WG C1.27 - The Future of Reliability

Definition of reliability in light of new developments in various devices and services which offer customers and system operators new levels of flexibility

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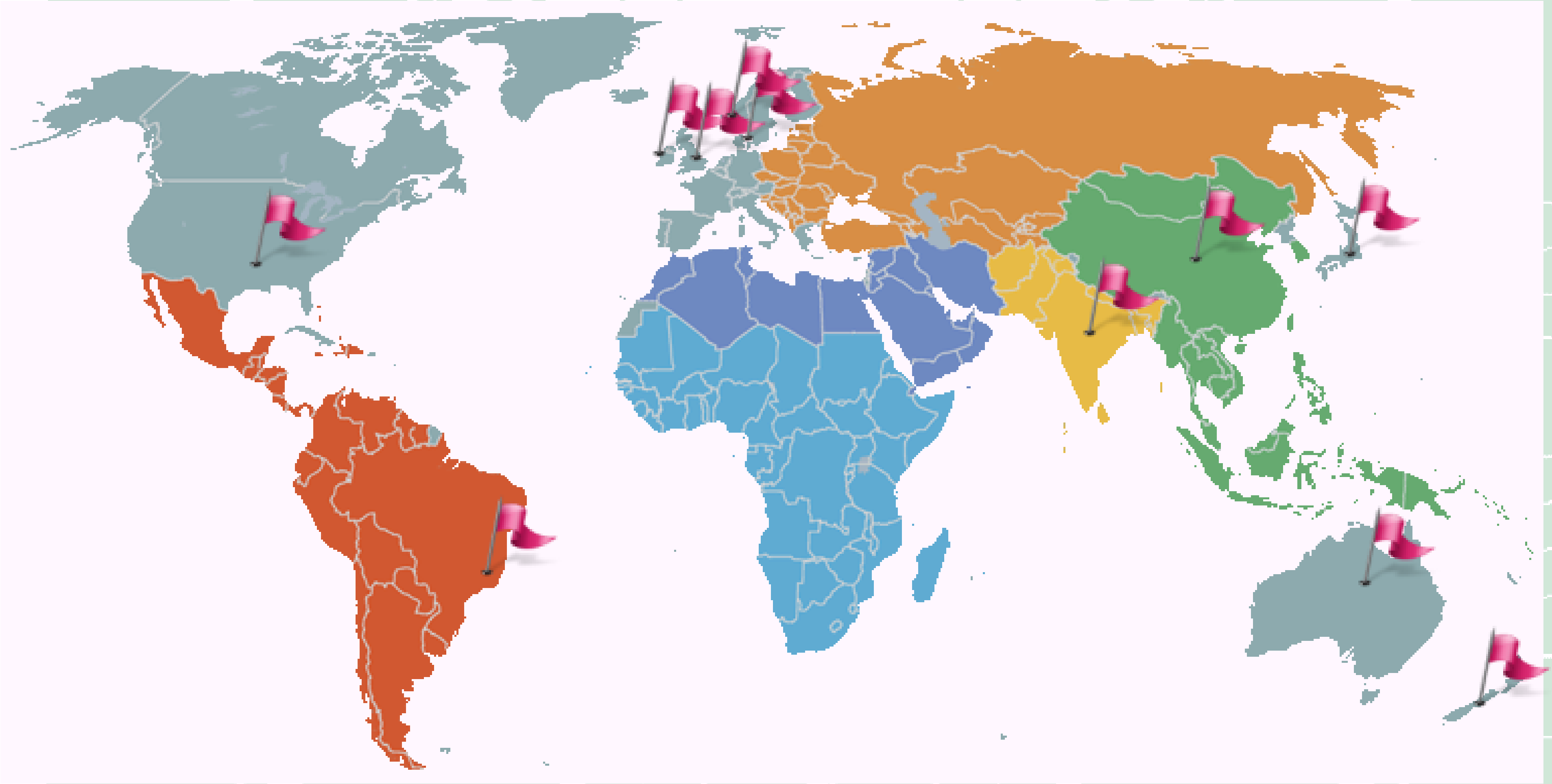
WG Members

11 countries members



Scope of WG C1.27

- Present worldwide conditions show an increased use of renewable generation by individual customers, independent developers, and utilities.

  In addition, there are potential new developments in communication and information processing that should accelerate these trends, and innovations associated with inexpensive storage technologies may be just over the horizon. All the identified trends point to increased customer participation as suppliers.

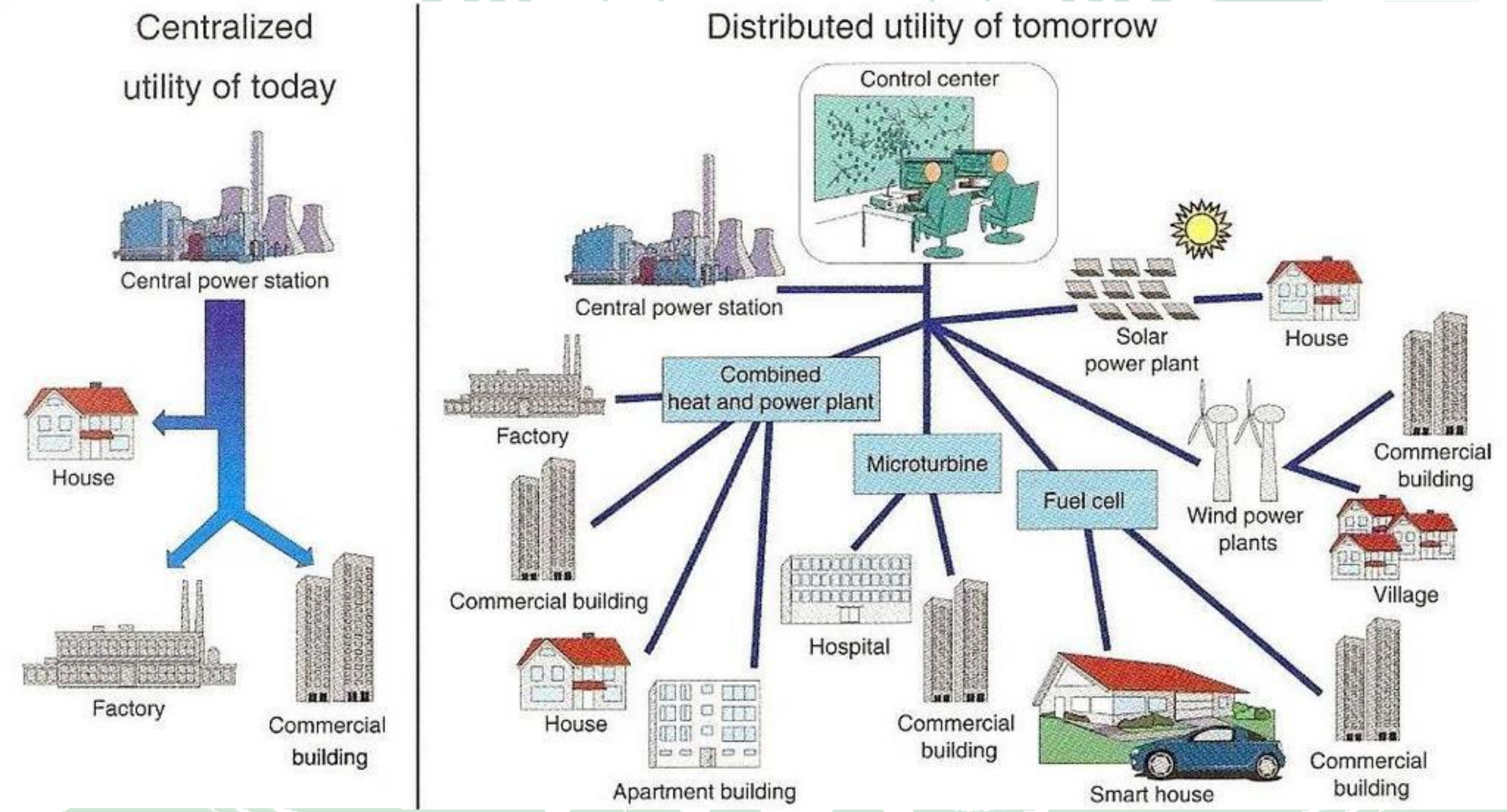
- WG C1.27 was formed to address the possible need to change the definition of reliability in light of these changes.

Preliminary

- It was not the purpose of this WG conclusions to dictate the service standards that a particular utility should provide. Rather, it is to illustrate the multitude of new factors that should be considered when defining a level of reliability for a particular network.

- A range of customers utilizes the interconnected network. In general, there are multiple system layers used by these customers. Distribution-connected customers are supported by a transmission system, and the transmission system may be supported by an EHV transmission system, each with a defined level of reliability.

Power System



Current Cigre Definition

- Reliability: A measure of the ability of a bulk power system to deliver electricity to all points of utilization within accepted standards and in the amount desired considering two basic and functional aspects:

  1. Adequacy
  2. Security

The need to change the definition of reliability

- Current reliability definition is designed for and suitable for a one-way world of power supply: From a world where power flowed from producers to the bulk power system and is then delivered to consumers at their various sites. In this world, it is the bulk transmission system that ties the suppliers to the consumers.

- The following describe briefly the various changes that are turning this traditional utility world into today’s and tomorrow’s electricity system. This will be a system that gives customers much more choice, and which includes more and more renewable and other forms of clean energy.

The need to change the definition of reliability

- The important trend is that customers are actively participating in their electric supply by providing power to serve their own load, and, that this often leads to power flowing out from customers facilities during many hours of the day.

- In addition, communication and control technology advances allow these customers to participate in utility power and ancillary service markets. This is a significant change from the historical pattern of one-way flow of power from the utilities to their customers.

The need to change the definition of reliability

Important changes occurred:

1. Adoption of renewable-energy targets by governments and utilities;
2. Decreasing cost of solar photovoltaic panels and wind turbines, and potential cost reductions of energy storage;
3. A range of developments collectively known as the smart-grid.

More customers are taking steps to supply more of their own energy use from on-site generating sources such as rooftop solar panels.

Changing of paradigmas

1. Open access for generation

- ✓ Beginning in the 70s, a trend began that allowed independent generators to interconnect with utility systems. This trend accelerated when large wind turbines were developed and practical rooftop photovoltaic (PV) became available.
- ✓ High energy prices in many parts of the world made wind and PV technologies economic.
- ✓ Finally, economic incentives to reduce global warming further accelerated their adoption.

Changing of paradigmas

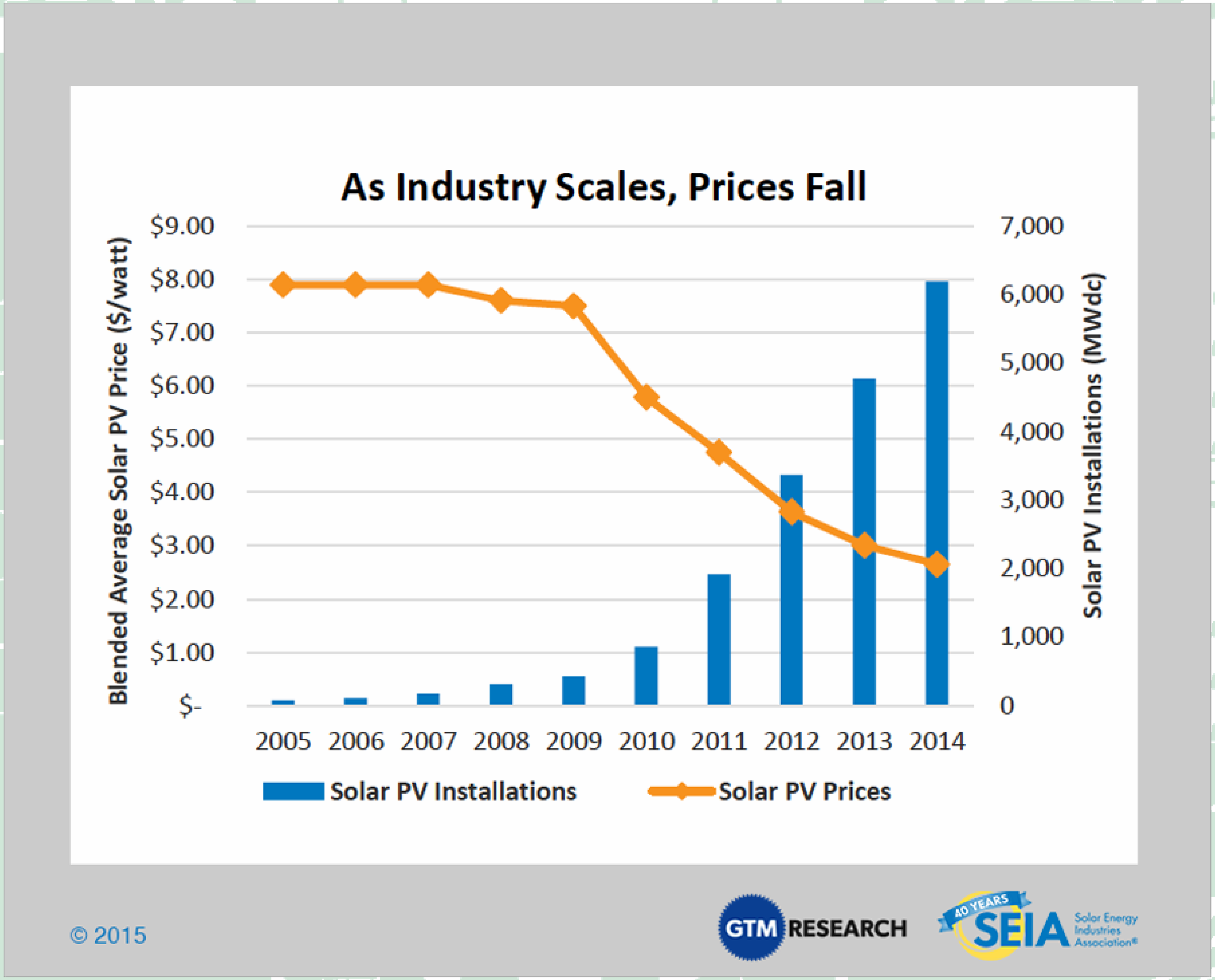
2. The rise of wind and solar generation

The combined changes of restructuring and steps to reduce global warming has increased the amounts of wind and PV power sources—nearly all on a much smaller scale than conventional power plants.

To improve the security and reliability level of the power grid connecting with wind farms, the technical connection rule for wind farms has been changed in China, for instance, in relation to wind power forecasts, active power control, reactive capacity, voltage control, low-voltage ride-through capability and grid compliance tests.

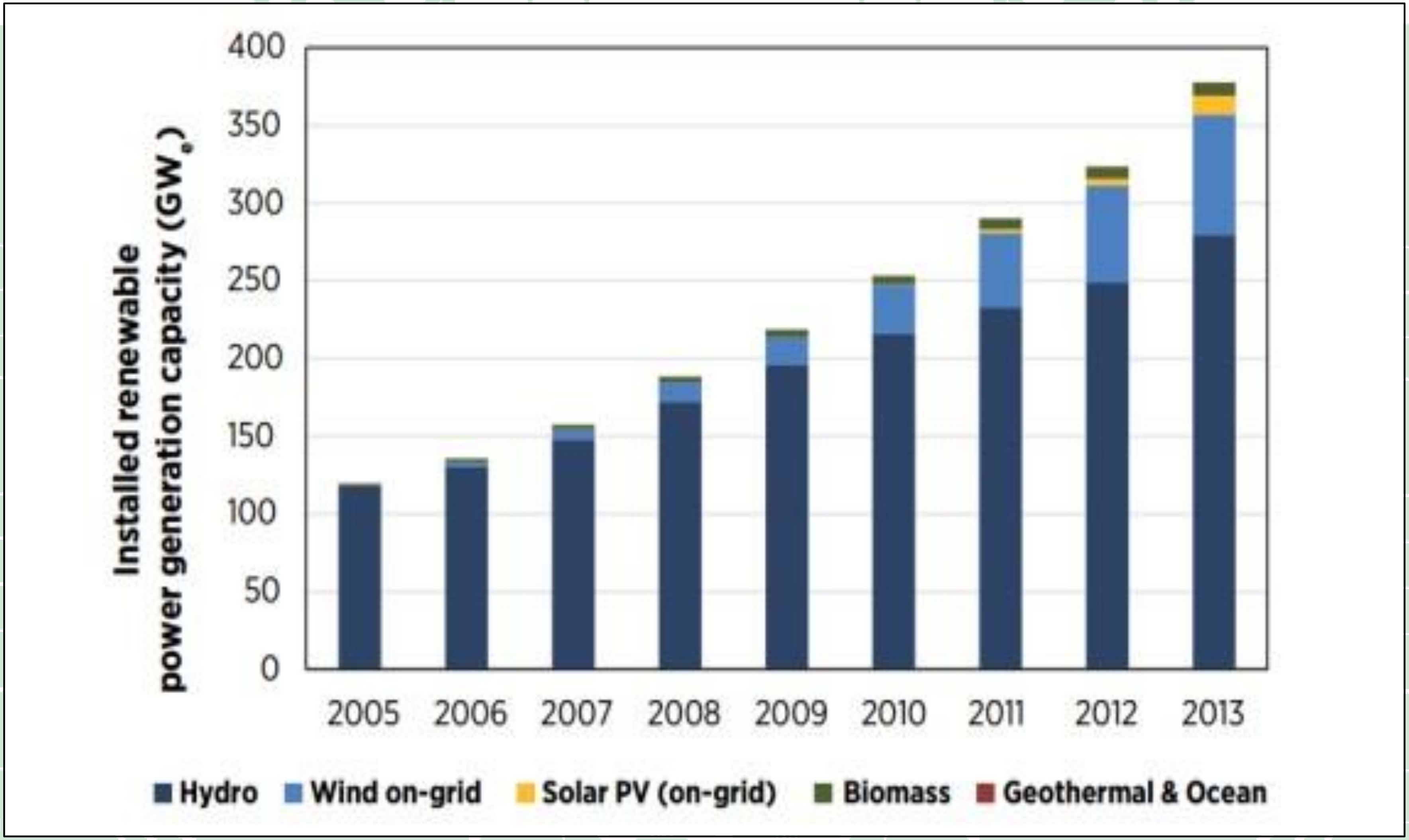
Changing of paradigmas

US installed prices of residential and commercial PV systems



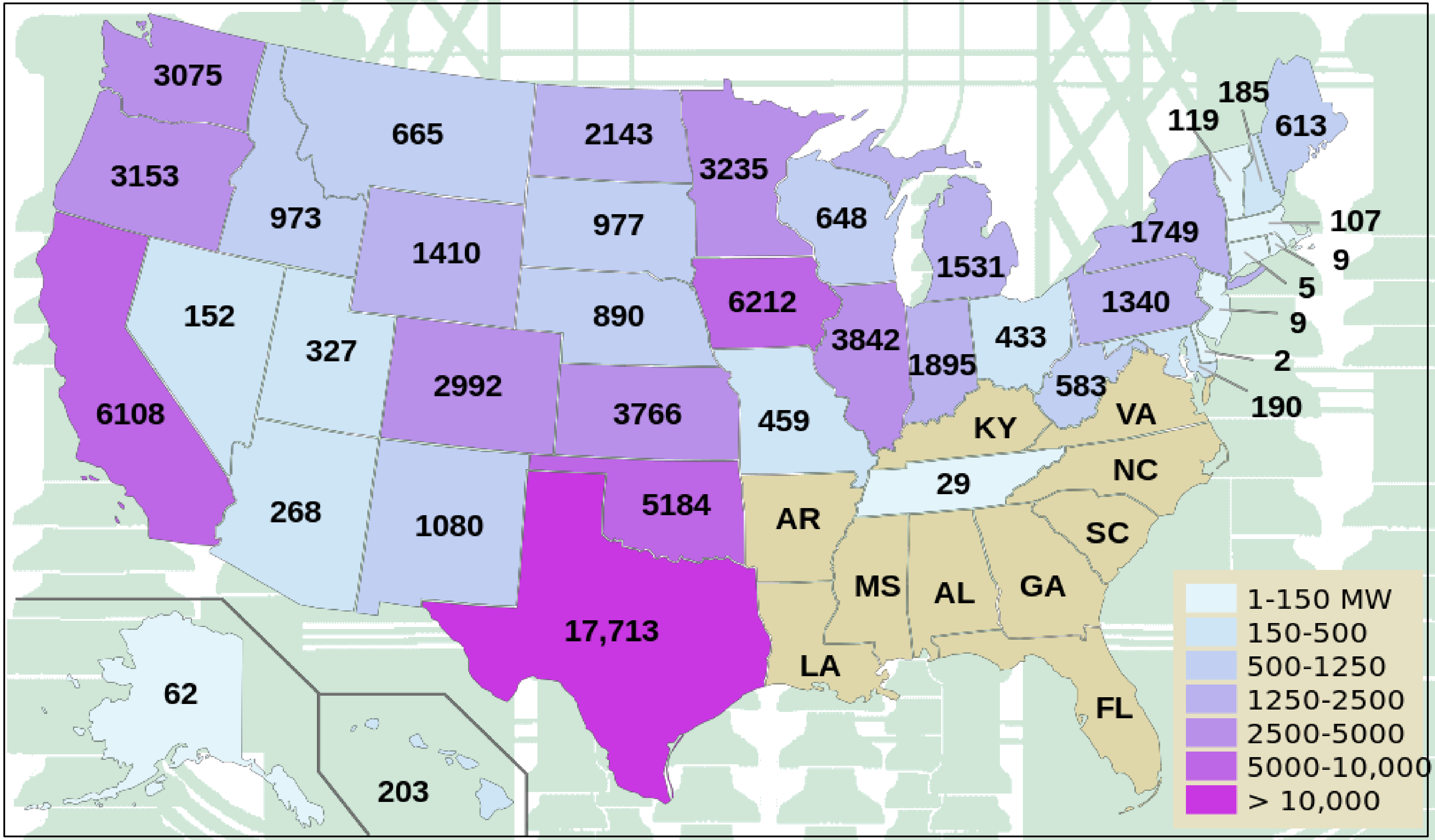
Changing of paradigmas

Installed renewable generating capacity in China



Changing of paradigmas

Installed wind capacity (MW)—USA, December 2015



New technologies affecting reliability

Large scale wind and solar power

- According to the Global Wind Energy Council, there was 432.9 GW of wind generation installed worldwide by the end of 2015.

- By the end of 2015, there was approximately 256 GW of PV installed worldwide. Some projections see over 500 GW installed by the end of the decade. While wind tends to be installed in relatively large amounts, PV can be installed at very local levels, including rooftops.

  A significant portion of solar, however, still consists of larger distribution-connected and transmission-connected plants.

New technologies affecting reliability

Large scale wind and solar power (continuation)

- Most renewable generation cannot be fully dispatched-down: it must be used when available. If communication and control is available, it can be dispatched-down if required, but there is often a large opportunity cost to do so, and many regions have requirements for a certain penetration of demand to be met by renewable sources.
- Other characteristics may also impact on reliability: much of the wind power is located far from the load and thus may not provide local support, and will require significant transmission lines. Besides much of the PV generation may be distributed, bringing significant challenges.

Summary of current (2015) worldwide renewable generation

System	Generating capacity (MW)	Wind (MW)	Solar (MW)	Comments
China	1,260,000	129,000	35,800	Best wind resources are far from load centers
USA	1,250,000	75,000	28,000	Percentages vary widely across the country
Hawaii	1,800	202	574	Percentages vary widely
Germany	192,000	35,000	34,000	Wind and solar deliver about 20% of energy
Ireland	10,300	3,100	<5	About half of wind is distribution-connected
Australia†	48,000	3,600	3,810	Most solar is rooftop, connected in distribution systems
South Australia	4,940	1,473	700	During light load, nearly all generation from wind and solar

New technologies affecting reliability

Main concerns due to high renewable penetration

1. Flexibility
2. Reserve capacity for short term
3. System adequacy has to be maintained
4. Voltage profiles must be kept within the operational limits
5. System security must be kept in maintenance situations
6. Transmission congestion
7. Observability and controllability
8. Small RES units must behave in a system-friendly way
9. A lack of short-circuit power for system stability and protection

New technologies affecting reliability

Distributed generation

- DG will need communications and control capability in order to ensure that they can be used in a way that helps the system.
- Many DG resources are connected using standards that prioritize local safety, to ensure the resources behave as expected and do not cause safety or reliability problems. When penetration levels become high enough, bulk system operations can be impacted.

  As example, in many regions DG is connected at unity power factor and is required to trip after sensing a voltage or frequency drop. If enough DG resources are operating, then their disconnecting after a fault on the bulk system could make the event significantly worse.

New technologies affecting reliability

Battery energy storage

- Today they are usually energy limited. They can only make a relatively small contribution to resource adequacy. In the future, longer duration batteries may also start to become more prevalent as costs of storing energy come down, and then, may be able to better contribute to resource adequacy.

  With increasing renewables, and their increased capacity contribution with storage, they should become more relevant during peak-demand periods.
- Batteries are also ideally suited for many other reliability services. Their quick and accurate response means they can contribute to frequency regulation and spinning reserves.

New technologies affecting reliability

Other energy storage resources

- Pumped Hydro Storage has been established for many decades, and is by far the form of energy storage with the most currently installed capacity, (over 120 GW, that is 99% of installed storage capacity).
- Compressed Air Energy Storage shows some promise, where suitable geological formations are available. Today, there are only two plants worldwide, built in the 80s, but there are efforts exploring new locations.

Demand-side options

Smart grids

Changing planning standards

- System planners use reliability criteria to judge the acceptability of various plans and options. The criteria are tests or measures of system performance used to balance cost and reliability. Reliability planning criteria and indices are used to guide investments that balance system supply and load, and provide an adequate transmission system.
- Changes to the definitions of reliability, adequacy, and security recommended by the WG could be implemented in revised planning and operating criteria and standards, presenting challenges to markets, system planners, system operators, transmission and distribution owners and of course customers, generators and market operators.

Changing planning standards

New technologies can change the design and operation of the power system with a resulting change to the reliability expected of the bulk power system. There are two ways in which a typical deterministic standard can be changed:

- The list of contingency events that are covered can be changed. Contingency events that do not result in a loss of supply due to DG, DR, microgrids, etc., are much less important.
- A probabilistic element can be incorporated into deterministic standards. Standards such as n-0.x, where 0.x is the proportion of time when n-1 security is not met. For example, n-0.5 means the transmission system provides n-1 security for 50% of the time with prosumers making up the difference in reliability.

New technologies affecting reliability

- Large wind and solar
- Distributed generation—all types
- Battery energy storage
- Electric vehicles
- Other storage
- Demand-side options
- Micro grids, smart grids, nano grids

How new technology might affect reliability

- Storage becomes significant
- Rise of active demand
- Large wind and solar
- Changing planning standards
- Implications for future definition of reliability

The new definition of reliability

- *A measure of the ability of a ~~bulk~~ power system to deliver electricity to all points of ~~utilization~~ consumption and receive electricity from all points of supply within accepted standards and in the amount desired.*

Moving toward 2-way power flows

The new definition of adequacy

A residential consumer with rooftop PV and energy storage might be a typical residential consumer for many hours of the year, but would sometimes sell power and energy to the system, while at other times use the storage to provide peak-load shaving, voltage control, frequency regulation, or other services.

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The new definition of adequacy

- *A measure of the ability of a power ~~the electric~~ system to meet ~~supply~~ the ~~aggregate~~ electric power and energy requirements of its ~~the~~ customers within acceptable technical limits ~~at all times~~, taking into account scheduled and unscheduled outages of system ~~facilities~~ components.*

The new definition of security

- *The ability of the power ~~electric~~ system to withstand ~~sudden~~ disturbances ~~such as.~~*

This definition explicitly gives both an obligation and flexibility in maintaining system security. The obligation is to fully meet customer requirements, while the flexibility is to use the various forms of flexibility offered by customers.

MUCHAS GRACIAS!!

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