To increase the amount of power available and to improve the reliability, the plant adopted the concept of providing supplementary power by "underdriving" a portion of its large motors. This required connecting diesel prime movers, with appropriate controls, to eight of the large motors in the plant. These prime movers were then routinely run to provide approximately 15 percent of the total operational load. Further, they were so connected that when power outages occured they could serve as emergency generators to maintain control over the hot processes. Under this system, production approached anticipated levels and the reject rate declined sharply.[8]

The studies found that major needs for emergency power would come from shelters, mass-care centers, utilities and industry. In the event of failure of conventional systems emergency power sources would be engine generator sets, industrial generators (isolated from main grids), and unconventional sources. Such unconventional sources would include synchronous motors (found in industry) which could be "reversed" to provide emergency generators (locomotive and ships). Specific studies were done on the feasibility of converting induction motors to run backwards as induction generators.*

*The basic principle of the induction generator is easily understood when one considers that the energy flow in induction machines is a reversible process. An induction motor energized from a power source develops mechanical power by running at a speed slightly less than its synchronous speed. Conversely, an induction motor driven in the same direction at a speed slightly greater than its synchronous speed will deliver electrical power when connected to a power system. If the machine is driven above synchronism by the same rpm that the machine normally operates below synchronism, the generator will deliver approximately rated current at rated voltage and rated efficiency, and the electric power output will be approximately equal to the rated shaft motor power. However, the generator power factor will be much lower than when operated as a motor.[9]

The URS study on induction motors found that 10-150 horsepower motors are common in many industries and commercial facilities. Components to construct induction generators are commercially available; they include induction motors, power capacitors, motor controllers, engines, equipment to connect drive shafts of engines to motor shafts, and fuel and coolant sources. Figure 4.2-1 and 4.2-2 illustrate the connection of a truck engine to an induction motor for induction generation, and a schematic of the load connection.

Figure 4.2-1[10]

CONVERSION OF TRUCK ENGINE TO INDUCTION MOTOR

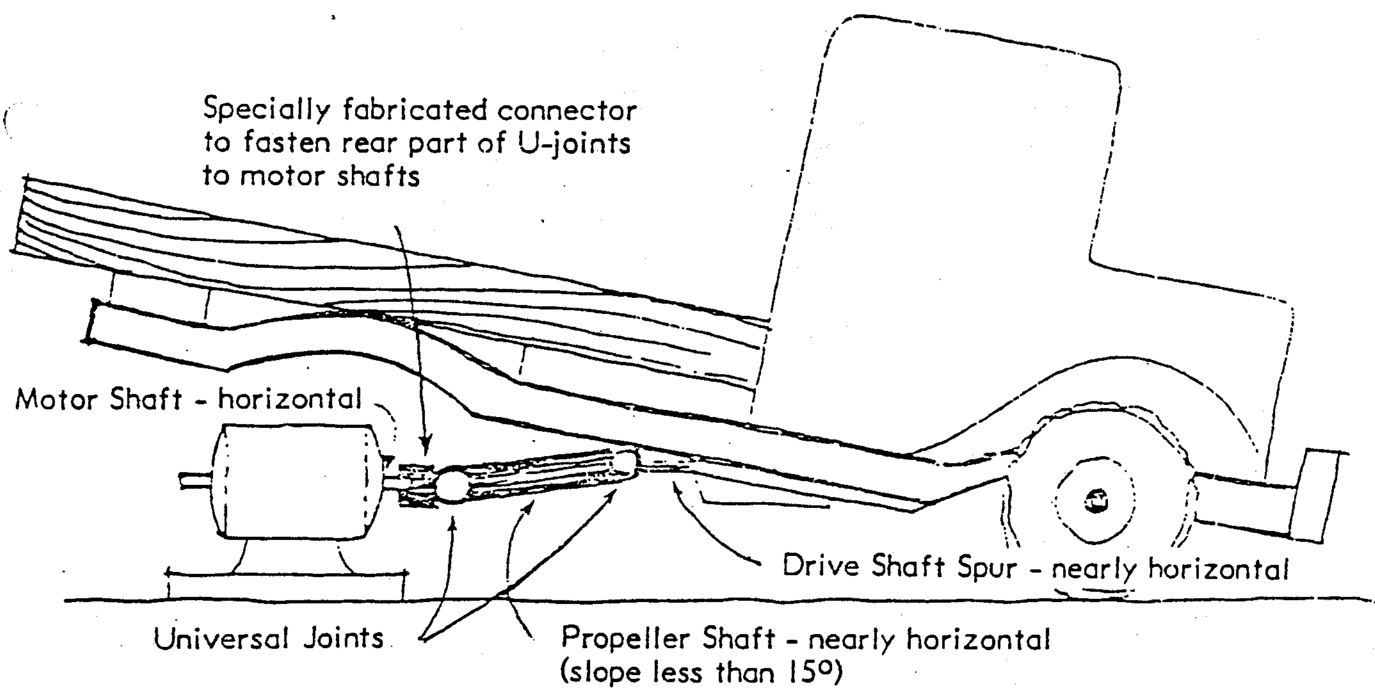
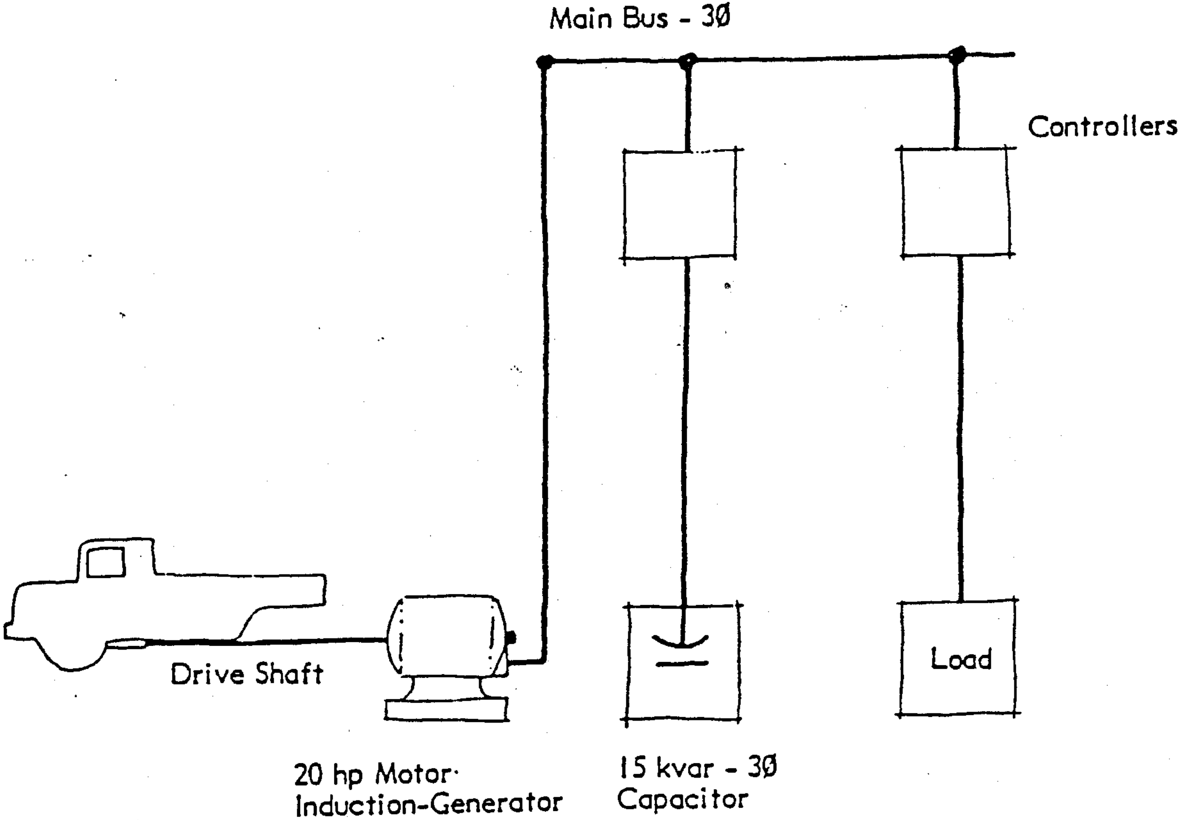


Figure 4.2-2[11]

SCHEMATIC OF LOAD CONNECTIONS



The URS study found that improvised induction generators can develop useful electric power to fill a wide variety of needs during power shortages. Electric motors, heaters, fluorescent lamps, and other devices can be operated. The safety of the systems and other considerations were addressed, as well as connecting these dispersed systems into local grids. The study developed a manual and training program which should be a valuable addition to emergency and civil defense programs. The conclusions were as follows:

- The skills of competent craftsmen are required at some stage of assembling or using an improvised source of electric power. The skills required for improvising an induction generator are an electrician, a welder, and a mechanic. Pre-disaster planning and an exercise can substantially reduce these skill requirements during an emergency.

  It is important to define electric power requirements specific to each facility, especially with regard to rapidity of response (how fast must power be restored), reliability (cost of an unscheduled shut-down), maximum load, and degree of power regulation. If these requirements are very stringent, then an improvised power plant—either an induction generator or a rental engine generator set—is very likely unsuitable. A stand-by power plant that is permanently installed and with a transfer switch will be necessary to meet stringent requirements. It must also be tested regularly to maintain operability.

  An induction generator is the preferred source of improvised electric power when:

  - All of the major or expensive parts are available
  - Time and resources can be made available to set up and test it
  - Equipment to be served can function adequately with the power developed by the machine
  - An interval without power, while assembling the induction generators, is acceptable
  - Renting or leasing an engine generator set is either unattractive or impractical
  - Maintaining engine generator sets is either too expensive or impractical

  Despite the practicality and convenience of using induction motors as induction generators, the idea probably would not occur to most of those who could benefit from it either during pre-disaster planning or during a prolonged power outage.[12]

SECTION 4

DISPERSED ENERGY SOURCES AND COMMUNITY SURVIVAL

FOOTNOTES

1. Civil Defense for the 1980's—Current Issues, Defense Civil Preparedness Agency, Washington, D.C., July 13, 1979, p. 35.

2. Garwin, Richard L., letter to Representative John Seiberling, February 4, 1980.

3. Calder, Nigel, Nuclear Nightmares, An Investigation into Possible Wars, Viking Press: New York, N.Y., 1980, p. 155.

4. Ibid.

5. Van Horn, W.H., G. Boyd, and C.R. Foget, Repair and Reclamation of Gas and Electric Utility Systems, URS Corporation, Burlingame, Ca., July, 1967.

6. Foget, C., W.H. Van Horn, Availability and Use of Emergency Power Sources in the Early Postattack Period, URS Research Corporation, Burlingame, Ca., August, 1969.

7. Black, R.H., Improvising Electric Power from Induction Generators During Prolonged Power Outages, URS Research Corporation, San Mateo, Ca., September, 1971.

8. Foget and Van Horn, op. cit.

9. Ibid.

10. Figure 4.2-1, "Conversion of Truck Engine to Induction Motor," Source: Black, op. cit.

11. Figure 4.2-2, "Schematic of Load Connections," Source: Ibid.

12. Ibid.