When size matters

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Not so long ago the USA and some European countries experienced major blackouts. Stability problems and blackouts in large, complex electricity networks like these are often caused by the tripping of a large generating unit or by transmission system problems.

In smaller grids or isolated networks, smaller units can create similar problems. For grids smaller than 1000 MW, even a trip of a 50 MW unit can create a major local blackout.

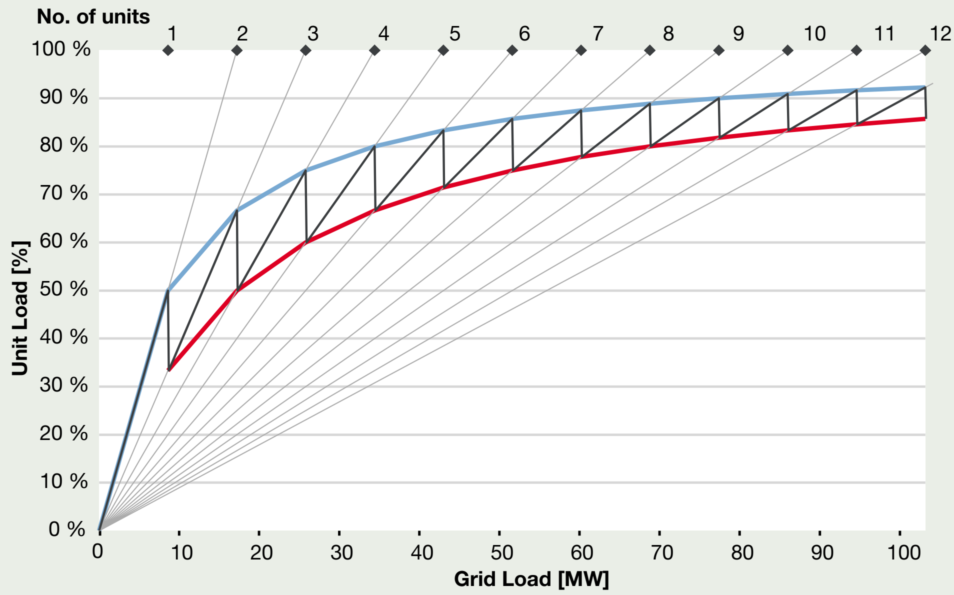

Fig. 1 Number of units in operation and unit loads in a secured system.

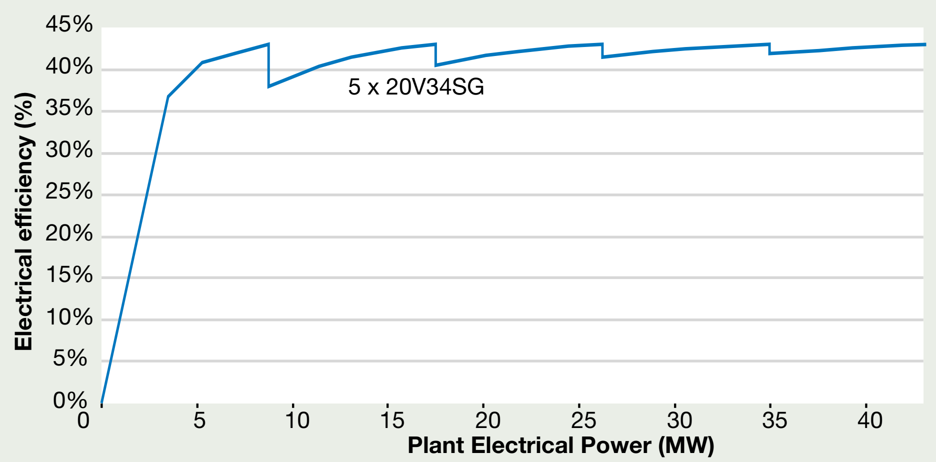

Fig. 2 Part-load electrical efficiency of a 43 MW 5 x 20V34SG plant.

When installing new capacity in existing grids, the tendency is often to go for bigger unit sizes, to obtain lower investment costs per kW and higher efficiency. Installing these large blocks of power endangers the stability of the grid. To obtain an efficient gas turbine combined cycle plant (GTCC) with low costs per installed kW, the unit size is normally 150 MW and above. If the plant consists of one gas turbine and one steam turbine, the plant can be considered as just one unit. The same goes for steam turbine plants, where the plant normally has to be bigger than 100 MW to be efficient.

Power plants built up of diesel or gas engines have normally been the favourite choice for islands and small isolated grids. The new gas engines are state-of-the-art technology with low emissions and high efficiency. Investment costs have also come to very competitive levels. The world's largest spark ignited gas engine, the Wärtsilä 20V34SG, gives 8.73 MW at the generator terminals in the 50 Hz version. The optimized engine cooling system and ventilation system have reduced the plant's own power consumption to a minimum. For pure power generation, the plant's own electricity consumption including the step-up transformer is less than 2%. For plants with these engines, this gives an output of 8.5 MW per generating unit and a real net electrical efficiency of over 44%. To reach the same efficiency with gas turbines, the plant would have to be a combined cycle plant. In practice, to achieve this level of net plant efficiency with a GTCC, the unit size would be close to 100 MW. Similar efficiency with a steam turbine power plant can only be achieved in special places with cold conditions and large units of several hundred MW. A gas engine plant could also be built as a combined cycle and then achieve close to 50% net efficiency with 30 MW plants.

A 1000 MW grid cannot use these large single unit power plants efficiently. It would require investments in back-up power and part-load operation of all the installed units. With reciprocating engine plants, the situation is totally different. Since the generating units are highly efficient even as 8.7 MW units, it is preferable to build up a plant from several units.

Let us consider the case where a firm power requirement of 100 MW is based on the 20V34SG gas engine. 12 units are

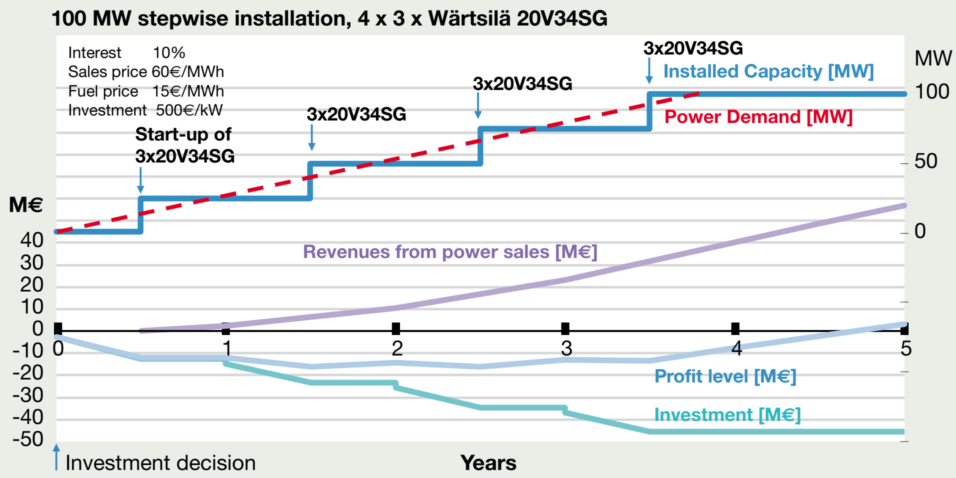

Fig. 3 Fast delivery and stepwise expansion means rapid profit generation and low risk.

Ringkøbing Fjernvarmeværk in Denmark is powered by a Wärtsilä 20V34SG engine.

needed to generate this output. With 13 units at 90% load, the remaining engines can easily take up the load if one engine trips. Part-load operation of the plant can also be achieved with part-load operation of individual units. This is illustrated in Figure 1. Adding one or two engines to cover maintenance intervals will provide almost 100% availability for a 100 MW plant. This can be achieved with 15 units in a 128 MW plant. With this setup, even a grid or network of only 100 MW can be stable and reliable with 28% reserve capacity installed. To achieve the same reliability and redundancy with a 100 MW GTCC, a more than 200 MW plant would have to be built (>100% reserve capacity) and still not meet the same demands.

If some reserve capacity is available, the units can be operated in a more optimal way at plant part-load operation. This is illustrated in Figure 2. For part load operation, these units can be started or stopped individually according to load. As the figure shows, even just five units give an almost flat part load efficiency curve.

Smaller unit sizes also mean easier transportation and shorter delivery times. A 100 MW gas engine plant can be delivered in as little as 6 months. The delivery time for a corresponding GTCC is at least three times as long.

A multi-unit setup also makes it possible to install a plant rationally. Extra generating units can be added as demand for power increases. This optimizes not only the operating performance of the engine plants but also investment costs. It is possible to start small and increase capacity as power demand increases. This is illustrated in Figure 3. Fast-track delivery means rapid profit generation. This gradual approach may create the possibility of self- financing. Time factors and the level of investment reduce risks to a minimum in these projects when compared with large unit power plant projects.

With the above multi-unit setup, maintenance can be planned and scheduled carefully. Since all maintenance can be done on site and all the units are identical, maintenance work is easier and spare parts costs are low. Even the breakdown of one unit will not have much impact on availability.

The combination of high efficiency and small unit sizes gives an unbeatable solution, especially for small and medium size grids. For these grids, plants built as multi-unit installations give clear benefits. Unit size really matters. ■