

The Energy Control Center of the Future in the 100% Clean & Renewable Energy Systems

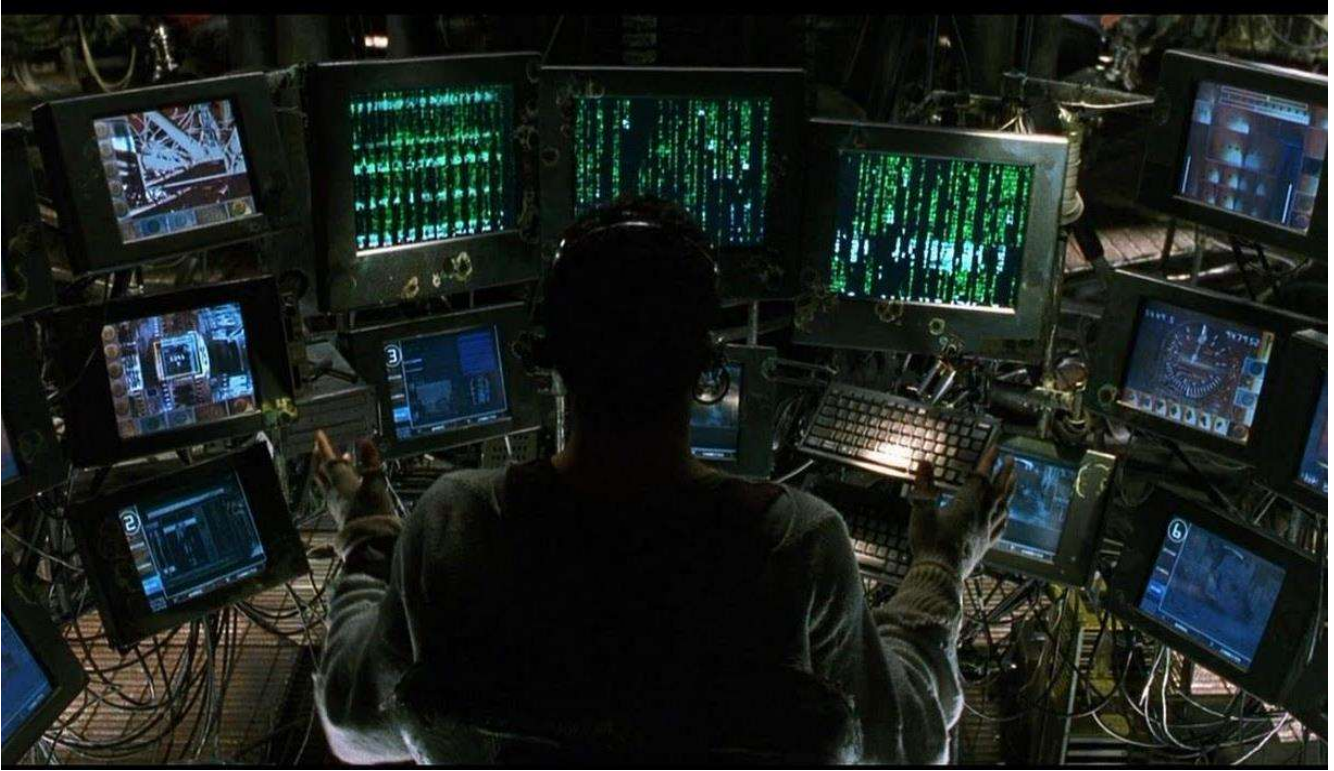
An Online Continuing Education Course for Engineers

Course Number: E-2100

Credit: 2 Hours / 2 PDH / 2 CPD

The Energy Control Center of the Future in the 100% Clean & Renewable Energy Systems

Ahmed Mousa, PhD



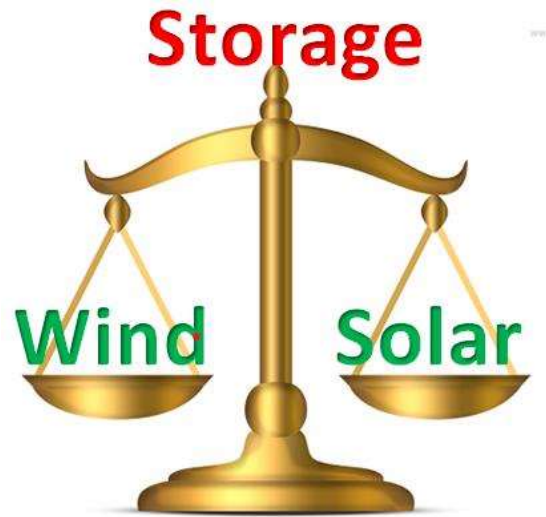
Introduction:

There is no doubt that the energy system is going through a massive transformation and digitalization phase. Political and customer demands are needing to be met, such as:

- Building smart grids,
- Transportation electrification (electric vehicles, vehicle 2 home grid),
- Building electrification (converting gas heating to electric heating),
- Cybersecurity,
- Transactive energy,

- And accommodating distributed energy resources, i.e., solar, onshore, offshore wind, and energy storage.

Several governors, commissioners, cities, states, and the country's massive goals expect 100% clean or renewable energy by 2050 or sooner.



Clean and renewable energy systems share the reliance on wind, solar energy storage, and hydropower. Nuclear energy is only included in 100% clean energy systems. Both systems include energy storage which is expected to play a major role since both systems will rely on intermittent energy resources, i.e., solar and wind energy.

To meet those aggressive goals, a very large percentage, if not all fossil fuel power plants are expected to shut down. Also, locations that adopted 100% renewable energy will shut down all their nuclear power plants. The utility world is split concerning the stability and reliability of the future grid, where engineers and energy control center operators argue that the future system is not promising due to the lack of large power plants, which results in a much weaker system inertia when compared to the current system. Also, the intermittent nature of renewables is another major issue that must be addressed. Politicians, vendors, the market, etc. are confident that large power plants are not required for the future and that there will be sufficient renewables to support the future system and enable a future system that meets all the climate change goals.

Planners are accustomed to providing load relief plans for the next 10/20/30 years based on the latest load forecast. Energy control center operators operate at a very narrow timeframe, i.e., the current moment, their current shift, and the next shift. However, energy control center operators have a very difficult future task/challenge which is operating 100% clean and renewable energy systems every day, i.e.:

- Sunny days
- Slow-moving clouds
- Fast-moving clouds
- Very windy
- Non-windy days, etc.

New York City has the most complex electric system in the country, if not globally. New York City is known for many great things, i.e., the financial capital of the world, the medical capital of the world, the NY Yankees, Central Park, etc. However, it is not known for having great or even good solar irradiance, thus because of the poor solar irradiance in New York and many locations globally, other alternatives are required to meet the daily system peak hour and the other 23 hours in the day, every day, 365 days, and every other year. It is worth noting that if the future 2050 energy system is not successful or suffered from a lack of resources/generators, one cannot just click a button to restart a fossil fuel power plant that was closed 20 years ago (not to mention dismantled and decommissioned), other closed power plants have been converted to solar sites, energy storage sites, etc. Thus, there is nothing available to restart.

The Energy Control Center Structure

The energy control center structure varies significantly by the utility; thus, it is almost impossible to create a “one size fits all” future control center. One major difference is the BES, the bulk electric system refers to the transmission system that starts from 100 kV (1,00 thousand volts). Many utilities have transmission systems/circuits lower than 100 kV, the most common being 69 kV; some even have transmission circuits as low as 13 kV → Basically, they create a medium voltage system that has the same characteristics as the transmission voltage. The higher the voltage, the higher the capacity, thus a 500 kV transmission circuit has exponentially higher capacity than a 13 kV transmission circuit. Also, the longer the circuit in length, the greater the voltage drops; thus 13 kV transmission circuits will not be able to travel far.

According to the North American Electric Reliability Corporation (NERC), a system operator is “*an individual at a control center (Balancing Authority, Transmission Operator, and Reliability Coordinator) whose responsibility it is to monitor and control the electric system in real-time.*”

Also, according to NERC, the control center is defined as *one or more facilities, including their associated data centers that monitor and control the Bulk Electric System (BES) and host operating personnel who:*

- *Perform the real-time reliability-related tasks of a Reliability Coordinator*
- *Perform the real-time reliability-related tasks of a Balancing Authority*

- *Perform the real-time reliability-related tasks of a Transmission Operator for Transmission Facilities at two or more locations*
- *Can act independently as the Generator Operator to develop specific dispatch instructions for generation Facilities at two or more locations*
- *Can operate or direct the operation of a Transmission Owner's BES transmission facilities in real-time*

According to NERC, the operating personnel does not include the following:

- *Plant operators located at the generator plant site or personnel at a centrally located dispatch center relay dispatch instructions without making any modifications.*
- *Transmission Owner or Transmission Operator field switching personnel.*

In the system operations world, it is now common to discuss the need for DSOs, and TSOs. DSO is the distribution system operation control center, while TSO is the transmission system operation control center. As the reader will see, the author believes the grid is in dire need of an ASO, not a DSO or a TSO, where an ASO is the advanced system operations control center that is not limited by a distribution or transmission voltage. The current energy control center jurisdiction includes all the required switching, protection, monitoring, reacting to system emergencies, etc.

The author is proposing that the proposed ASO will not replace existing control center functionalities; ASOs will supplement existing control centers by addressing all other futuristic grid changes. Smart utilities will invest in additional control centers that resemble ASOs, while others may struggle to maintain the integrity, reliability, and stability of the system.

It is very rare for utilities to discuss research & development (R&D) projects/possibilities among energy control center operators, on the contrary, operators are encouraged, trained, and instructed to focus on the current task at hand, not to multi-task, and to utilize existing standards and guidelines to operate the system, thus, the need for the ASO to be the research and development arm of system operations. Currently, the planning and other engineering groups provide ongoing support to the control centers, and they even have a watch engineer on shift to perform any required analysis.

System Planning vs. System Operations:

It is worth repeating that most planning groups are not involved at all with the daily system operations; this is one of the system operations' main tasks/functionalities. However, planning does support system operations when asked to evaluate a proposed outage or perform load flow simulation(s) based on various system conditions usually because of emergency temporary system conditions or an upcoming scheduled job.

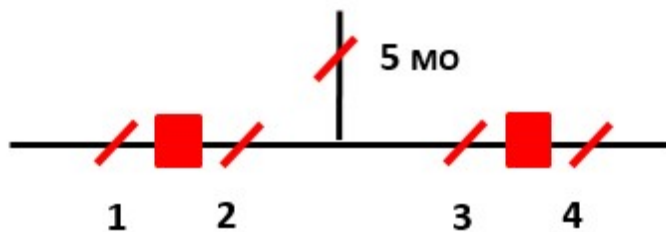
There are numerous standards, reports, and documents that planning provides regularly to system operations. Numerous groups provide support, guidelines, reports, etc. to system operations as well. Three very critical documents that are the backbone of system operations are:

- Load forecast by substation, feeder, etc.
- Equipment ratings: unlike planning, system operations use various feeder and equipment ratings, i.e., long and short-term emergency ratings, and most importantly, they require dynamic ratings.
- Weather forecast.

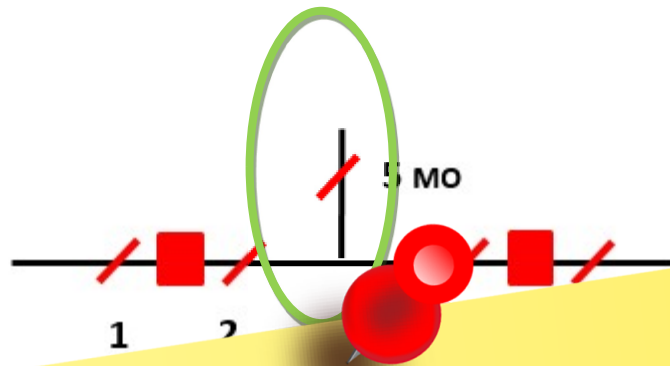
A Glimpse of the Daily Energy Control Center Operator Tasks:

Before we dig deeper, it is worth discussing two tasks that energy control system operators perform during major system emergencies and post-event switching to restore the system to normal or semi-normal status. By going thru the examples below, the reader will appreciate the need for the ASO in parallel to the existing control centers and not instead, as most of the regular control center functions are not expected to change significantly in the future.

The first example below depicts a small portion of a transmission substation, the (/) symbol refers to a disconnect switch that is a very critical device to allow maintenance, protection, scheduled jobs, and post-emergency restoration. It is worth noting that this device is not designed to operate while the system is energized, i.e., cannot interrupt load current. The diagram below shows the system is energized (all breakers are energized – red refers to the breaker being closed). For the example below, assume the transmission line that connects to disconnect switch 5 is a 345 kV transmission line that is connected to another (remote) transmission substation (this is the norm for transmission lines as they connect several transmission substations).



Assume the 345 kV transmission line develops a fault, i.e., insulator failure that resulted in a flash over → single line to ground fault.



As soon as
multiple s
below will
completely

and send
the station
open, thus

To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

Close this window and click "Add to cart" on the product page.

Depending on the
to swiftly restore
transmission subs
urgency to restore
accomplished if the
fault is north (not o

ed

Once system protect determine that the fault is north of the disconnect switch and concur that the bus section can be restored by releasing the troubled section, the energy control center operators will start the long process of restoring the ring.

It is important to iterate that different utilities have different standards and specifications regarding system restoration; thus, the following steps may vary significantly. Two tasks are paramount during the restoration:

- Protecting all the employees who will be working on the feeder and the bus.
- Avoid accidental energization of any section of the bus or feeder that was not meant to be energized.