ranging from engineering to writing, if you're willing to find them and persevere. Remember what head, flow, and love have in common: more is better!

Access

Paul Cunningham, Energy Systems and Design, Box 4557, Sussex, New Brunswick, Canada, E4E 5L7.

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Staff Publications

Hydro Siting

Paul Cunningham

Many people have access to some form of running water and are wondering just how much power, if any, can be produced from it. Almost any house site has solar electric potential (photovoltaic). Many sites also have some wind power available. But water power depends on more than the presence of water alone. A lake or well has no power potential. The water must be FLOWING. It also must flow from a high point to a low one and go through an elevation change of at least three or four feet to produce useable power. This is called the head or pressure, usually measured in feet or pounds per square inch (PSI). The flow is measured in gallons per minute (GPM) or for those blessed with larger flows, cubic feet per second (CFS).

At most sites, what is called run of river is the best mode of operation. This means that power is produced at a constant rate according to the amount of water available. Usually the power is generated as electricity and stored in batteries and can be tied to an existing PV or other system. The power can take other forms: shaft power for a saw, pump, grinder, etc.

Both head and flow are necessary to produce power. Even a few gallons per minute can be useful if there is sufficient head. Since power = Head x Flow, the more you have of either, the more power is available. A simple rule of thumb to estimate your power is Head (in feet) x Flow (in gpm)/10 = Power (in Watts). This will give you a rough idea of the power available at the average site and reflects an overall efficiency of 53%. This is a typical output for a well designed system. For example: if your head is 100 feet and the flow is 10 gpm, then 100 x l0/10 = 100 watts. Keep in mind this is power that is produced 24 hours a day. It is equivalent to a PV system of 400-500 watts - if the sun shines every day. Of course, the water may not run year round either. So it is apparent how a combined system can supply your power needs on a continuous basis.

Determining Head & Flow

Let's start with the head since that is easier than the flow and will give you confidence to continue. The best method to determine the head is also the easiest and can be used at any site. It is also very accurate. It involves using a length of hose or pipe in the neighborhood of 1/2" diameter. You can start anywhere along the brook and proceed upstream or down. First submerge the upstream end in the water and weigh it down with a rock or something similar. With the top end fixed in place underwater you move the rest of the pipe downstream. When you have reached the end, it is now time to start the water flow through the pipe. This may require you to suck on the end. Once flow is established and all air bubbles are removed, slowly raise the pipe upward until the flow ceases. When this point has been reached, use a tape measure to measure the distance from the end of the pipe to the surface of the water. This reading is the head for the stretch of brook. The pipe then becomes a convenient measure of horizontal run if you use a standard length like 100 feet. If you are working with a brook longer than your length of pipe, then simply carry the pipe to the next section to measure and repeat the procedure as required, starting where you ended before.

It is probably best to "map" more of the brook than you intend to use. This will give you a good overall idea of your site and may reveal some surprises.

Measuring flow is a little more difficult. This should probably be done in more than one place too. This is because most streams pick up water as they go. Therefore choosing the best spot for your system requires careful consideration of several things, There are several ways to measure flow; here are two. In both cases, the brook water must all pass through either a pipe or a weir. The weir system uses an opening that the water flows through and measuring the depth of water gives the flow. The first involves a technique very similar to the head measuring technique. You must divert all of the water into a short length of pipe. This will usually require the use of a dam in order to pack dirt around the intake end. Pipe size may be from 1" to 6" depending on the flow rate. Once that is done the water is directed into a bucket or other container of known volume. The time required to fill it is then noted and this is converted into GPM.

Many materials can be used for the weir but sheet metal is the easiest to make since the thickness is slight. Wood requires a beveled edge for accuracy. A stake is driven into the streambed a foot or so upstream of the weir and level with the bottom of the notch. This is the point the depth of water is measured since the level drops somewhat at the weir opening.

Water flow should be measured several times during the year. Once a month will give a good idea of how much power can be expected year round. The 50% efficiency rule applies to sites with heads greater than 30-40 feet or so. At lower heads everything becomes more difficult. Turbine and pipes become larger and speeds of rotation decrease.

The diameter and length of pipeline can now be determined once you have an idea of the potential power output of your site. It is assumed that you are planning on using a TURBINE and will generate ELECTRICITY. Other courses of action are possible but will not be discussed now. A rough average of the stream flow can be made after you have made measurements at different times of the year. Most sites will have periods of very high flow that don't last long and times of very low or no flow at all. You need a pipeline capable of handling a reasonable flow average.

Let us use an example of a typical site and see what is involved. Assume your measurements show that 100 feet of head is available over a distance of 1,500 feet. The water will be taken from the high end of the pipe and discharged at the low end through the turbine at a point as close to the brook as is reasonable. This will give you the maximum head available. Exceptions to this will be where the discharge water is to be used for another purpose (aquaculture, irrigation). Assume for the example that a flow of 30 gpm is available most of the year. Any pipeline will produce maximum power when the pressure drop due to friction is 1/3 of the pressure when no water is flowing. The pressure available under conditions of water flow is called the NET or DYNAMIC head. The pressure under conditions of no flow is the STATIC head. The difference between these two is the loss due to friction. Therefore the larger the pipe the better. For the example you will require a pipeline that has no more than a head loss of 100/3 or 33.3 feet (over 1,500'), This is 33.3/15 or 2.22 feet of head loss per 100 feet of pipe. Since this flow rate will probably allow the use of fairly small pipe, let's use the chart for polyethylene. Two inch pipe gives a flow loss of .77 feet per 100 feet and 1 1/2 inch gives 2.59. From this information, the 1 1/2 inch looks a little small and with the 2 inch we can use up to almost 55 gpm before the power drops off (50gpm = 1.98' head loss and 55gpm = 2.36 feet head loss/100').

So the choice of 2 inch pipe will cause a pressure drop of .77/100 x 1,500 = 11.55' head loss or a NET head of 100 - 11.55 = 88.45 feet at a flow of 30 gpm.

Editor's Note: See pages 25 and 26 of this issue for Poly and PVC; Pipe Tables. We put them in the center as a tear out for your wall.

These can also be found in the Owner's Manual.

Water must be channeled into the intake end of the pipe. This may require a minimal dam sufficient to raise the water level a foot or so. It is useful to make a small pool off to one side of the main flow for this so that the trash (leaves, twigs, sand) will largely bypass the inlet. The inlet can be covered with window screen and need only be a simple wooden frame to support the screen and have a hole for the pipe to enter. . To facilitate draining the pipe, valves can be fitted as shown. A valve the size of the pipe can be installed just downstream of the intake. This is followed by a small air inlet valve to allow the water to exit and prevent pipe collapse. At the turbine end of the pipe a valve should be installed just before the turbine with a pressure gauge upstream of it. This will enable you to stop the flow and determine the pressure under both static and dynamic conditions. Another valve may be added on a tree to drain the pipe without running the turbine. A pressure relief valve can be added in higher pressure systems. Keep in mind that even if you are always careful to shut the stop valve slowly, the pressure can still rise suddenly for at least two reasons. A piece of trash may plug the nozzle or air pockets may discharge causing the water to speed up and then slow down abruptly when water hits the nozzle. Some respect for the forces involved will help protect your system.

Another area that may require protection is the aquatic environment your system intrudes upon. Remember that your water needs should not cause the stream level to become too low. Many areas also have legal guidelines for the use and diversion of stream water.

Access

Paul Cunningham owns and operates Energy Systems & Design, PO Box 4557, Sussex, NB, Canada, E4E 5L7, or call 506-433-3151. Paul specializes in microHydro system design and manufacture.

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Manuals

Pipeline & Machine

Please choose a Manual to view:

MANUAL 1

The Stream Engine
Personal Hydropower Owner's Manual

MANUAL 2

The LH 1000 Low Head Propeller Turbine
Personal Hydropower Owner's Manual

Manuals may take a few minutes to load due to size. Please be patient.

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Staff Publications

Hydro Systems Using LCBs

Paul Cunningham

For a given magnetic field, and driven by a water jet of given pressure and flow, a DC hydro generator will produce its greatest power at a certain combination of voltage and current. This combination is called the maximum power point". The problem of running a PM generator at near its maximum power point voltage while charging a battery at a significantly lower voltage has a simple solution --- a linear current booster or LCB.

Conditions

Most hydro machines will only perform well under certain conditions and only perform at their best under one set of conditions. Using a variable field, as with automotive alternators, is one solution. These machines can be used with an RPM range of around l000 to 4000 or more. Although these alternators are low in cost and fairly reliable, they have low efficiency, typically 50% or less, depending on conditions. So with variable field strength, controlled electronically or with a rheostat, an optimum match between input power and output power can be made.

Improving the situation

Let's look at some ways of improving the situation. The automotive alternators have a place. But at low-head sites they work poorly or not at all. The problem is made worse because they not only are less efficient at low speeds, but more power is required to operate the field as the speed (head) is reduced. The only practical solution is a generator that uses permanent magnets (PM) for the field. This can be done using either stationary magnets with a rotating armature like DC motors have, or the rotor can contain the magnets with the armature and its coil of wire being stationary. Either way, the permanent magnets supply the magnetic flux that moves in relation to the output coils (where the power is generated). Because no energy is added to produce the magnetic field (and for other reasons) permanent magnet generators are significantly more efficient than their wound field counterparts. PM hydro machines can operate at very low heads and low rates of water flow because of their higher efficiency.

Half Solved

This is a step in the right direction, but the problem is only half solved, The field strength must be controlled (or some other techniques used) to produce optimum output. One way is to custom build each generator for each site (ARGH!). Another is to mechanically adjust the distance of the magnets from the armature (ARGH again!). In the case of stationary coils and PM rotors, it is possible in some designs to reconnect the output coils to vary the loading. But this cannot be done in small increments. And I won't even discuss mechanical drives like belts and pulleys for these very small machines. This is because of their complexity and losses.

Maximum Power Point Trackers

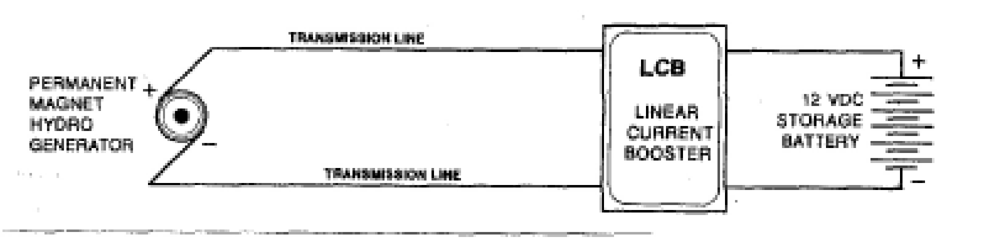
Wouldn't it be nice if this could be done electronically so one machine could be used at widely differing sites? There are device called Maximum Power Point Trackers that do this. The automatically seek out the best operating point of a power source and effectively match the power source to the load. The only ones I know of are very expensive. We aren't going to benefit if the operation is successful but the financial strain kills the patient.

LCB

Recently, I used a standard LCB (linear current booster) made by Bobier Electronics (type 3-4-8-T) with a permanent magnet, DC hydro machine and had excellent results. This machine (model DCT-1) could charge a 12VDC battery with a five foot head. I wanted to operate it at a 15 foot head. This meant that if the PM generator was connected directly to the battery it would run too slowly and the power output would decrease. The PM generator would produce a higher power output if the generator could turn faster which meant operating the system at a higher battery voltage. The optimum voltage increases in proportion to the speed of the PM generator. With an LCB the generator can operate at this higher optimum voltage and in a sense trade voltage for current thus charging batteries at their voltage.

Easily Retrofitted

An LCB can easily be retrofitted to a hydro site. If you have a PM generator, or In some cases an induction machine, you may benefit. With a PM generator, if the no-load voltage exceeds twice the battery voltage, a performance increase is possible. The installation of the LCB is very simple. It should be installed according to instructions as if it were operating in a PV system, see the figure below.



The LCB should be mounted neat the battery bank. Then it can simply be adjusted for maximum output current. This is a nonstandard use of the LCB and you are advised to use an LCB with twice the current rating of the PM generator.

The Proof of the Pudding

At the 15 foot head site, the no load voltage was around 47 VDC. This meant that the correct voltage under load should be about 23 Volts. By using a variable resistance, I determined that the maximum power point was to 22.1 VDC and 2.1 Amperes giving 46.4 Watts. Connecting the generator directly to a 12 VDC battery produced 3.0 Amperes and 12.5 VDC or 37.5 Watts. This is about 81% of the maximum that was produced at 22 VDC. Using the LCB in the circuit produced an output of 3.6 Amperes at 12.6 VDC giving 45.4 Watts. This means the efficiency of the whole system with the LCB is around 98%. It is important to note that the power increases will rise as the difference between generated voltage and battery voltage increases. LCBs are available from Bobier that are rated up to 250 VDC.

Other Benefits

There are other benefits from using an LCB. Whenever nozzles are changed, the machine can easily be re-adjusted for maximum performance. Another plus is that the generator voltage is increased which greatly reduces transmission line losses.

Bobier has just introduced new models of LCBs. Devices specifically designed for use with batteries must be ordered.

Access

Paul Cunningham, Energy Systems & Design,
P.O. Box 4557, Sussex, NB Canada E4E 5L7
(506) 433-3151

Bobier Electronics, 800-222-3982

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Staff Publications

Induction Generation: an exciting possibility

Paul Cunningham

Why does it make a difference what type of generator we use to produce power? Let's take a look at the standard types and see what the features are. Two broad categories include most types. Either the output coils can rotate or they can be stationary. Almost all of the older designs used output coils of wire that rotated. These designs used a stationary "field" which provided a magnetic flux for the moving output coils to pass through which in turn generated an electrical flow in the coils. This design is represented by direct current (DC) motors and most older alternating current (AC) generators (alternators). The major disadvantage of this type of machine is that the full output must pass through carbon brushes. Many generators of this type are used in alternative technology applications but they require more maintenance. Also, because of the rotor design, the wire is more difficult to retain at higher speeds as it tries to fly outward from the rotor. It is for these reasons that automotive generators (DC) were replaced by alternators.

The other major category of generators include those designs in which the output coils are stationary and the field rotates. This includes automotive alternators. All machines of this type produce alternating current output. If DC output is required, then RECTIFIERS are used to convert AC to DC. These are solid state electrical one way "valves" usually using silicon diodes.

Thus far, all of these designs mentioned could use permanent magnets for the field. This means several things. The field requires no electricity to operate, so efficiency is higher. It can operate at very low speeds since the power of the field is not taken from the output of the machine. On the negative side, there is no easy way to control the output of such a machine. With a wire wound field the output can easily be varied by alternating field current. A rheostat is a simple way to do this, and in this way, output is easily optimized.

EXCITATION IS WHAT AN INDUCTION GENERATOR IS ABOUT

You can use most motors as generators to produce electric power. A standard induction motor can also be used this way, These motors consist of stationary coils of wire that carry the current to operate them wound through slots in steel laminations. The rotor consists of steel laminations with aluminum conductors (usually) cast into slots in the steel. These are called squirrel cage rotors. When alternating current is applied to the stator coils, a rapidly changing magnetic field is produced. Once such a machine is running, there is always a speed difference between the rotor and changing field in the stationary coils. This difference is called "slip". This difference in speed INDUCES an electric current in the rotor and as a result a magnetic field. It is this field in the rotor that now causes it to "follow" the direction of the field in the stator.

For quite some time it has been recognized that if shaft power were applied to an induction motor already running, it would operate as a generator and push electricity back into the source used to operate it. For this to occur, our motor must now be running slightly faster than the "synchronous" speed instead of slightly slower. This technique is widely used on a large scale in commercial power generation systems. The electrical power already present provides the necessary "excitation" to correctly operate the machine. In this context, the system is fail safe.... if the grid power fails, generator output ceases also.

How is all of this going to help us with our stand alone remote system? There is the possibility of using a standard electric motor to efficiently generate electricity. One technique is to generate an "exciting" current for the motor/generator to "follow". Induction seduction, sort of. I have not been successful with this. Anyone who has should contact me with their findings. What DOES work with excellent results is to simply apply capacitance in parallel with the output lines. I ignored this tantalizing possibility until I met Bill Thomson and Fred Howe (of Thomson and Howe, Kimberly, BC, makers of electronic controllers for hydro systems) at a small hydro conference in March '87. It was their encouragement and information that enabled me to progress. The simplicity, low cost, and high efficiency of such a system were all self evident, once work was begun in this direction.

In the first issue of Home Power, I wrote about the conversion of a standard three phase induction motor to a permanent magnet alternator. With my new information, I removed the P.M. rotor and replaced it with the original. Then I added the 15 microfarad capacitors across each line (parallel). When the machine was started again, I found that not only did it start generating by itself (yes, "self excitation" an interesting term for a dry subject) but the output was identical to the P.M. rotor machine. This was a revelation to me.... how easily it could be done.

It should be instructive to note what makes up a complete battery charging system. The water driven turbine in turn drives a 1/3 H.P. three phase 230 VAC motor that has the three capacitors connected across the output lines. In this case power is generated at 120 VAC and can thus be transmitted very long distances with minimal losses. Then at the point of use three transformers step the 120 volts down to battery voltage and with a bridge rectifier, produce direct current.

You are probably wondering how induction generation works and why it isn't more widely used. In a stand alone system, the key to operation is the presence of capacitance. This gives electricity somewhere to "go" without the capacitors acting as a load. Thus enabling current to flow in the motor and get it all excited. Most motors I have tested as generators will start producing power on their own with the use of capacitors. This is due to the small residual magnetism in the rotor. It is also necessary that the generator not "see" a load until it is up to proper voltage. If a load is present at the start, the voltage will be unable to rise at all. In a battery charging system this is more or less inherently provided for, as the generator only "sees" transformers as a small load until proper voltage is reached.

Induction generation is more limited than a P.M. alternator in the type of situation in which it can be used. The induction machine should be operated at or near its rated speed. This can be as low as 800 rpm depending on the motor specs. A P.M. machine can be operated at very low speeds and still work well. However, if a site can use an induction generator, then it can be implemented at low cost since the motors are not expensive and the capacitors are only a few dollars each. Motors are also available in different speed ranges.

You might wonder why I am using three phase systems when a single phase one might do. It is possible to use single phase motors for this. However, they require more capacitance, operate at lower efficiency, and are not easily excited. Three phase alternating current is also more efficiently converted to DC for battery systems.

For those of you wishing to experiment, some further information may prove useful. The size of capacitor will largely control output voltage. Smaller capacitors are needed as voltage rises. Use only AC motor run capacitors. Not all electric motors are created equal and may produce results differing from what I found. Also keep in mind that if the system is to operate at a fairly fixed speed (like most hydro systems) that no adjustments are required from minimum to maximum output. As a starting point, a 1/3 HP 3 phase 230 VAC 4 pole (1800 rpm nominal) Westinghouse motor needs 15 mf per line to generate 120 VAC at 1500 rpm. A 1 1/2 HP Leeson 3 phase 230 VAC 4 pole motor requires 40 mf. per line at 1500 rpm, 230 VAC. If any readers have trouble getting things to excite, the most effective technique is to apply 12 VDC to one phase (two output wires) of the motor while stopped. After a few minutes remove the DC and try starting again. This "imprints" the rotor with magnetic poles and should get things going. Try no load at first just to see if it works.

There are some further points of interest that will probably be discussed in a future update. Presently there is still much work to be done before a more complete understanding is possible. Readers are encouraged to both try experiments and report their results.

Access

Write Paul Cunningham at Energy Systems & Design,
P.O. Box 4557, Sussex, New Brunswick, E4E 5L7, Canada

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Staff Publications

Long-Distance Power Transmission for Renewable Energy Systems

Paul Cunningham

Sites with good renewable-energy power production are frequently far removed from the point of use. This is particularly true of wind and hydro systems, where the location of the energy source cannot be easily altered. Even in many solar situations, the site where the energy is used may be shaded and this may require going to more open or higher ground to find sufficient insolation.

Several techniques have been developed to solve the problem of power transmission over distance. They involve generating power at a voltage higher than battery voltage and stepping that down at the usage site. This enables lower current values to be used, which reduces transmission losses.
(This is a modified form of the technique that utilities use.)

However, the first possibility to investigate is generating power at the battery voltage. Often a higher battery/inverter voltage (48 or 120 V) can be used to advantage. The larger transmission wire associated with direct transmission may cost less than the power conversion equipment otherwise needed. This also means a simpler system.

Most wind and hydro systems (unlike PV) generate alternating current first. This is then rectified (by the alternator) to direct current for storage in batteries. Transmission of alternating current over a longer distance is easier than transmission of direct current, because the power can either be stepped up or generated at a higher voltage. This enables lower current values and again reduces transmission losses.

Utilities require power to be generated at 50 or 60 Hz, as used by standard transformers. However, renewable energy systems do not need to match this; most transformers will readily accept higher frequencies with even an improvement in performance. Transformers can also be custom built for the task at hand. Solid-state transformers can also be used if the DC input needs to be converted to battery-voltage output.

For PV systems that produce DC output, the solid-state converter is the only option. These use high-frequency transistor topologies to convert a high input voltage into a lower battery voltage. They operate at high efficiency and are typically light and compact. Most are adjustable, which allows them to be tuned for optimum output. Some converters automatically optimize themselves and are know as maximum-power-point trackers or MPPTs. This is a very useful feature, because it makes the device more user friendly and the optimum generation voltage can vary widely with power output.

In a wind or hydro system, the power is often generated using a permanent magnet alternator. These usually operate at high efficiency and are brushless. They can often be supplied to produce the higher voltages associated with long-distance transmission.

Another option to consider is the use of induction generation. A standard three-phase induction motor with capacitors for excitation makes possible a simple, inexpensive generator. These are very reliable, brushless and can operate with high efficiency. When they are used with a tuneable converter, a very effective system is possible. Optimization of the power output would otherwise require the use of transformers with multiple output taps or changing capacitor values.

Which of these possible solutions should one use in practice? Three recent hydro installations have adopted different solutions, related to the needs of the application. At a site in New York state, hydro generators using about 20 litres/s from a 5 m head generate power at a nominal 240 V and 200 W. The power is transmitted to one site is 800 m away and a second 2 km away. At both sites the power is stepped down using standard transformers and rectified for 12 V batteries.

At a site in Arizona, a 3 m head uses about 15 litres/s and produces 130 W from the only surface water on a 200 square mile ranch. Two houses are supplied on a priority system. The first is only 50 m away and uses a solid-state converter; once the batteries are fully charged, the converter starts to reject the power. The generator voltage then rises from its nominal 40 V and the converter at the second house, about 200 m away, starts working and delivering power to the batteries there.

At an installation in New Brunswick, Canada, a flow of about 2 litres/s comes down a 50 m head through an 800 m poly pipe. This powers a hydro machine with an induction generator consisting of a standard three-phase induction motor with capacitor excitation. The power is send 500 m to a house where the 500 W is used directly without storage. Output is controlled manually, using a dimmer switch to shunt power to a dummy load to maintain the correct voltage! In most direct AC systems an electronic governor would do the job automatically.

Access

Paul Cunningham, Energy Systems & Design,
P.O. Box 4557, Sussex, NB Canada E4E 5L7
Tel: +1 506 433 3151 Fax: +1 506 433 6151

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Staff Publications

Micro Hydro-Electric Evolution

Paul Cunningham

Since the 1970s, there have been many examples of very small hydro machines to enter the marketplace. I am referring to those machines which are usually used in a battery based system, with an output of typically a few hundred watts and usually less than 1 kW. To put this in perspective, meeting the electrical demands of a typical home usually requires 3-400 W continuous. This is sufficient power to operate lights, refrigerator freezer, washing machine and entertainment.

Most of these generators have used impulse turbine runners as the hydraulic component, including Pelton, turgo, and some cross-flow designs. Materials for these runners include bronze, aluminium, steel and plastic. With efficiencies of the runners alone exceeding 80%, it is unlikely that much improvement will be possible here.

Automotive alternators are usually used to convert the shaft power of the runner into electricity. While this technology can provide a cost effective means to generate power, it is far from ideal. On the plus side, they are readily available, cheap, simple, and the field current can be easily varied in order to match the output of the turbine runner with the generator. On the down side, they usually employ carbon brushes to carry the field current (creating a maintenance issue), the efficiency is low (around 60%), and performance at low shaft speeds is problematic, since most machines use direct drive (often the speed is simply too low to achieve desirable outputs without using belt drives, etc).

It has proven advantageous to rewind these automotive alternators, as the stators are usually not more than half filled with wire. By using more wire, the efficiency can be raised and we can now use the wire size that best matches output to the load. However, the basic limitations are still there, in that these alternators were designed and evolved for automobiles, not hydropower. Note that by combining an 80% turbine efficiency with a 60% alternator efficiency, the best one could hope for would be an 48% water to wire efficiency.

It is only natural that a machine designed for the task of residential power generation would eventually be developed. Ideally, it should be brushless; use permanent magnets to avoid field losses and excitation problems; be water cooled since all that water is only a few centimetres away; be highly efficient; and be easily adjustable so load matching can be facilitated by the average user.

This has now been done with the alternator used on the Stream Engine made by Energy Systems and Design. Neodymium magnets are used in the rotor to maximise field strength, the alternator and rectifier are both thermally bonded to tile turbine housing to ensure cooling, and efficiency is typically in the 80% range at full load. The output is adjustable by raising or lowering the rotor which affects its proximity to the stator in tills axial alternator design. In this manner, turbine power can be matched to generator output. Reconnectable windings are used so that outputs of 12, 2.4 and 48V can be produced front the same machines, and in some situations, stators .arc custom wound to transmit at 120V over long distances, thereby minimising wire losses.

An example of a typical installation follows:

Renewable energy dealer Harold Lunner of British Columbia, Canada, has recently completed an installation of a Stream Engine. The head vertical drop at this site is approximately eight meters. The system, with two 22 mm nozzles, uses about 10 l/s and is fed by a 150 mm pipe, 200 m long. Output from the machine is 8.5 amps. in a nominal 48V system, which actually operates at 54V at this current level. This gives an output, in watts, of 459. A water to wire efficiency of 65% is achieved.

Micro-hydro systems have come a long way. They can produce power more cost effectively than any other kind of renewable energy system. It will be interesting to see what the future brings.

Access

Paul Cunningham, Energy Systems & Design,
P.O. Box 4557, Sussex, NB Canada E4E 5L7
Tel: (506) 433-3151

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Staff Publications

Small Water Power Siting

Paul Cunningham

There are small streams running over much of the countryside. Perhaps you are wondering if a brook in your area is suitable for developing into a power source. The following is intended to show the procedure I used in my case to arrive at solutions to various problems. Discussing the thinking involved will provide some interesting insights.

How Much is Enough

A small scale water power system requires a more specific site than either a wind or photovoltaic one. You do need to have some flowing water. On the other hand, it isn't necessary to have very much, or much pressure, and it doesn't have to be very close to the point of use. My situation will illustrate this.

Here in the Canadian Maritimes it is difficult to go very far without finding some type of stream. I live in an area of rugged topography which enhances the water power potential. My house is located near a brook that most times of the year has a fairly low flow rate. There is normally little water in the stream above the house while water from springs which come to the surface steadily increase the flow as the water runs downhill.

One logical place for the intake and beginning of the pipeline is near my house. Although flow increases further downstream, the slope decreases. Near the house the brook drops around 8 feet for every 100 horizontal feet. So running a pipeline downstream 1,000 feet produces a combined drop or "head" of 75 feet. This looked like a reasonable place to start although the site permits running a pipeline 3,000 feet before the brook meets another one running almost level.

1000 ft. of 1.5 in. polyethylene pipe was purchased (in 1978) and simply laid on the ground. A small screened box served as the intake and was set in the brook with a "dam" of earth and rocks sufficient to raise the water level about one foot. At this site, the maximum power will be produced at a flow rate of about 20 gallons per minute (GPM). This is the point where the dynamic (running or net) head is equal to two thirds of the static head. So there will be 50 feet of net head at the end of the pipe when the water is running with a suitable nozzle at the end.

Losses within the Pipe

Any increase in flow will result in a decrease in power available due to increased pipe friction losses. Right away one third of the precious power potential is lost. At lower flow rates the pipe loss decreases which results in an increase in efficiency as flow decreases.

So why don't I use a larger pipe? Well, it costs more and sometimes 20 GPM is all there is in the brook. Also a larger pipe would aggravate the problem of freezing at low temperatures with no insulating snow cover. This is because the residence time would increase with larger pipe. In my case, the water entering the pipe is (slightly) above freezing and cools as it travels along (when temperatures are very low).

So why don't I bury it? Yes that would be nice and hopefully I will when I can afford that and larger pipe too. It is a case of the shoemaker being inadequately shod as I content myself with the present system. Besides, it has spurred me on to other possibilities that we will look at later in future articles.

Nozzle Velocity

Back to the 20 GPM at 50 foot head. A 3/8 inch diameter nozzle is about the right size for this, giving l9 GPM according to the spouting formula the velocity of a jet of water will be:

V= Ö2gH = Ö2 * 32.2 * 50= 56.7 ft./sec.

g = 32.2 feet/sec/sec (acceleration due to gravity)

H = head, expressed in feet

Moving Water as Energy!

How much potential power is this? A U.S. gallon of water weighs 8.34 lbs. and the flow is 19 GPM; then 8.34 lbs. per gallon X 19 gallons per minute = 158 lbs. per minute. Now, 158 pounds of water per minute falling 50 feet has 7,900 foot-pounds/minute of energy (simply multiply the factors). Conversion to horsepower is accomplished by division by 33,000, thus 7900/33,000 = .24 horsepower. Since 746 Watts of energy is equivalent to one horsepower, .24 hp. X 746 Watts per hp. = 179 Watts of potential squirting out the nozzle. This means that the potential power was .36 horsepower or 269 Watts before going through the pipe. Since nozzles tend to be very efficient not much loss is expected. But keep in mind that every time the energy goes through a change, power is lost. All right, how about a 9 Watt loss to make an even 170 Watts.

This may appear a little sloppy. But you must realize that these systems do not have to be very precise -- they are quite forgiving. Also many of the measurements are difficult to determine with high accuracy. So close approximations are sufficient.

Thus far things are reasonably straightforward - a pipeline with a nozzle at the end. Now what Conventional practice would suggest some sort of impulse turbine such as a Pelton or Turgo. It would also be possible to use a reaction machine. It would have to resemble one of those spinning lawn sprinklers rather than say, a propeller type. This is because of the very small nozzle area. The impulse type looked easier to build.

Low Voltage DC Hydro

At this site it is necessary to send the power back upstream 1,000 feet to the house. I wanted to use 12 VDC and wanted some way to transmit the power other than the very large wire that would be required at this voltage.

In the spring, when the flow in the brook was very high, various 12 VDC generators were operated with the pipeline ending near the house. But this could only be temporary, as ways of solving the transmission problem had to be discovered. Of course using wires wasn't the only possibility. I could always charge batteries downstream at the generator and then carry them up to the house. Or perhaps a reciprocating rod kept in tension could be used to transmit the power. But all things considered, producing electricity at a voltage higher than 12 VDC looked the easiest.

Let's Raise the Voltage

I thought generating AC electricity at 60 Hz. like regular commercial power would permit using standard transformers and make it easy to change the voltage. For this I bought a "Virden Permabilt" 120 VAC generator. This produces 1,200 Watts rated output and 60 Hz. at 3600 RPM. These machines are reworked DC auto generators with rewound field, rotor with a slip ring and brush to carry the output.

An impulse turbine should have a surface speed of about half the jet velocity. So at 56 feet per second, a turbine wheel slightly less than 2 inches in pitch (hydraulic) diameter is required. This is a little on the small side but I did make a Turgo wheel of this size so the rotational speed would be right for direct drive. Yes it's possible to use speed increasers with a larger turbine but I didn’t think there was anything to gain and only power to be lost. It turned out that the alternator would not generate t 20 VAC at a low power level. The field required 10% of the rated 1200 Watts output to put out 120 VAC regardless of the load. Therefore a lower output voltage was necessary to properly balance the system. It was determined that under the site conditions an output of 50 Watts at 24 to 25 Volts was required to be in the correct ratio: 120 VAC/10 Amperes = 24 VAC/2 Amperes or 48 Watts.

Now you are probably wondering how come only 48 Watts was being produced. Well that is what that combination of turbine and generator put out. And this isn't the end either. Next the juice went through a 25-110 volt transformer, through 1000 feet of 18 gauge wire (two strands), another transformer down to 12 volts and then through rectifiers to give DC. In the end only 25 Watts or about 2 Amperes actually found its way to the battery.

This setup didn't last long enough to make many improvements. It was hard just keeping it alive. The alternator used only one slip ring. The other conductor was the bronze tail bearing! Both items had limited life under 24 hour service. Besides the efficiency was low anyway.

A Functioning Higher Voltage System

I still needed a reasonable system. At least one with a longer life.

In the next attempt a 4 inch pitch Pelton Turbine was cast in epoxy using a silicone rubber mold. This directly drove a car alternator with a rheostat in series with the field to adjust the output. Transformers (3) were connected to the three phase output to raise the voltage for transmission with the (now) 3-18 gauge lines. Then a similar set of three transformers were used at the house to lower the voltage and a rectifier to make the DC conversion. About 50 Watts was still generated (4 Amperes at 12 volts) but more made it into the battery --- about 3 Amperes. The reason for this is the automotive alternators have more poles (12 Ford, 14 Delco) and generate at a higher frequency. This improves the efficiency of small transformers even though they are "designed" to work at 60 Hz. Now the system has an efficiency of around 21% (36 Watts/170 Watts) using the power available at the nozzle as the starting point.

What Can Be Done With 25 Watts

Three Amperes in a 12 VDC system doesn't sound like much. But this is sufficient to run the lights, a small fridge (Koolatron) and a tape player-radio. My house is small and so are my needs. There was sometimes even extra power and I could run Christmas lights or leave on things just to use the extra power.

At some point it occurred to me that I might generate more than electricity if I could produce turbines for others in a similar situation. Peltons were made first for sale. Originally these were made of epoxy and later of a high-strength and abrasion resistant Polyurethane. This endeavor busied me some but it soon became apparent that to survive doing this sort of thing would mean producing complete generating units.

Turgos

Turgo turbines looked more reasonable than the Peltons for this, due to their greater flow handling capability for a given size. Using a 4 inch pitch diameter turbine wheel allowed as many as four one inch diameter nozzles to be used. This resulted in a very versatile machine.

The first production models used automotive alternators (Delco) since they are inexpensive, dependable, available and most people wanted 12 VDC output. But these couldn't operate with heads of less than 20 feet or so. Also the efficiency of these alternators is in the 40-50% range and I thought there was room for improvement.

Back in the R and D department, work was proceeding to develop a better machine. The Turgo turbines operate in the 60-70% efficiency range. These are made in re-usable silicone rubber molds. This placed certain constraints on their design and so limited the efficiency. But other tests showed there wasn't much to be gained by changing the shape of such a small wheel.

Permanent Magnet Generators

However, the generators used so far had efficiencies in the 50% range or less. They also had electric field coils which made for easy adjustment of the output but also took part of the output to operate. It looked like the use of a permanent-magnet (PM) field would be a help and could make operation at very low heads feasible. Yes, DC motors with PM fields could be used as generators. But my experience with machines where brushes carried the full output was disappointing. Longevity was a problem --- remember these are going to run 24 hours a day. If alternating current could be generated then transformers can be used to alter the voltage to suit the site.

It is well established that the most efficient generator type, especially in small sizes and at low speeds, is the PM-rotor alternator. Just like a bicycle generator. There is also nothing to wear out besides two ball bearings. That would be a feature and a half.

After a few tries, standard induction motors were used by keeping the stators and building new PM rotors. This produced a machine capable of generating power with an efficiency of over 80%. Standard 60 Hz. AC output was possible at 1800 RPM for these 4 pole machines. Experience suggested that frequencies of 50-400 Hz. would operate standard transformers quite well. This, combined with the reconnectable output wiring, produced a machine able to generate almost any voltage.

Meanwhile Back At The Ranch...

So how is it looking back at my site? Using the new PM rotor alternator about 100 Watts of power is produced. This is an efficiency of 100 Watts/170 Watts or about 59%. Dynamometer testing of the alternator shows it has an efficiency of 85% at this condition which means the turbine is running at 69%. Now 120 VAC is generated so no transformers are used at the generating site. The same transformer set used with the Delco installation is used at the battery end. About 6 Amperes are delivered to the 12 volt battery. This gives an overall efficiency of 72/170 or 42% water to wire (water to battery?).

With this system appliances can be tun directly off the alternator output as long as this requirement is less than the available power. This creates a hybrid setup that produces both 120 VAC @ 60 Hz. and 12 VDC. A future article will discuss how to deal with more difficult sites.

Access

Paul Cunningham, Energy Systems & Design,
P.O. Box 4557, Sussex, NB Canada E4E 5L7
Tel: (506) 433-3151

Paul Cunningham is CEO of Energy Systems & Design. He manufactures water machines and lives on hydro power.

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Staff Publications

AC/DC: Micro-Hydro-Electric Options

Paul Cunningham & ROBERT G. FIFE

When considering a micro-hydroelectric installation, one of the primary issues is whether it win be all AC direct system or battery based system.

AC direct systems consist of a turbine-generator unit producing AC power which is used as needed. That is, it is fed directly to the appliances. Governing of such a system is usually done electronically, with reliable, off-the-shelf equipment that is readily available. In order to maintain the correct voltage and frequency within the parameters required, the power is monitored and that which is not used by the appliances is directed to an alternate load, such as heating. This also means that the appliance load can not exceed the power generated, as this win result m system collapse. The generated power is monitored cycle by cycle and is diverted as required.

In a battery based system, the generated power is used to charge a battery bank, then the power is sent to DC loads, or to an inverter to power AC loads, or both. Regulation consists of diverting excess power to an alternate load to prevent battery overcharge. The battery/inverter combination can provide large surges of power to handle loads such as pumps, lights, tools etc. As well, with battery based systems, other sources of power call be easily integrated (i.e. PV cells, or wind turbines) and fed to the batteries.

An AC direct micro-hydroelectric scheme is simpler in its overall design than battery based systems, and for this reason they are sought by many people. However, the output of AC direct systems must be capable of handling all of the power requirements at any instant, which can be substantial when startup surges are considered. For instance, incandescent lights typically require ten times their running current at turn-on; induction motors, such as those typically found in refrigeration and water pumps, may require five to seven times their operating current for starting. This power must be available when needed for the system to continue functioning, as exceeding its capacity win cause an electrical collapse. Since AC power cannot be stored, and kinetic energy can, the addition of a flywheel to the turbine can help carry the system through such power overdraughts. A battery based system stores the generated electricity chemically, and so only the average usage needs to be generated. The batteries handle the peaks and valleys of the electrical loads. The generation components of the system can even be taken out of service for repairs or maintenance without immediately affecting the power delivered to the loads.

Both AC and battery based systems can supply AC power to appliances that is indistinguishable from commercial power. The AC direct system usually requires far more power to be generated than in a battery scheme. This may be the most important factor in determining the system type at any given site. As an example, when a refrigerator drawing running power of 200 W starts, there is a surge of less than a second during which it may require up to 1500 W. If this power is not available, beyond the other loads operating coincidentally, the system voltage will drop to the point of failure. AC direct systems, for these reasons, seldom have a capacity of less than 2 kW. This contrasts with battery systems which typically require generator outputs of around 300 W in order to meet the needs of standard household electrical loads (excluding heat). Exceptions to this are some residents who use AC direct induction systems to produce only a few hundred watts to meet their needs for lighting and small electrical appliances (mention was made of a system of this sort in the September 1998 issue of Renewable Energy World, 'Long Distance Power Transmission for Renewable Energy Systems', p. 72). Note that if power on this scale was used to charge batteries, then far more substantial loads could be sustained. The big advantage to the large output AC direct systems is that they meet the need for appliances and lighting while the excess power is usually sufficient to meet all the hot water needs and most, if not all of the space heating requirements.

If there are sufficient resources to implement an AC direct micro-hydro system, there arises one significant consideration: the infrastructure required to complete such a system is much more weighty, both physically, and in the finances necessary to procure it at the outset, than that of a battery charging system. Firstly, the pipeline used to feed a battery scheme is seldom larger than 6 inches (about 15 cm), and is typically 4 inches (10 cm) or less. Compare this with the much larger piping necessary to carry the flows required for AC production, and the price difference can be prohibitive, not to mention the considerable toil and expense required to move and bury large-scale pipe. Secondly, consider the power generating components, and the equipment necessary to support them. Beginning at the pipeline, the differences between the AC direct and the battery based systems can easily be seen, primarily, in the actual size of the generators. Usually, a generator that produces a few hundred watts can be on the scale of the typical automotive alternator, while a generator in the multi-kW range is certainly much larger, and depending on whether it is a synchronous or induction generator, the price can be even more disproportionate. Add to this the turbine runners that would necessarily be much larger in the AC system, and one can easily see how the initial costs involved in the generation components would outweigh a battery based micro-hydro generator. From the generator, leading to the point of usage, run the conductors, in the form of copper or aluminum wire. The size of the wire is dependent upon the voltage and current of the transmission and the distance over which it is to travel. In long distance situations, AC travels well as it is usually high voltage, thereby minimizing line loss on a given wire gauge; in battery based schemes, the voltage is determined by the battery bank, so in the cases of low voltage battery banks, transformers may be necessary in order to step, then step down voltage, so as to minimize line loss. Large gauge wire can be used to the same effect. On the side of battery charging systems, if the transmission distance is modest, the wire gauge necessary to conduct hundreds of watts is significantly smaller than that required to carry thousands.

While there are many factors to consider when choosing a micro-hydroelectric scheme, if the pertinent details involved are given adequate attention, an optimal solution can be found for the generation potential of any given site. It is hoped that the information necessary to begin this process has been summarized in this article so as to be a starting point for the system designer where ever the site may be.

Access

PAUL CUNNINGHAM & ROBERT G. FIFE
Energy Systems and Design
P.O. Box 4557, Sussex, N.B.
Canada E4E 5L7
Phone: +1 506 433 3151
Fax: +1 506 433 6151
e-mail: hydropow@nbnet.nb.ca

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Staff Publications

Micro-hydroelectric Installations: A beginner's perspective

Bob Fife is manager of a company that manufactures micro hydro equipment, but until he decided to help out some clients with his colleague Paul Cunningham, he had never taken part in an installation himself. There were some surprises in store when he put theory into practice.

Late in the summer of 1998, we received a call from Valerie, a woman representing Earthaven Ecovillage, an intentional community in Black Mountain, North Carolina, USA, who sought information regarding the hydroelectric potential at their community. This began a learning process unlike that faces me day to day. Usually, my workplace is a modest shop in New Brunswick, Canada, where I control the environment and set the tone; on site, I would be at the mercy of the elements, the geography and those with whom I would be working.

Site Assessment

Planning the system from our shop in New Brunswick, I began with a preliminary site assessment, as I usually do when contacted by a potential client. These are difficult to do at times, depending on the skill level and experience of the individual, but in their simplest form can be reduced to a few elementary concerns that are common at any potential installation:

1.What are the load demands of this potential system? 2.What resources are available to meet this demand? (Accurate head and flow figures are vital if the suppliers are to be of any help to their customer in matching the resources to the most suitable turbine design, and in accurately assessing the power output potential.) 3.What is the transmission distance from the site of generation to the site of use? This will determine the voltage, and therefore amperage of the transmission, in order to gauge potential losses along the lines. Large gauge wire may be necessary, or transformers. 4.What size and length is the pipeline to be? Choosing the proper pipe diameter can deliver the water to the turbine with a minimum loss and a maximum amount of power. Friction losses due to undersizing can reduce a potential site to a pitiful disappointment.

Load demand

Load demand was a minor consideration because the community required all the power that could be generated. They were relying on a few PV panels to provide power to some buildings. At the outset, Valerie sought a system which might equally divide output between four separate structures (she thought perhaps a timer for 6 hours charging per location) but for reasons of cost, simplicity of design, and the pre existing Trace 5548 inverter, it was decided that a centralized system -- using this large inverter to transmit power to its points of use -- was most appropriate and effective. After all, to decentralize a scheme in this manner would require four smaller inverters, four battery banks etc., which would drive the cost of this project up prohibitively, and complicate future maintenance.

Resources

The water resources were described as about 15 metres of static head, and a minimum flow of 750 litres/metre, which showed promise as a power source. Using the formula Hn (net head in metres) x Q (flow litres/metre) / 8, the power potential in this body of water was found to be approximately 1400 W continuous, which is a generous battery charging scenario, to say the least. By cross referencing the head measurements with a RPM chart, we found that our generator could achieve 1300 rpm; since our generator produces approximately 400 W/ l000 rpm, we estimated the output potential from one of our generators (I will be calling the electricity generating component of our system a generator despite its production of AC. It is immediately rectified, in most cases, and transmitted as DC, and it is the generic sense of the term, generator, to which I refer) to be between 520-550 W. This site was indeed viable, and we agreed to explore it with the community.

Transmission distance

The transmission distance was found to be negligible, as the turbine was to be positioned next to the battery shed. This said, we used 10 gauge wire to lead front the turbine to the batteries but in some cases, a turbine may be a considerable distance from the point of use, and high voltage transmission may be necessary, or large gauge wire, in order to minimize line losses {see article entitled Long-distance power transmission for renewable energy systems, REW September 98, page 72). Something to be kept in mind is that one can never possess too many good tools, and in this instance, a simple wire loss table goes a long way, with Ohm's Law, to helping find the most suitable wire for any given transmission distance. A collection of up to date, accurate tables will always be useful.

Pipeline

The pipeline was already installed when we were contacted, and measured 300 metres of 10 cm polyethylene. Once again, the use of a pre-existing chart allowed us to cross-reference the pipe size and type to determine the friction losses for this installation at this head and flow. They were found to be about 3 metres loss at a flow of about 400 litres/metre (this corresponds to a nozzle size of 22 mm) at this site which gave us the net, or 'dynamic' head of 12 metres or so. This completed the picture with regards to information and allowed to determine what the potential was, in this instance, and to proceed to what might be called the 'hands on' stage of the installation.

Packing

It is at this point that the more trying stage of the installation begins. In this, as in most cases, the installers find themselves faced with the most difficult of issues: how, and which equipment, does one pack in order to complete the installation of a system which is usually miles distant and often with limited resources beyond those packed; it is difficult to fashion custom tools from those which are more commonly found, so be prepared, and be flexible. We settled on a list which was thorough, and seemingly complete (even so we found ourselves without a few tools) so before setting out over what may be a long trip, it is a good idea to determine your eventual proximity to the nearest hardware and plumbing supplier. (We were assured that everything would be ready and waiting when we arrived, but in several instances found components missing. This is the nature of the game. However, with willing help and a co-operative effort, these obstacles were overcome and the components found.)

My associate, Paul Cunningham, and I packed an array of tools and resources, including the following: a complete set of sockets and wrenches, a good, reliable multi-tester, pipe wrenches, plumbing tape and cements, literature (manuals for the support components of the system), and a range of screw drivers, wire strippers, and miscellany. There is not room to include the complete list of the tools necessary, but the ones listed above are essential. It is wise to over-pack rather than under-pack, keeping in mind that its better to not need a tool and have it than vice versa.

On site

Feeling as though we were prepared, and familiar enough with the site, we set out to Earthaven to undertake the installation. The community was a collection of 35 or so members who had carved a niche in the beautiful southern Appalachians. They lived in everything from straw bale and wood-frame houses to a collection of tents, tarpaulins, and yurts which housed the semipermanent members, and the newly arrived. Paul and I were glad to discover that we were to be lodged in a beautiful wood-frame cottage, with a lovely deck overlooking the stream, and a small garden plot that accompanied the dwelling. It was a beautiful home base from which we would operate for most of the next week. As soon as we settled in, a preliminary survey was in order, and we set off into the lush North Carolina forest.

The community had constructed the supporting infrastructure for their micro hydro system at the tailrace of their pipeline, and to our surprise, we found they had constructed a small wood-frame outbuilding (of scrap wood they had milled themselves), which was to house the electrical components, along with a cinder block battery storage compartment with a separate turbine compartment - all in the shape of a boat so to survive the eventuality of a seasonal flood! Not only were the type and design of the buildings unusual, but we had also advised against any permanent concrete work before seeing the turbine (I had seen too many construction sites in other trades gone wrong to wish this upon these people, and knew how far astray the eager and inexperienced can go in a desire to be helpful). Our first appraisal was therefore a critical one, as their concrete work was not only insufficient, but the bolt pattern for the turbine had been incorrectly installed and the turbine support was undersized in the interior dimensions. A judicious blow or two with a sledge hammer, and a few hours of reconstruction, left this section in fine order. The wood frame building was in need of some elementary carpentry, and was still in the works when we left.

These deficiencies are pointed out in order to demonstrate two points. The first is that you never know what you'll find when you arrive on site, so be ready to react to circumstances constructively and with an eye to the clock. And secondly, the system you are about to install is an investment of several thousand dollars, mountains of research, and something that will be depended upon for years to come, so make the supporting structures first class and budget for good, sturdy buildings to protect and maintain these vital pieces of equipment.

Plumbing

Installation of the final plumbing was to be a bit trying, despite the already installed pipeline. It is here that I learned a valuable lesson as a foreman/group leader: be sure to 'take the bull by the horns': give clear, unmistakable directions and ensure that they are followed to the letter when necessary. Despite the clearest of instructions, including a list, a few 'free thinkers' can really cause chaos when they decide to interpret where no interpretation is wanted. (We required a wide array of plumbing fittings and supplies, and it took several trips by one of the group leaders before he finally fathomed that we really did want what was on the list rather than what he thought we needed! Next time I will take charge in an unmistakable fashion so as to meet time constraints and budgets. However, despite these difficulties, the plumbing was secured and we proceeded.)

We split the 10 cm (4 inch) pipe with a Y and from this ran two 5 cm (2 inch) adapters. These were coupled again to 38 mm (1½ inch) adapters which were joined to flex hose leading to the nozzles on the turbine. It is important to bring the large diameter pipe up as close as possible to the turbine before reducing its size to minimize friction losses (see photo in 'Micro HydroElectric Evolution' REW July 98, page 60). Then, by using flex hose, the friction losses are minimized further as the water is sent around a slow curve, rather than a series of sharp bends. If these friction losses are kept minimal you can really draw a lot of power from surprisingly little water.

Electrics

Paul and I proceeded to install the Trace 5548 inverter, the Trace C40 charge controller, and the load centre. Needless to say, this was a real eye opener for me. 1 have never been gifted when it comes to electrical matters, but I soon found out that the manufacturers of these products have people like me in mind. The products are very user friendly as long as no assumptions are made, and homework is done. The process went rather smoothly, and the community had a couple of residents who were rather competent in these matters; they made a great tithe of this work as we all explored the technology, and relied on one another to do a good job. Aside from these things, the actual installation of these components is a real delight. It is sometimes amazing to behold what it is we humans can do when we think it out. The 16 batteries were placed into a 48 V configuration, and placed into their compartment. Then all of the components were linked together, and the turbine inspected to see that all looked all right. A good visual inspection is usually an excellent way to begin start-up; if something looks wrong, it may well be, so take a close look around, and follow your instincts.

Turning on

As we opened the valve to the turbine, we found the machine began to 'freewheel', or run in operation without a load on it. This is indeed a serious situation so we immediately closed the valve and investigated further. When a generator is run without a load,

voltage can rise to very high levels, and can cause damage to the unit itself. With this in mind we quickly found a breaker to be tripped, and reset it. We opened the valve again. Same results, and again, another secondary breaker in need of attention. But, third time lucky, and when the valve was reopened, the generator wound up under a load, and the ammeter began to register. It seemed I had completed my first installation with neither damage nor death to my credit. That spelled success to me. The community had still not used their consensus style decision making process to decide upon a diversion load, but the two women who worked with me during the installation, Ellen, and Adeha, reassured me it could be handled, and the batteries still had a while to go until they were charged anyway. Besides, they weren't exactly sure what they would do with all the power.

The final results were tremendously encouraging. With the 48 V battery bank at about 50 V, the amperage hovered around 12 A. This gave a final output of 600 W, thereby more than doubling the community's generating capacity. Paul and I were delighted, and the rest of the community concurred.

This was the ultimate in renewable energy schemes in many ways, from our perspective. Not only was a water powered generator installed, which would sustainably provide power to this community for years to come, but the community itself was renewed to an extent. In their search for a way of life that was friendly to the planet, and each other, this new power source would allow development and continuation of their ambitious agenda. The permaculture with which they experimented, their forays into alternative construction methodology, and the collective governing that they employed all benefited from this development of reliable power. As in many developing countries, the stability inherent in reliable infrastructure has given a little more freedom to the individuals to pursue higher goals than mere survival, and has attracted new members to their society whose ideas and energies will carry them into the future.

Access

Robert Fife works with Energy Systems and Design,
New Brunswick, Canada.
Tel: +1 506 433 3151 Fax: +1 506 433 6151
e-mail: hydropow@nbnet.nb.ca

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Definitions

Link:
World Wide Metric Calculator
(will open a new broswer window)

Commonly used terms on this website:

Head	The vertical distance the water falls.
Flow	The rate at which water moves. Measured in liters per minute (l/m) or gallons per minute (gpm).
AC	alternating current
DC	direct current
V	Voltage of power
kW	Kilowatt
Feet, Meters	Units of distance
Pounds per square inch/ kilo-pascals	Units of pressure
RE	Renewable Energy
ES&D	Energy Systems & Design

Common conversions:

Capacity	
1 imperial gallon (gal)	4.546 litres (L)
1 litre (L)	0.220 imperial gallons (gal)

Volume	
1 cubic inch (in3)	16.387 cubic centimetres (cm3)
1 cubic centimetre (cm3)	0.061 cubic inches (in3)
1 cubic yard (yd3)	0.764 cubic metre (m3)
1 cubic metre (m3)	1.308 cubic yards (yd3)
1 cubic foot (ft3)	0.028 cubic metre (m3)
1 cubic metre (cm3)	35.315 cubic feet (ft3)

Length	
1 inch (in)	2.540 centimetres (cm)
1 centimetre (cm)	0.393 inch (in)
1 foot (ft)	0.304 metre (m)

1 metre (m)	3.280 feet (ft)
1 yard (yd)	0.914 metre (m)
1 metre (mi)	1.093 yards (yd)
1 mile (mi)	1.609 kilometres (km)
1 kilometre (km)	0.621 mile (mi)

Mass	
1 ounce (oz)	28.350 grams (g)
1 gram (g)	0.035 ounce (oz)
1 pound (lb)	0.453 kilogram (kg)
1 kilogram (kg)	2.204 pounds (lb)

Commonly used metric system units & symbols:

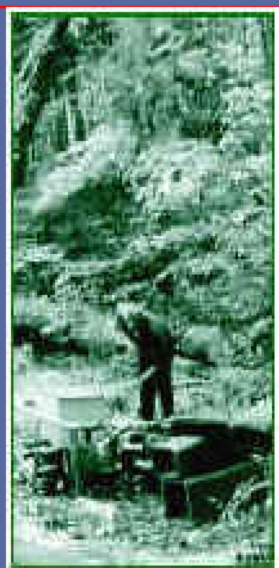
Type of Measurement	Unit Name	Symbol
length, width, distance, thickness, girth, etc.	meter	m
mass (or weight)	kilogram or metric ton	kg / t
temperature	degree Celsius	°C
area	square meter	m2
volume (liquid or other)	liter / cubic meter	L / m3
density	kilogram per cubic meter	kg/m3
velocity	meter per second	m/s
force	newton	N
pressure, stress	kilopascal	kPa
energy	kilojoule	kJ
power	watt	W

Some charts from the
US Metric Association Inc.

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Clients



Boiestown, NB

Energy Systems & Design offers design and installation services to international communities at competitive rates.

Our team of technicians design and prepare your system at our facility in Canada, and then complete the installation at your site. We are prepared to handle any system, from solar hot water systems to photovoltaic, wind & microhydro.

Projects:

- Boiestown, New Brunswick
- Morant Bay, St. Thomas Parish, Jamaica

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

New Retail Price List ($USD FOB-ES&D)
January 1, 2003

Price List

Stream Engine showing multi-meter (included) used to measure output current.

We now accept Visa and MasterCard

Note: prices are in U.S. dollars. Prices are subject to change.

Please contact us for shipping costs

(Posted: August.12, 2003)

Stream Engine	Product code	$USD(Retail)
2 Nozzle SE Standard	SE-STD2	$1695
4 Nozzle SE Standard	SE-STD4	$1845
2 Nozzle SE Bronze	SE-BR2	$2195
4 Nozzle SE Bronze	SE-BR4	$2345
High Voltage Option	HV-OPT	+ $150

Parts List for Stream Engine		
Turbine housings, rough	TH-0	$250
Turbine housings, 2 nozzle	TH-2	$300
Turbine housings, 4 nozzle	TH-4	$350
Universal nozzles	UN-NOZ	$25
Bronze Turgo wheel	BR-TRG	$550
Plastic Pelton wheel	PL-PLT	$100
Bearing kit	BRG-KT	$25

Low-Head Propeller Turbine		
LH1000 w/Draft Tube	LH1000	$1695
SE to LH Conversion Kit	SE-LHK	$1000

Permanent Magnet Generators		
Series	GEN-SR	$ 950
Parallel	GEN-PR	$1000
High Voltage	GEN-HV	$1150
Junction Box w/Multimeter	J-BOX	$ 200

Transformers for SE & LH		
400 watt Transformer	TRN-400	$ 600
1000 watt Transformer	TRN-1000	$1500

Please Note: Prices do not include shipping from Canada;

Pre-payment required on all retail orders;
Energy Systems and Design Ltd. is on Atlantic Time (E.g., New York-8:00 am/ES&D-9:00 am).

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Energy Systems and Design has diversified and now offers “balance of system” components to its customers upon request. So, feel free to contact us with any queries you may have regarding wind turbines, PV panels, batteries, inverters, charge controllers, transformers, or residential appliances.

Thank you for your business, and we appreciate your efforts to make this planet a little greener, and a lot more peaceful.

Yours,

Paul Cunningham (owner, CEO)

Energy Systems and Design is on Atlantic Time.
(E.g., New York-8 a.m./ES&D-9a.m.)

www.microhydropower.com
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

"Innovative Micro-Hydro Systems Since 1980"

Staff

- **Paul Cunningham** (center)
- **Jo Pach** (right)
- Â **Jody Graham** (left)

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Contact Us

Energy Systems & Design
P.O. Box 4557
Sussex, NB
Canada E4E 5L7

Telephone: (506) 433-3151
Fax: (506) 433-6151

Send us an e-mail: hydropow@nbnet.nb.ca

Meet the Staff

Your Name:

Your mailing address:

Your phone number (required):

Your E-mail address (required):

Your fax number:

How did you find out about Energy Systems & Design?

The following section request information about the proposed site. This information will help us in determining the viability of the site. For help in finding the requested information, see the Owner's Manuals.

Head:

Flow:

System Voltage:

Transmission Distance:

Pipeline (Type):

Pipeline (Diameter):

Pipeline (Length):

Expected Power:

Notes or Comments:

Submit Reset

www.microhydropower.com

"Innovative Micro-Hydro Systems Since 1980"

Links

- Renewable Energy World
- Home Power

www.microhydropower.com