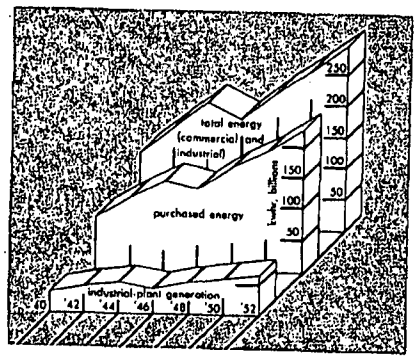

Industrial power generation has risen slightly in recent years but nowhere as fast as has amount of energy purchased. This relative decline in industrial generation stems from the fact that, in general, the small private plant is less fitted to cope with rising costs of fuel and labor than is the large central station. Yet in spite of this general trend, decision to make or buy depends on the often complex economics of each individual situation.

Purchasing energy avoids need to make a relatively large investment in generating equipment. Many industrialists today believe that capital invested in manufacturing facilities yields a greater return. They also believe that purchasing energy gives more economic flexibility to meet business slumps, or changes in markets and products. And they feel it shifts problems of operating and maintaining generating equipment to a specialist in them — the utility company.

Private generation should be considered in many cases, however. It often proves economical in industries where large quantities of process heat are required, particularly where the relationship of heat and power loads is such that all or most of the electrical energy can be generated as a byproduct of process-heat demand. Availability of cheap byproduct or waste fuels also favors generation.

Even without process demands or byproduct fuels, private generation may pay in large plants with high load factors, where conditions approximate those which permit efficient utility operation.

And, in rare cases, you may not be able to buy what you need, in terms of amount, reliability, etc. In all cases, make a complete study and don't overlook possibility of buying part and making part.

Is outdoor generation practical?

Rising building costs make outdoor generating facilities look more attractive. Yet among central station designers who have had wide experience with outdoor construction there's still less than full agreement as to how far it pays to go.

Against savings in building structures you must stack cost of protecting outdoor equipment and, some say, higher costs of operation and maintenance influenced by weather conditions.

Certainly, if your new plant will enjoy a favorable climate, look into the many possible outdoor and semi-outdoor layouts. Check carefully into effects on operation and maintenance. And if you decide to go outdoors, be sure to "sell" your operating force on the practicality and merits of it.

If you decide to generate all your needs, or part, study factors affecting size and number of units, look into short-circuit ratio

If you decide to generate, you need to look into some basic considerations of generator selection—size and number of units, and their characteristics.

Generating Units. We use the term "generating units" advisedly, since performance of the prime mover is perhaps even more important than that of the generator and we must *always think in* terms of the combination. Here are some considerations that affect decision on number and size of units:

In general, cost per kw of generating units goes down as size goes up. Efficiency usually improves *as size goes* up. (This is notably the case with steam plants; efficiency of diesel and hydro units doesn't change as markedly with size.) Operating labor costs are more nearly proportional to number of units installed than to total plant capacity.

In any given generating unit, *efficiency varies with load.* It's usually low at light loads, rising to a "best point" somewhere between 75% and full load and falling off slightly at higher loads. Shape of the efficiency curve depends on type of prime mover, and to a lesser degree on size, design, etc.

Nature of Load. Above characteristics of generating units point in the direction of supplying load with one large unit. Yet this is rarely possible because of load conditions.

Take the question of continuity, for example. Where operation is continuous and interruptions are costly, reserve capacity is indicated, not only for forced outages but for scheduled maintenance outages. It's usually more economical to provide reserve for several smaller units than for one large one. A typical setup might use three units, any two of which can carry the load. This also provides economically for load growth—adding a unit gives four machines with any three able to carry full plant load. Where continuity is a factor, always check to see what standby service, if any, your utility can provide, and what it costs.

Load factor also exerts strong influence. Low load factor works against use of one or two large units since much of the operation would necessarily be on the low part of the efficiency curve. A special problem in some industries is weekend load, which may require a special small unit. The load-duration curve proves a valuable device for relating unit sizes to plant load conditions.

Problem of obtaining a good balance between process-steam and *electrical* demands also influences number of units, since more than one type of steam turbine may be required.

Generator Characteristics. Now let's look at the generator itself. Start by checking characteristics as catalogued in manufacturers' literature. Standard-design generators meet most ordinary requirements but a "special" may be the answer to highly fluctuating loads, pulsating driving torques, abnormal power factors, especially leading or unbalanced single-phase loads. Where you intend to operate new generators in parallel with existing units, make sure that prime-mover, governor and generator characteristics are compatible.

See that the generator is able to withstand any overspeed it may meet in service. This is generally 85 to 100% for waterwheel generators, 25% for engine-driven and 20% for turbine-driven units. In probing the characteristics of industrial generators it's a good idea to consult suggested specifications proposed by *NEMA* for the type of generator unit under consideration.

Short-Circuit Ratio. Met in every generator specification, the term *short-circuit ratio* (scr) may not call immediately to mind its full meaning. The textbook definition is "*ratio* of field current required to produce rated voltage at rated speed and no load to the field current required to circulate rated stator current when operating at rated speed under sustained short-circuit conditions."

What significance has this in an industrial-generator specification? High scr gives desirable voltage stability characteristics, but to get it *designer* must put more copper and iron in the generator. This means larger housing and structural parts, greater weight, higher cost. Other drawbacks are higher initial and sustained short-circuit currents and some increase in generator losses.

But today desired stability characteristics can be obtained at lower scr values because of improved excitation systems. These are more sensitive and able to produce the rapid and large changes in field current needed to accommodate new conditions. Trend over the years is to lower values of scr, smaller and less costly generators.

Also consider layout of cooling equipment, exciter cooling and speed, generator... ...regulation and voltage rating. Remember — voltage trend keeps moving upward

In the past, generator air coolers were *usually in the* basement directly below the machine. Today's units offer them built into the frame or directly alongside it. This is important where noncondensing units are used since the basement may be eliminated. Choice depends on a comparison of cost of basement construction against increased cost of generator with cooler built in or *alongside. Don't overlook* reduced ductwork and installation cost and easier maintenance of the above-floor layout.

Exciters. Separate cooling systems for generator exciters are now available. One justification for a separate system is the difference in cooling requirements. Reducing cooling pressure *in the exciter rules* out possibility of air bubbles working their way in and through bearing lubricant.

While you look at the exciter from the cooling angle, consider its optimum speed. This applies particularly to engine-driven generators running below 600 rpm. In such cases, consider belting the exciter so it operates at a higher speed. Think *in terms of* a maximum speed of 1750 rpm to get maximum speed of response in your voltage-regulating system.

Regulation. Standard generator regulation figure of 40-45% at 0.8 pf will satisfy most requirements. But there are exceptions. Typical would be the case of a paper mill, where the large chipper motor, biggest single load, would influence selection of generator capacity and set a precise voltage-regulation requirement. Starting needs of this single heavy load might materially change the 40-45% figure above.

Generator Voltage. In general, generator voltage is a function of load size, distance from generator to load, voltage of connected system and, in a growing number of cases, the size of the largest single load unit.

Standard voltage ratings for various generator sizes are catalogued by NEMA as follows: For small ac turbine-generators in the 75- to 400-kw range, standard ratings are 240, 480, 600 and 2400 v. For geared-turbine synchronous generators 500 to 1500 kw, voltage range is anywhere from 240 for 500 kw to 4160 for 1500. *Minimum standard voltage for 1000- and* 1500-kw units in this class is 480 v. All other geared units can be supplied at 240, 480, 600, 2400 and 4160 v. Stick to these standard voltage ratings; where possible select the highest.

In still larger sizes, namely direct-connected turbine-generators rated 2000 to 10,000 kw, inclusive, available voltage ratings are shown in the chart, right.

In all questions of generator voltage, keep in mind the trend toward generating at higher voltages (up to 13.8 kv) and distributing at that voltage to secondary substations.

Modernization. In any modernization program, review the voltage question completely. Always think in terms of higher generator and distribution voltages; transformers will serve well to tie sections of different voltages. In adopting higher voltages study the insulation techniques used by each generator builder. How the maker copes with winding bracing and insulation problems in general may affect your maintenance requirements for years to come.

If you plan, at some later date, to swing from delta to Y connection to boost generator voltage, make sure the generator is now connected delta.