

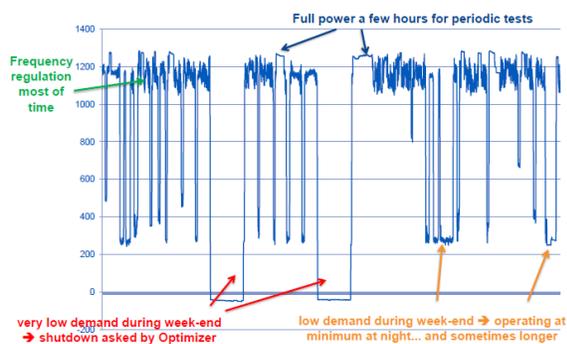
Flexible Operation Support

Background

When Nuclear Power Plants (NPPs) are constructed, electrical grid design and operating requirements have most often led plants to operate in baseload generation. Changes in market conditions, mainly driven by lower cost natural gas prices and expansion of renewable energy sources, has, however, led to new thinking in operating and maintaining NPPs. As market conditions continue to change, Westinghouse has the knowledge and experience to support your Flexible Operation (FO) goals.

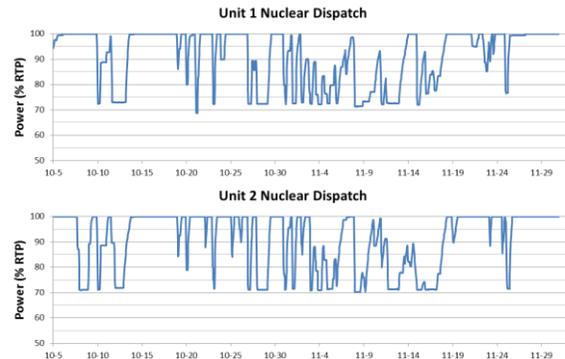
Plants were designed for load follow

The majority of the world's pressurized water reactors (PWRs) were designed for load-follow operation. The load follow design basis for these plants includes the ability to manage thermal power between either 15% or 50% to 100% thermal power at a rate of 5% per minute with an assumed number of load follow cycles, which range up to 18300 depending on the vintage of the plant. Thus the plant has the capability to do this daily for the 40-year original operating life of the plant, and this functionality is tested during plant commissioning. An extreme example of load follow is shown below as an indication of what is possible.



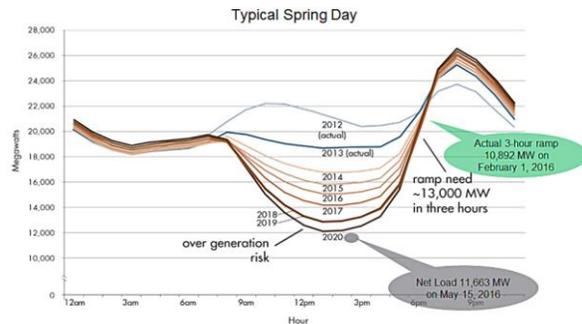
This kind of operation has been used successfully in Europe for many years – especially in France and Germany.

Until recently, this type of load follow was not practiced in the U.S.; however, this is changing as the U.S. energy market evolves, as utilities use FO to balance their supply needs. The figure below is an example of FO being used by a U.S. utility.



Why are we seeing more FO?

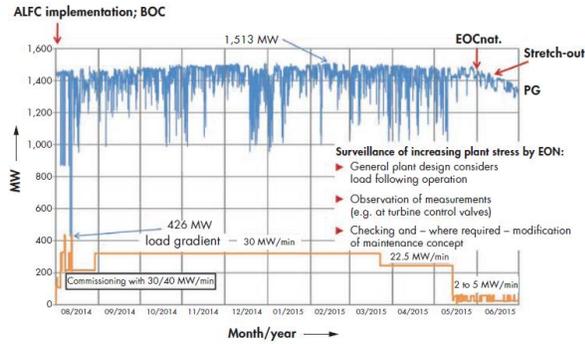
As renewable capacity grows, the baseload demand (net demand – renewable generation) becomes more dynamic, placing new demands on baseload operators.



The same price per installed MW now exists for wind as it is for gas turbines, even without any tax credits, so continued growth in wind power is both economic and expected. Pricing on other renewable sources are also decreasing.

Solar production sources are also becoming cost competitive, and governments around the world are seeing this as the future.

Renewables mean new thinking

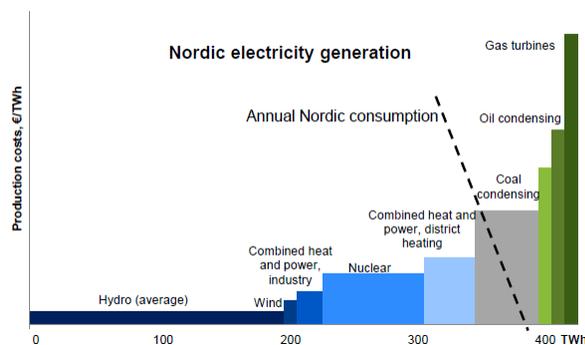


Fuel cycle 2014/2015 in E.ON NPP KKI 2 with ALFC and surveillance of plant stress.
(Information Courtesy of E.ON)

For the ISAR2 Grondhe plant according to Platts.com: "While the plant was used exclusively in baseload [around the clock operation] in the past, it is now used up to 600 hours each month to regulate load," E.ON said, adding that "it has increased fourfold the capability of the reactor to ramp up or down to now 40 MW per minute."

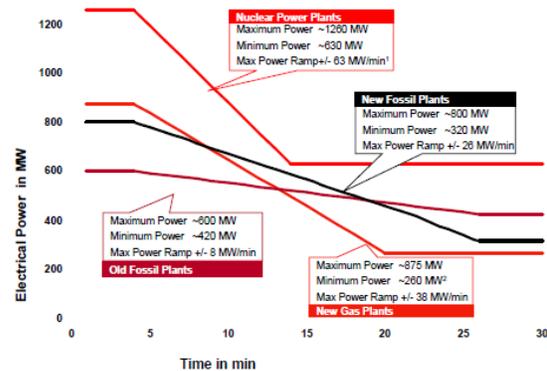
Will I need to do this?

Flexible operation is likely to occur at your NPP if your service area is adding significant renewable generation or neighboring areas with renewable generation are adding transmission lines to your service area. Renewable generation typically has the lowest incremental cost, and, therefore, will generally receive priority to support demand. NPPs that cannot operate flexibly may not be economically viable for the long term.



Generation is dispatched from left to right (lowest cost to highest cost) until demand is met

Won't other plant types do this better?



Nuclear plants are competitive in flexibility
(Figure Courtesy: EON)

The introduction of FO into operating NPP capabilities will increase operating flexibility to better compete with other sources of generation.

How does this impact my plant(s)?

- Core impacts / history effects – First Time Engineering needed to evaluate impacts and plant history, and cycle specific impacts will need to be evaluated each reload..
- Safety analysis – like an uprate, but most items are evaluated as no impact
- Load and Structural Verification (fatigue design margin). Many plants use existing margin for plant life extension.
- Seismic piping analysis which can, in some cases, be dispositioned without extensive analysis.
- Trade-off on boration vs. control rods for water management
- Balance of Plant impacts:
 - Control systems
 - Flow accelerated corrosion
 - Increased wear

Westinghouse can support your FO future

Westinghouse has the wide range of skill sets required to safely and efficiently address all of your potential plant FO impacts. Our experts will work with the NPP's to develop the FO strategy and identify/analyze modifications to operations and control strategies to optimize their ability to operate flexibly. Westinghouse is committed to working with you to define only the essential scope required to keep your plant operating competitively.