Maximum Load Optimization For Elvis

1 Introduction

Especially for commercial and other major customers, energy delivery rates are often including a highly performance-based component. This is usually determined from the measured quarter-hour mean value with the highest absorbed power within a billing cycle. Thereby, an incentive is created to avoid power peaks, which are particularly expensive for the power company because of the power reserves to be kept ready.

For the customer, it is therefore economically meaningful, to limit the maximum power by means of appropriate technical (or organizational) actions. In the simplest case, simple "maximum watchers" are used for it, turning off certain consumers, if an adjustable instantaneous power is exceeded.

More intelligent systems are using different optimization strategies in order not to exceed the adjusted quarter-hour target, but to utilize it as well as possible, taking into account the characteristics of different consumer types. Such a maximum load optimization can be realized comfortably by Elvis.

2 Basics

2.1 Process and configuration data

Which (dynamic) measurement and control variables and which configuration data are playing a role for the maximum load optimization?

2.1.1 Energy Data

Work	This is the current counter value (in kWh)
Power	Active power (in kW)
Sync Pulse	A pulse will be provided by the power company, to signalize the end of one (quarter hour-) measuring period and the beginning of the next one.

The sizes of work and power can either be calculated directly by a corresponding counter module and be delivered via the bus, or be generated by Elvis from the individual counting pulses. In the latter case, it’s necessary, to provide for a secure transmission, in particular you have to watch the bus load (possibly, use pulse dividers!), to avoid loss of telegrams.

2.1.2 Consumer data

Interruptible consumers must be selected, to be involved into the maximum load optimization. It‘s advisable, that these are plants, which

- need an appreciable performance (and typically are also switched on during peak demand times);
- can be turned off without or with acceptable interference of operation at least temporarily (e. g. due to storage capacity, catch up ability).

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Typical candidates are electric heating and cooling systems, fans, etc.

For installations, which can be switched in several steps, every switched step is considered to be a consumer.

For each consumer, the following process data are important:

State	Indicates, whether the consumer is switched on or off at the moment. This is important, because, by locking of a switched off consumer, no reduced performance can be achieved of course, too.
Release	The decisions of the maximum load optimization must have priority over "normal" operating functions. This can be reached, for example, via actuators with AND linkage function, whose one input is driven by the maximum load optimization. Alternatively, this link can be also done in Elvis.

Besides that, some information about the consumer is needed:

Off power	Estimation of the reduced performance, if the consumer is switched off.
Priority	Consumers with lower priority are turned off at first and reconnected at last. The priority may also be dynamically changeable (e. g. via a time program).
Minimum On time	Depending on the kind of the consumer, it may be necessary to wait a certain minimum time after power up, before it may be turned off again.
Minimum Off time	Depending on the kind of the consumer, it may be necessary to wait a certain minimum time after turn off, before it may be powered up again. That's relevant e. g. for motors, cooling units, etc.
Maximum Off time	Depending on the kind of the consumer, this one must eventually not be switched off for more than a certain time. That's relevant to all consumers exploiting a memory effect.
Dead time	At consumers consuming power for a certain time even after turn off (for example, if an ongoing operation cycle must be completed first), a dead time can be specified.

2.2 Procedure

Common to all methods of maximum load optimization is, that they are trying, due to a forecast of the power curve for the rest of the measurement period and due to consumer features, to reach the adjusted power limit as accurately as possible by selective disabling and enabling of consumers,

There are a number of methods differing in the prediction function. Without going into details, here are the essential characteristics of the methods used in practice:

- Free load procedure: Here, the instantaneous power is extrapolated substantially. This leads to a rapid response as well as many switching operations.
- Medium load procedure: Similarly, but uses the mean power instead of the instantaneous power, and therefore causes less switching operations.
- Base load procedure: Ensuring a certain base load across the entire measurement period. This method has the most customizable (and to be adjusted) parameters.

It depends on the type of consumer (e. g., are frequent switching operations unfavorable?), the typical load curve (variation in amplitude and frequency) and the total off power, which procedure is optimal for a specific application.

3 Implementation in Elvis

3.1 Developing

At the moment, there's only a part of the developing the maximum load optimization occurring in the Elvis Developer, and another part via an external configuration file. In later versions of Elvis, the information, included in the configuration file, will be incorporated in the Elvis database and can then be edited directly in the Elvis Developer.

In the Elvis Developer, the following steps have to be carried out:

1. The maximum load optimization uses some custom datapoint properties for the consumer datapoints. These must be created in (the easiest way via import of the file "LM-DPProperties.csv"):
   - "LMPower": For setting the off power (in kW)
   - "LMPriority": For setting the priority (1, 2, 3, ...)
   - "LMMinOn": For setting the minimum on time (in seconds)
   - "LMMinOff": For setting the minimum off time (in seconds)
   - "LMMaxOff": For setting the maximum off time (in seconds)
   - "LMDeadTime": For setting the dead time (in seconds)
   - "LMLastSwitch": For internal use.
2. For each consumer you have to create an own datapoint. The datapoint type is one of the Boolean types (e. g. switch, EIB switch).
   - The ActualValue must reflect the current operational state of the consumer (turned on or off).
   - The NominalValue is set by the maximum load optimization to True, if the consumer may be switched on, and set to False, if the consumer must be turned off. A corresponding link to the requirement, for example by local operation, has to be realized either in the plant or via an Elvis calculation.
3. In addition, at least the following four datapoints have to be created, which are needed by the maximum load optimization:
   - Sync pulse: The ActualValue of this datapoint must fire at each sync pulse; best to create as a Boolean command datapoint type (such a datapoint type can be imported from the file "LM DPTypes.csv").
   - Meter reading: The ActualValue of this datapoint must contain the current meter reading (in kWh).
   - Power: The ActualValue of this datapoint must contain the current active power (in kW). (Not required for medium load method)
   - Power limit: The ActualValue of this datapoint must contain the achievable power limit (in kW), Be sure, to make the ActualValue persistent!
4. It makes sense to create additional status data points for diagnostic purposes:
   - Mean power: The ActualValue of this datapoint is set to the mean power in the current measurement period.
   - Last Mean power: the ActualValue of this datapoint is set to the mean power of the past measurement period.
   - Maximum Mean power: The ActualValue of this datapoint is set to the largest so far achieved mean power per measurement period. This value can be manually reset to 0 at any time.

The further configuration is done via a file in the INI format, which must be named *databasename*-LM.INI. An appropriately commented template is available.

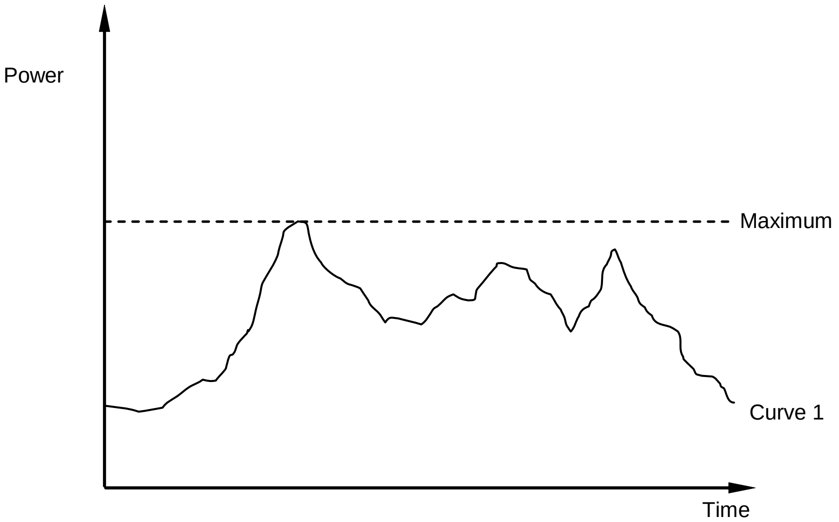
3.2 Configuration

If some of the datapoint properties described above are to be changeable by the user, this can be done easily via a corresponding (protected) configuration page in the Terminal.

3.3 Analysis and valuation

The most important parameter of the maximum load optimization is the power limit. If it is set too low, it cannot be met and the (futile) maximum load optimization might lead to not acceptable operating problems in the long term. If it is too high, the optimization potential is not exhausted and unnecessarily high energy costs are accruing.

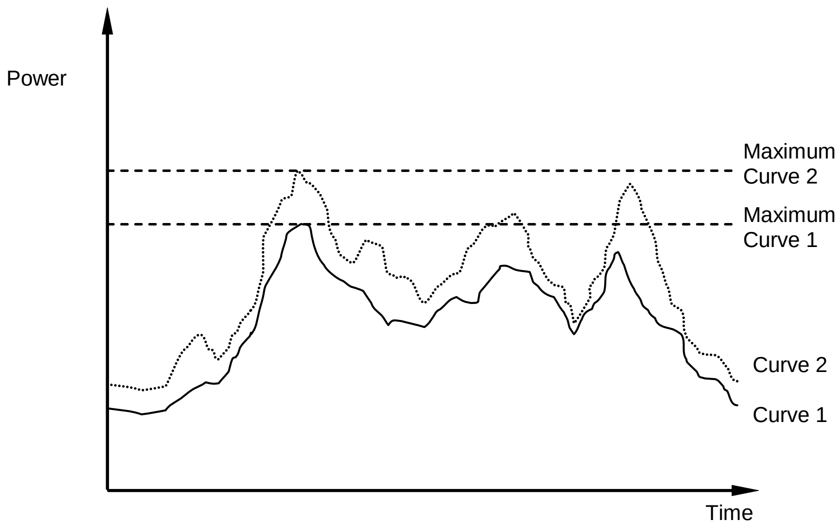
The power limit is determined mainly by the not interruptible consumers. For determination of the power limit, the sum of the powers of all not interruptible consumers, which are switched on together in typical operation (curve 1), can be initially used.



The power limit for the optimization cannot be less than the maximum of the curve 1.

Also the interruptible consumers will be considered next. The sum of the not interruptible consumers and the interruptible consumers is represented by the curve 2.

Here it is clear, that savings are available, because the peak load of the not interruptible consumers (maximum of curve 1) is significantly increased by the activated at the same time consumers, which can be switched off (maximum of curve 2).



The power limit for the optimization may be less than the maximum of the curve 2.

If the power limit is set close to the maximum of the curve 1, there is a high probability, that in some cases this limit can't be met. For example, by the combination of unfavorable circumstances, the sum of the not interruptible consumers only needs to be above this limit.

If the power limit is shifted upwards, the probability of exceeding decreases, but the cost increases. Near the maximum of the curve 2, an exceeding is almost impossible, but high, avoidable costs are entailing.

The historical data, provided by Elvis, are supporting the valuation:

- General:
    - Largest quarter hour power so far
- For each measurement period:
    - Achieved quarter hour power
    - Executed shutdowns

Optionally, a log file is generated by the maximum load optimization (can be enabled in the configuration file). This is a text file containing the following columns separated by TAB (can easily be viewed e. g. in Excel):

- Time: Time of day
- Event: Event ID:
    - Sync: sync pulse received
    - Lock (was On): An at the moment activated consumer is switched off
    - Lock (was Off) : An at the moment not activated consumer is locked against turning on
    - Unlock: A locked consumer is enabled for turning on
- Datapoint: Name of consumer datapoint
- Work: Current meter reading, calculated from the count at last sync pulse
- Power: Current active power
- MeanPower: Average power in the current measurement period
- Seconds: Time since the last sync pulse in seconds