SAARC Energy Centre, Islamabad

Pakistan

THE REPORT

Webinar on "Buildings to Grid Integration"

9th June 2020, Islamabad

Organized by:
SAARC Energy Centre

June 9, 2020

SAARC Energy Centre
697, Street 43, Sector E-11/4 (NPF),
Islamabad, Pakistan
www.saarcenergy.org

Introduction

SAARC Energy Centre, Islamabad successfully conducted a Webinar on "Buildings to Grid Integration" on Tuesday, 9th June 2020. Webinar Agenda is available at Annexure -I.

1. Focus of the webinar was to share an introduction to the concept of building-to-grid integration and its underlying vision, the enabling technology, technical opportunities, resulting benefits, challenges and barriers. The topics discussed during the webinar were: features of grid connected buildings, their benefits and their impact on the electrical distribution network.

Participation

2. The webinar was attended by 57 professionals representing public sector organizations, academia, private sector, and other stakeholders from within and outside SAARC region. The experts from USA and Spain shared their knowledge pertaining to evolution of building-to-grid integration. The participants list is available at Annexure-II.

Description

3. The webinar was started with welcome remarks by Program Coordinator, Mr. Ahmad Talha, Research Fellow (Technology Transfer) of SAARC Energy Centre. The technical session comprised of presentations by the expert speakers. Each presentation was followed by a brief Q & A session. The Program Coordinator read out conclusions, which were gathered during the webinar. Before closing the webinar, the Program Coordinator from SAARC Energy Centre offered remarks of appreciation to all the participants and presenters.

Technical Proceedings

4. Two resource persons from USA and Spain shared their knowledge in the webinar. All the presentations delivered during the webinar are available at SEC's website (https://www.saarcenergy.org/webinar-on-building-to-grid-integration/). Details of Resource Persons are available at Annexure-III and their Presentations at Annexure-IV. A brief information on the content of the delivered presentations is as follows:

Presentation 1 – Grid-Interactive Efficient Buildings

Mr. Jack Mayernik, Senior Energy Analyst, US Department of Energy, USA.

5. Mr. Jack Mayernik is a Senior Energy Researcher at the National Renewable Energy Lab. Currently he is on loan to the U.S. Department of Energy's Building Technologies Office (BTO) where he leads the Energy Efficiency Analysis team. His portfolio covers strategic planning and program evaluation, in addition to these responsibilities, he coordinates BTO's multilateral international collaborations. He has contributed to a wide variety of publications

including journal articles, congressional reports, and technical reports including BTO's Multi-Year Program Plan and Accelerate Energy Productivity 2030.

6. In his presentation, he started by sharing the changes brought about by the buildings with flexible loads and distributed generation resources, and introduced the concept of building-to-grid integration or grid-interactive efficient buildings (GEB). He highlighted the key characteristics of GEBs which enable them to respond intelligently to occupants' requirements as well as support the grid when required. He presented the demand side management modes for grid support offered by GEBs and the resulting potential benefits. He also showed the work done by BTO to realise the concept of GEB under four categories namely: valuation analysis, technology development, real world validation and system optimisation with relevant examples from US.

Presentation 2 – Is the Electrical Distribution Ready for a Revolution?

Dr. Pablo Arboleya, Associate Professor, University of Oviedo, Spain.

7. Dr. Prof. Pablo is currently working as Associate Professor at the University of Oviedo, Spain. He is the co-founder of the LEMUR research group which focuses on modelling and analysis of electrical systems and the implementation of operation and energy management techniques. Pablo is holding the SmartCities Chair at University of Oviedo funded by the city of Gijón. Aligned with the target of this chair, he participated in the development of the Gijón DemoLab in which an IoT infrastructure at city level is being tested and developed. He is also co-founder of Plexigrid, a University of Oviedo spinoff technology-driven company, that develops software tools specially designed for grid operators, aggregators and energy communities.

8. The focus of his presentation was the required changes on the grid side for integrating the flexible electrical loads such as electric vehicles, grid-connected buildings etc.; the driving factors behind these changes and the strategy to implement these necessary changes. He presented the case study highlighting the potential grid congestion caused by uncoordinated integration of distributed resources. By presenting the impact of flexible electrical loads/systems such as electric vehicles, HVAC systems of buildings, energy storage systems on electrical power system with examples from European region; he emphasised the importance of utilising the flexibility of these loads to avoid network congestion with minimum investment on electrical network. He also apprised the audience of the possible aggregator business models as well as required data storage and management systems for smooth integration of flexible electrical loads.

Wrap up and Conclusion

Mr. Ahmad Talha, Research Fellow (Technology Transfer), SAARC Energy Centre

9. Mr. Ahmad Talha thanked the speakers for sharing their insights on grid interaction of buildings and the flexibility that can be added to the grid through the coordinated installation of grid interactive buildings, electric vehicles and other such consumer owned resources. The following conclusion was drawn from the discussion of this webinar:

a. Building to Grid Integration can result in numerous benefits including improving energy affordability, enhancing grid reliability and reducing congestion. With increased digitisation of the grid and enabling communication technology, better utilisation of available resources is possible and the resource owner can economically benefit through transparent energy transactions. Given the potential of SAARC region, the grid interactive consumer resources can play an important role in the sustainable development of our region.

Closing of Webinar

Mr. Ahmad Talha, Research Fellow (Technology Transfer), SAARC Energy Centre

10. Mr. Ahmad Talha, informed all the participants that the presentations and recording of the webinar proceedings would be available on SAARC Energy Centre's website (www.saarcenergy.org). He closed the webinar with a thank you note to everyone attending the Webinar.

Annexures

Webinar Agenda

Webinar on
"Buildings to Grid Integration"

Tuesday, 9th June 2020

1400 – 1405	Introduction
1405 – 1435	**Grid-Interactive Efficient Buildings** *Mr. Jack Mayernik, Lead Analyst, Building Technologies Office, U.S. Department of Energy, USA.*
1435 – 1450	Q & A session
1450 – 1520	**Is the Electrical Distribution Ready for a Revolution?** *Dr. Pablo Arboleya, Associate Professor, Universidad de Oviedo, Spain.*
1520 – 1535	Q & A session
1535 – 1540	Conclusion and Recommendations
1540 – 1545	Closing of Webinar

Information for the participants:

1. All times mentioned in agenda are according to Pakistan Standard Time (PKT). The participants from other Member States may attend Webinar by following their own national time. The time conversion for all Member States is given below for reference:

Country	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Sri Lanka
Local time	(PKT-00:30)	(PKT+01:00)	(PKT+01:00)	(PKT+00:30)	PKT	(PKT+00:45)	(PKT+00:30)

2. The participants can ask questions to presenters by typing questions or clicking to the raised hand option into the Attendees pane of the main window of GoToWebinar software. You may send in your questions at any time during the presentations; we will collect these and address them during the Q&A session at the end of each presentation.

3. All participants can also submit comments/views and/or observations on the draft study report to SAARC Energy Centre through email to Mr. Ahmad Talha, Research Fellow (TT) (rftt@saarcenergy.org).

List of Participants

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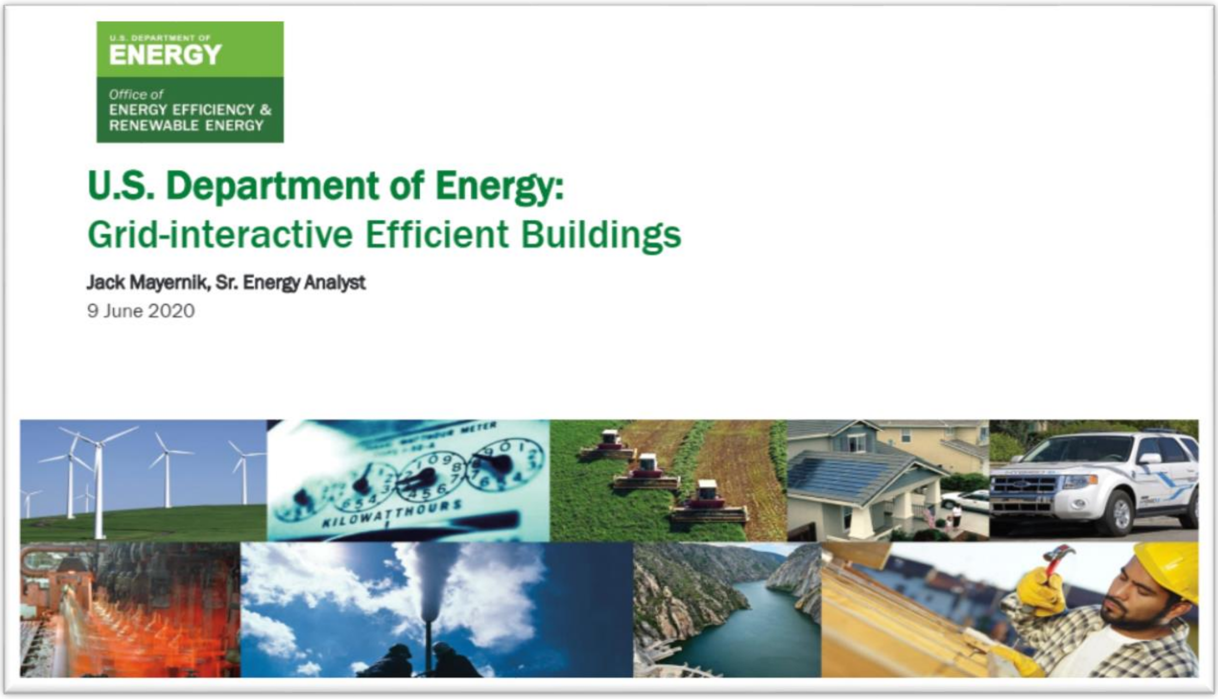
List of Presenters/Resource Persons

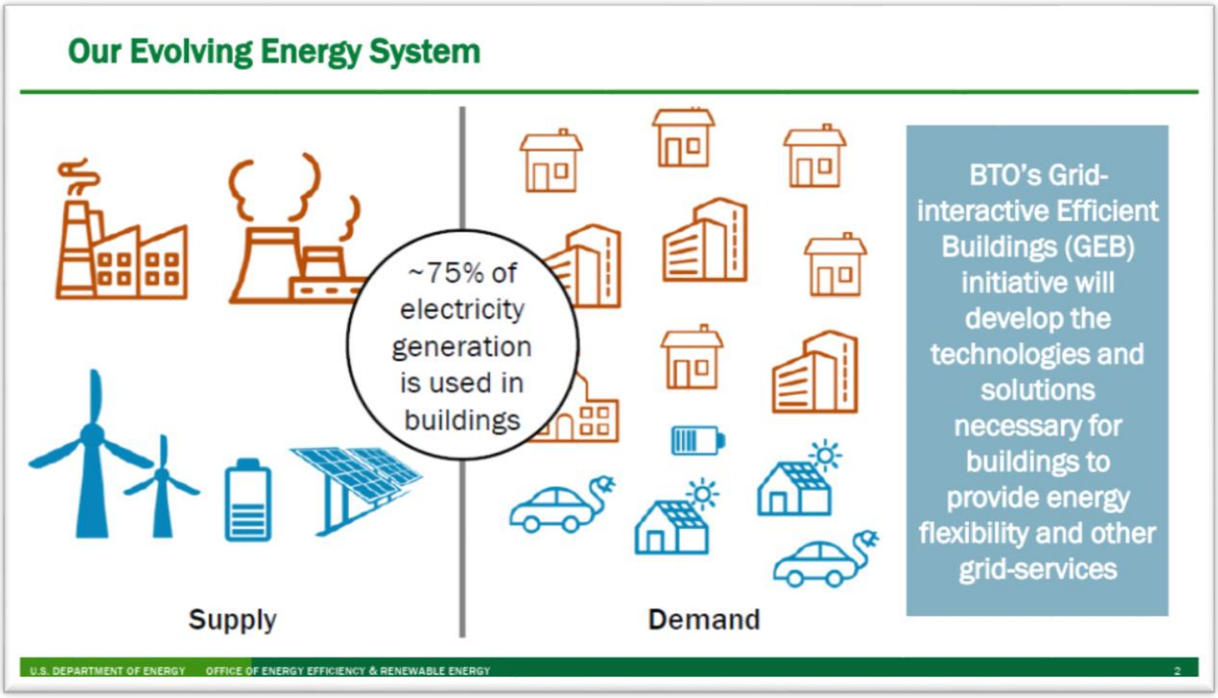
S. No.	Name	Designation	Organization	Email address
1.	Mr. Jack Mayernik	Senior Energy Analyst	Building Technologies Office, US Department of Energy, USA.	John.Mayernik@nrel.gov
2.	Dr. Pablo Arboleya	Associate Professor	University of Oviedo, Spain.	arboleyapablo@uniovi.es

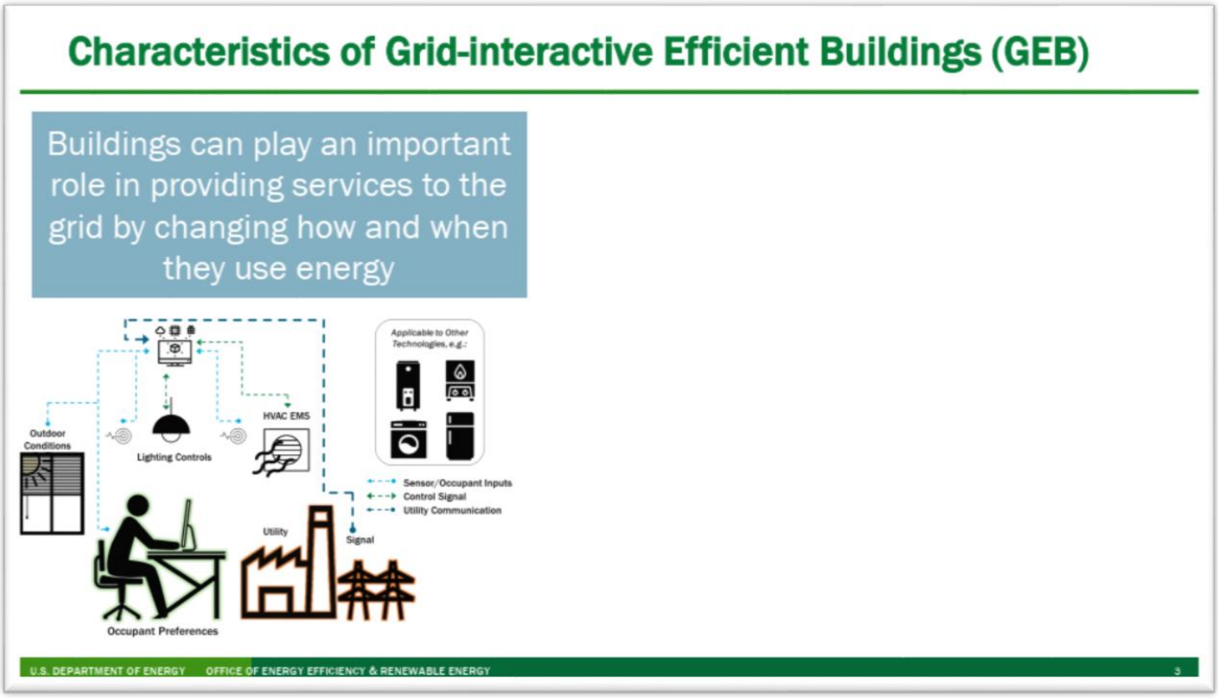
Presentations Delivered During the Webinar

1. "Grid-interactive Efficient Buildings" by Mr. Jack Mayernik,

Senior Energy Analyst, Building Technologies Office, US Department of Energy, USA.






Characteristics of Grid-interactive Efficient Buildings (GEB)
Buildings can play an important role in providing services to the grid by changing how and when they use energy
Applicable to Other Technologies, e.g.:
Outdoor Conditions
Lighting Controls
HVAC EMS
Sensor/Occupant Inputs
Control Signal
Utility Communication
Utility
Signal
Occupant Preferences
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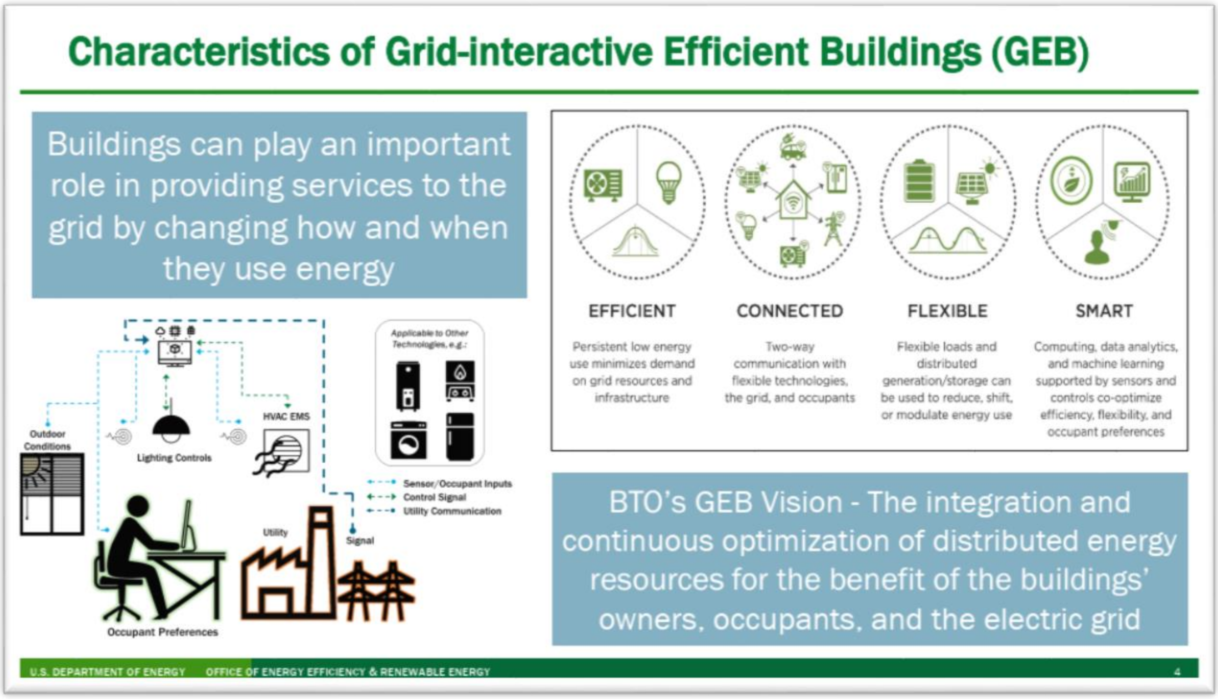
3


Characteristics of Grid-interactive Efficient Buildings (GEB)
Buildings can play an important role in providing services to the grid by changing how and when they use energy
EFFICIENT
Persistent low energy use minimizes demand on grid resources and infrastructure
CONNECTED
Two-way communication with flexible technologies, the grid, and occupants
FLEXIBLE
Flexible loads and distributed generation/storage can be used to reduce, shift, or modulate energy use
SMART
Computing, data analytics, and machine learning supported by sensors and controls co-optimize efficiency, flexibility, and occupant preferences
BTO's GEB Vision - The integration and continuous optimization of distributed energy resources for the benefit of the buildings' owners, occupants, and the electric grid
Applicable to Other Technologies, e.g.:
Outdoor Conditions
Lighting Controls
HVAC EMS
Sensor/Occupant Inputs
Control Signal
Utility Communication
Utility
Signal
Occupant Preferences
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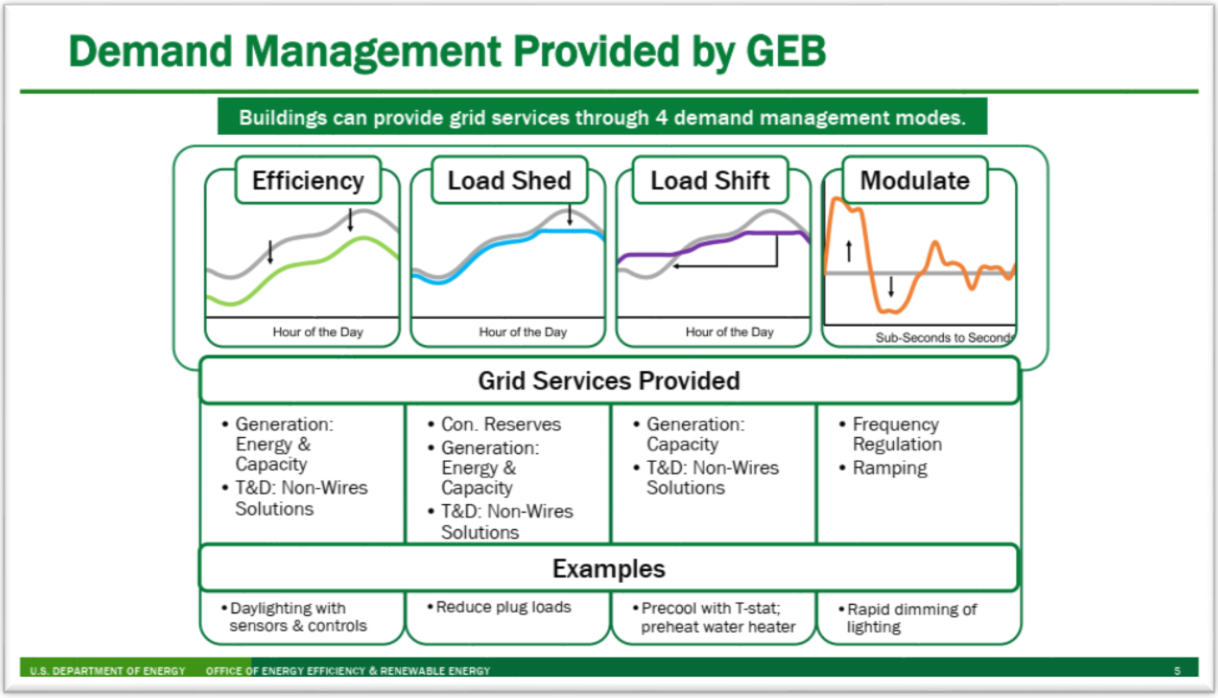
Demand Management Provided by GEB
Buildings can provide grid services through 4 demand management modes.
Efficiency
Load Shed
Load Shift
Modulate
Hour of the Day
Hour of the Day
Hour of the Day
Sub-Seconds to Seconds
Grid Services Provided
• Generation: Energy & Capacity
• T&D: Non-Wires Solutions
• Con. Reserves
• Generation: Energy & Capacity
• T&D: Non-Wires Solutions
• Generation: Capacity
• T&D: Non-Wires Solutions
• Frequency Regulation
• Ramping
Examples
• Daylighting with sensors & controls
• Reduce plug loads
• Precool with T-stat; preheat water heater
• Rapid dimming of lighting
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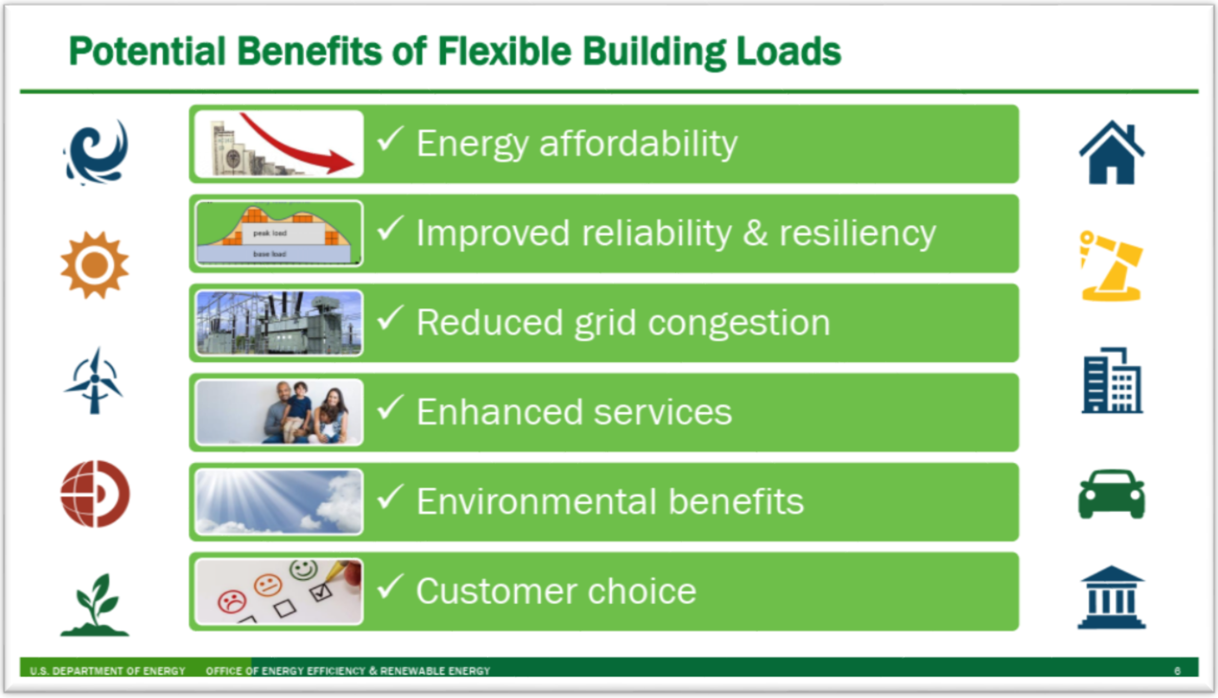
Potential Benefits of Flexible Building Loads
✓ Energy affordability
✓ Improved reliability & resiliency
✓ Reduced grid congestion
✓ Enhanced services
✓ Environmental benefits
✓ Customer choice
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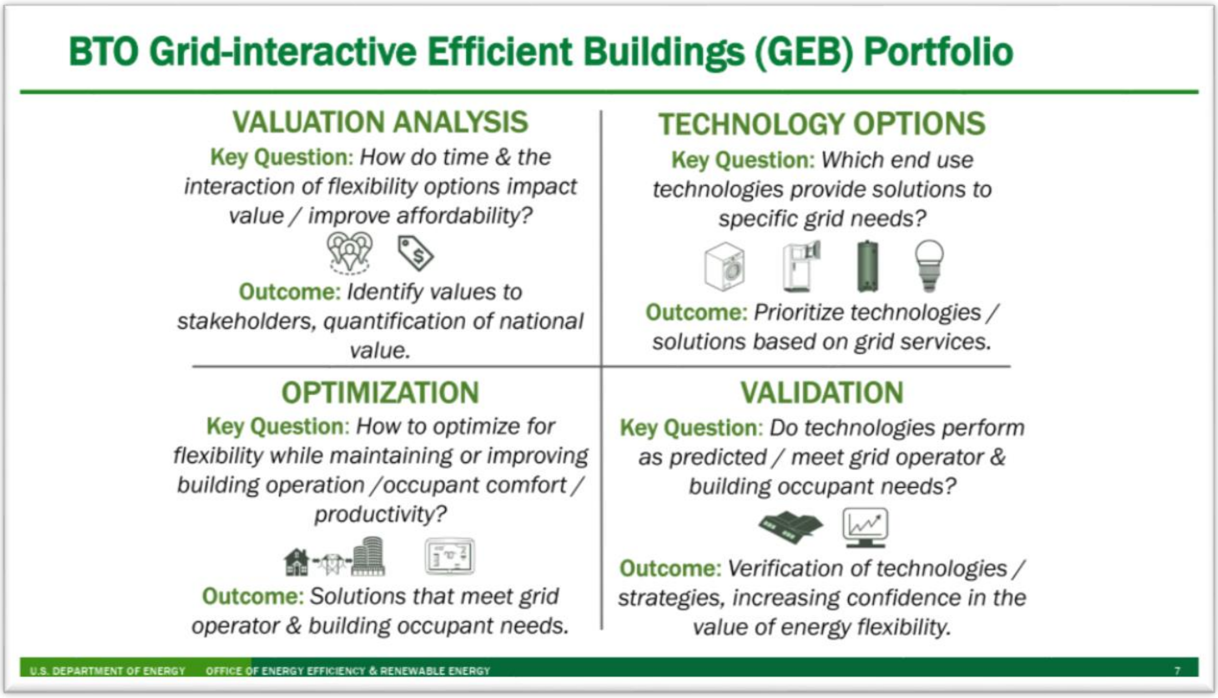
BTO Grid-interactive Efficient Buildings (GEB) Portfolio
VALUATION ANALYSIS
Key Question: How do time & the interaction of flexibility options impact value / improve affordability?
Outcome: Identify values to stakeholders, quantification of national value.
TECHNOLOGY OPTIONS
Key Question: Which end use technologies provide solutions to specific grid needs?
Outcome: Prioritize technologies / solutions based on grid services.
OPTIMIZATION
Key Question: How to optimize for flexibility while maintaining or improving building operation /occupant comfort / productivity?
Outcome: Solutions that meet grid operator & building occupant needs.
VALIDATION
Key Question: Do technologies perform as predicted / meet grid operator & building occupant needs?
Outcome: Verification of technologies / strategies, increasing confidence in the value of energy flexibility.
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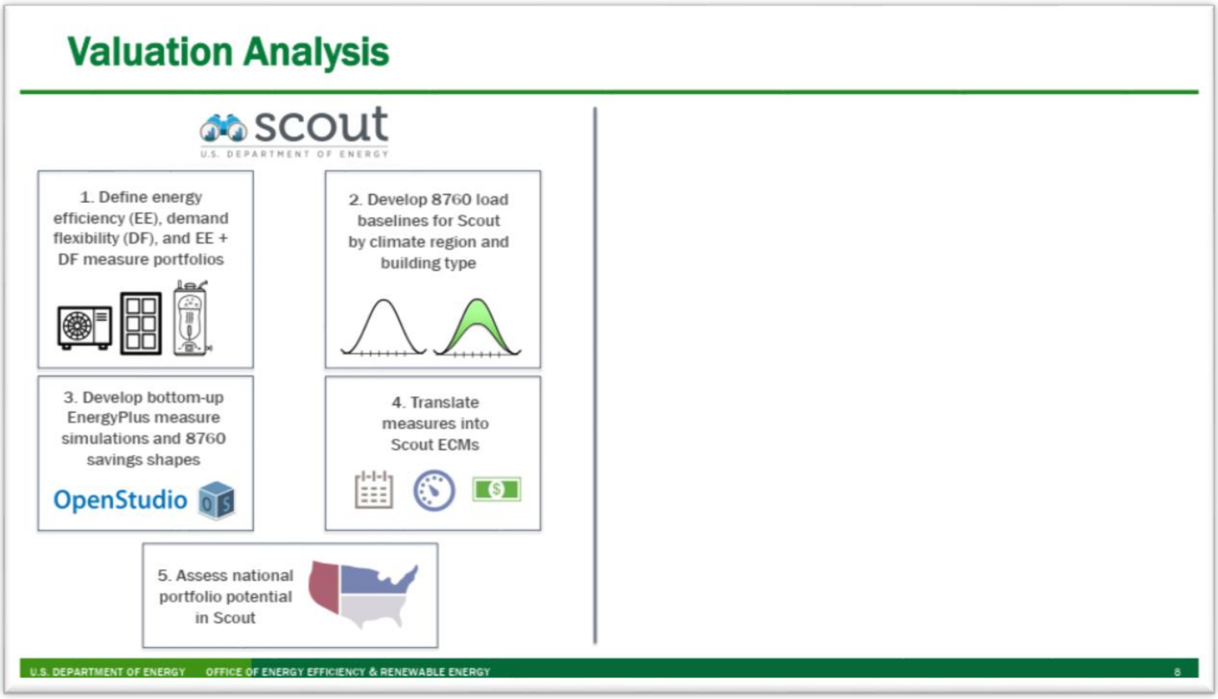
Valuation Analysis
scout
U.S. DEPARTMENT OF ENERGY
1. Define energy efficiency (EE), demand flexibility (DF), and EE + DF measure portfolios
2. Develop 8760 load baselines for Scout by climate region and building type
3. Develop bottom-up EnergyPlus measure simulations and 8760 savings shapes
OpenStudio
4. Translate measures into Scout ECMs
5. Assess national portfolio potential in Scout
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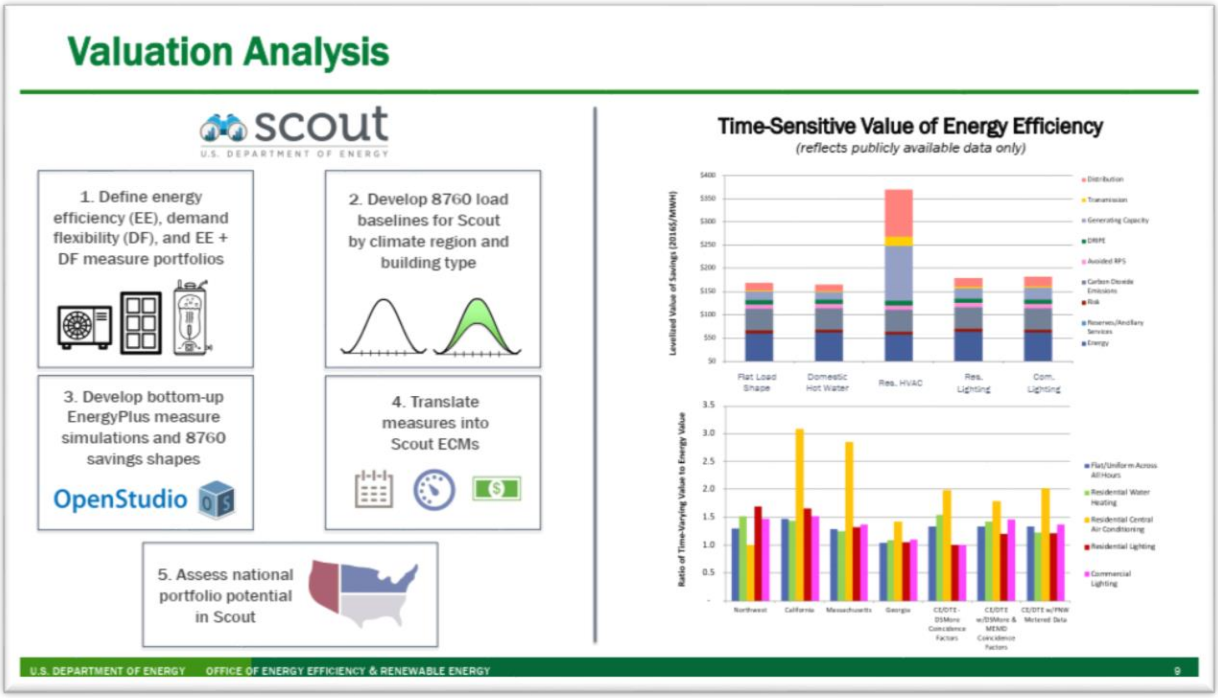
8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OpenStudio
4. Translate measures into Scout ECMs
5. Assess national portfolio potential in Scout
Time-Sensitive Value of Energy Efficiency
(reflects publicly available data only)
Flat Load Shape
Domestic Hot Water
Res. HVAC
Res. Lighting
Com. Lighting
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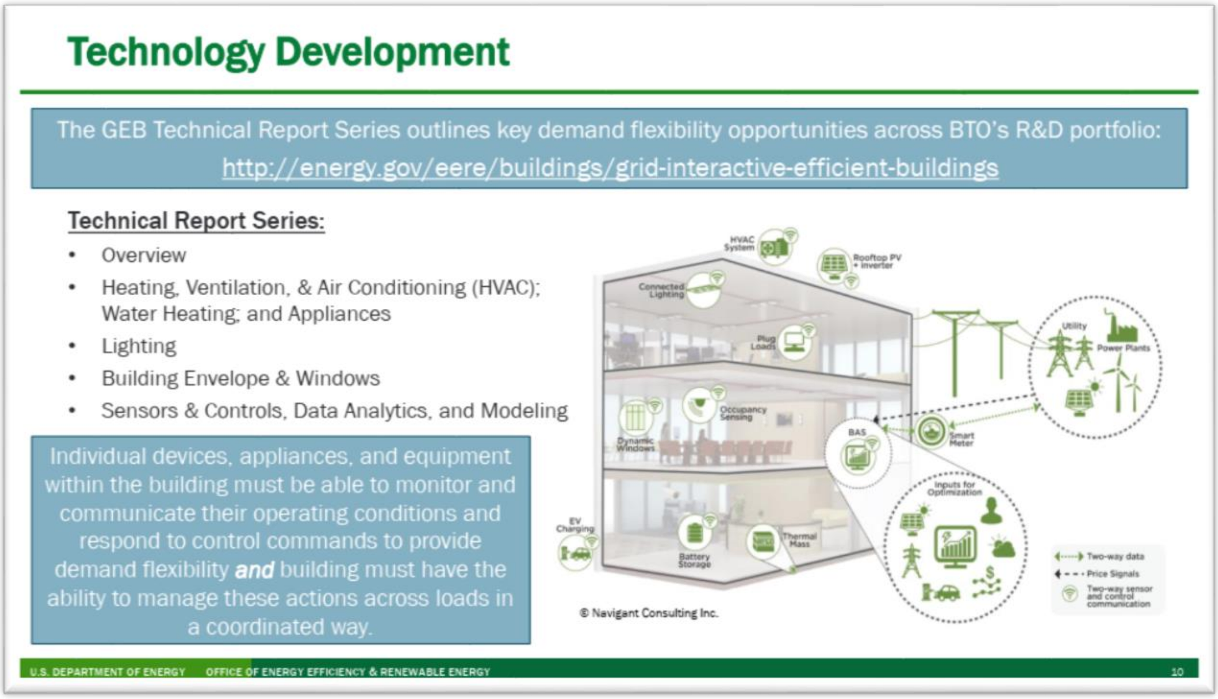
9


Technology Development
The GEB Technical Report Series outlines key demand flexibility opportunities across BTO's R&D portfolio:
http://energy.gov/eere/buildings/grid-interactive-efficient-buildings
Technical Report Series:
• Overview
• Heating, Ventilation, & Air Conditioning (HVAC); Water Heating; and Appliances
• Lighting
• Building Envelope & Windows
• Sensors & Controls, Data Analytics, and Modeling
Individual devices, appliances, and equipment within the building must be able to monitor and communicate their operating conditions and respond to control commands to provide demand flexibility and building must have the ability to manage these actions across loads in a coordinated way.
HVAC System
Rooftop PV + Inverter
Connected Lighting
Plug Loads
Utility
Power Plants
Occupancy Sensing
Dynamic Windows
BAS
Smart Meter
Inputs for Optimization
EV Charging
Battery Storage
Thermal Mass
Two-way data
Price Signals
Two-way sensor and control communication
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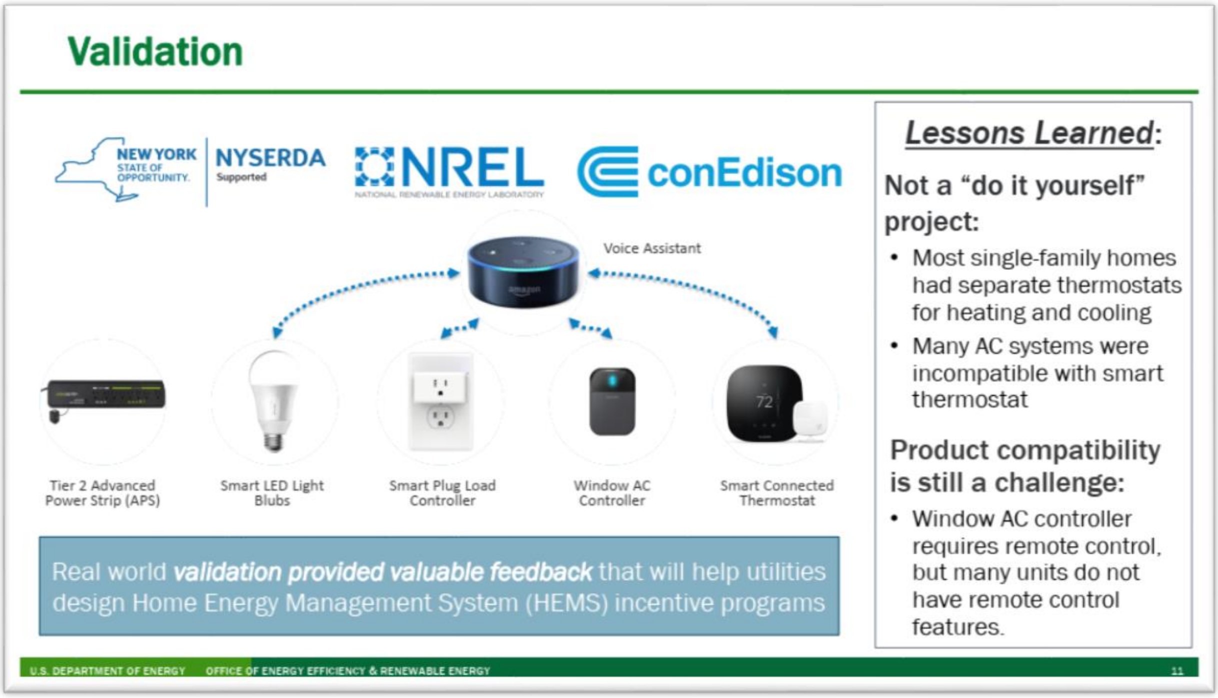
10


Validation
NEW YORK STATE OF OPPORTUNITY.
NYSERDA Supported
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
conEdison
Voice Assistant
Tier 2 Advanced Power Strip (APS)
Smart LED Light Blubs
Smart Plug Load Controller
Window AC Controller
Smart Connected Thermostat
Real world validation provided valuable feedback that will help utilities design Home Energy Management System (HEMS) incentive programs
Lessons Learned:
Not a "do it yourself" project:
• Most single-family homes had separate thermostats for heating and cooling
• Many AC systems were incompatible with smart thermostat
Product compatibility is still a challenge:
• Window AC controller requires remote control, but many units do not have remote control features.
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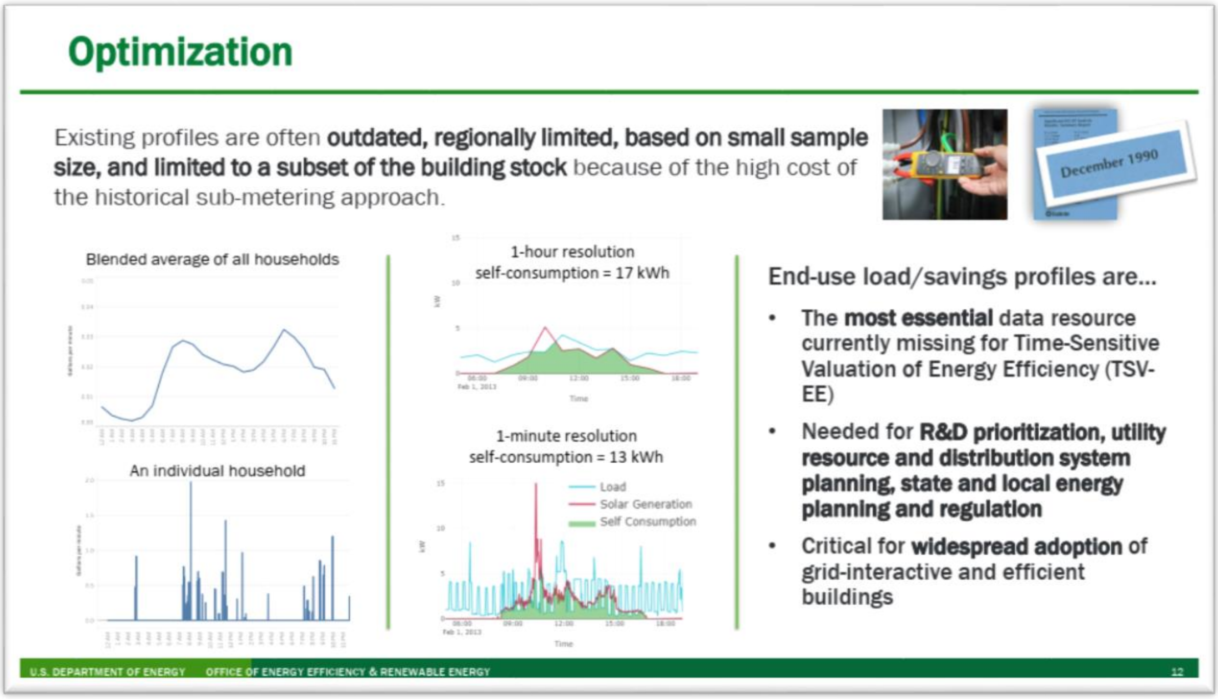
11


Optimization
Existing profiles are often outdated, regionally limited, based on small sample size, and limited to a subset of the building stock because of the high cost of the historical sub-metering approach.
December 1990
Blended average of all households
An individual household
1-hour resolution
self-consumption = 17 kWh
1-minute resolution
self-consumption = 13 kWh
Load
Solar Generation
Self Consumption
Time
End-use load/savings profiles are...
• The most essential data resource currently missing for Time-Sensitive Valuation of Energy Efficiency (TSV-EE)
• Needed for R&D prioritization, utility resource and distribution system planning, state and local energy planning and regulation
• Critical for widespread adoption of grid-interactive and efficient buildings
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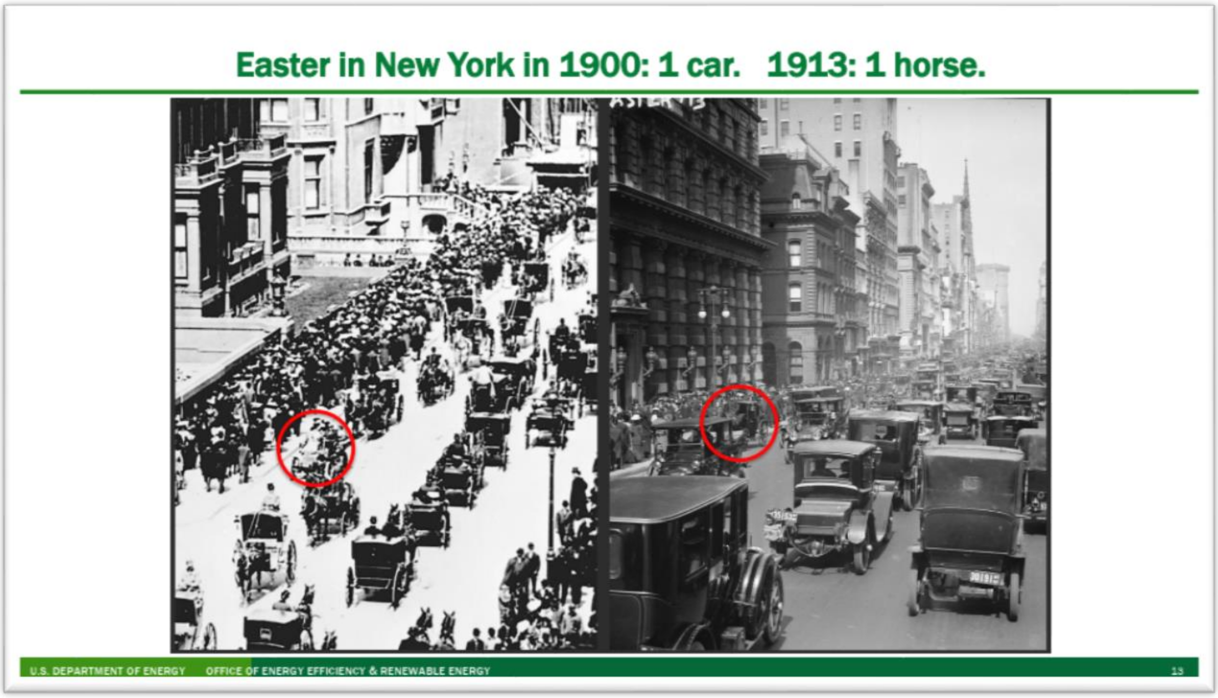
12


Easter in New York in 1900: 1 car. 1913: 1 horse.
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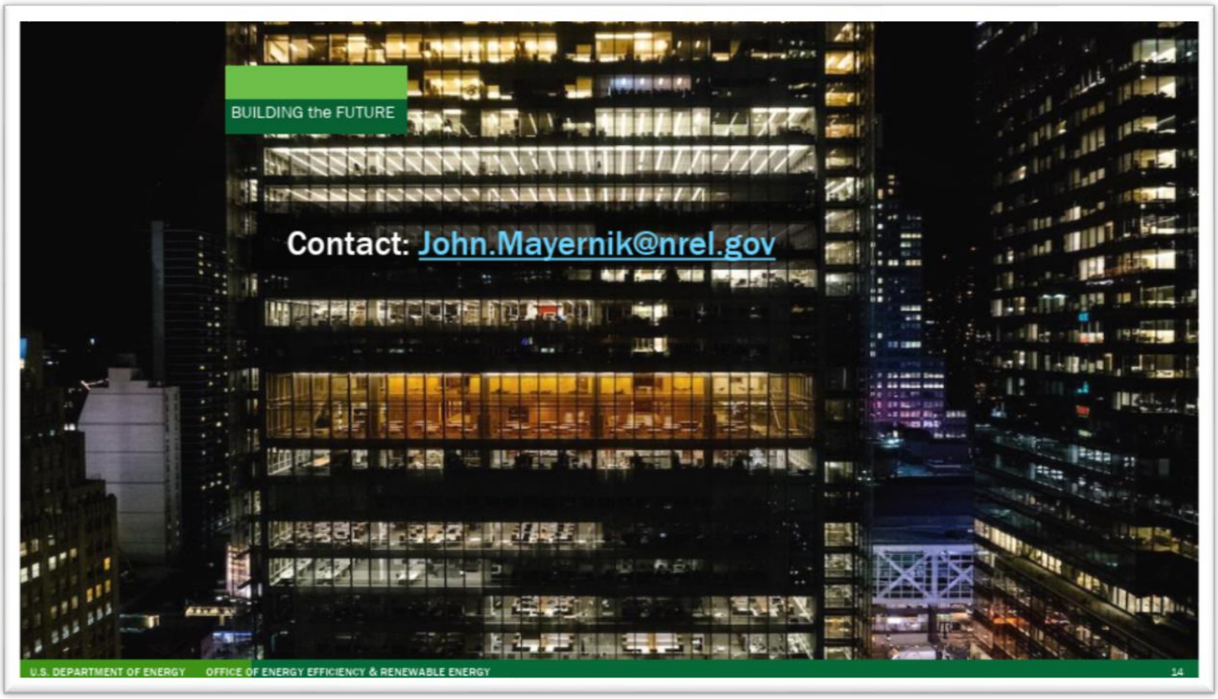
13


BUILDING the FUTURE
Contact: John.Mayernik@nrel.gov
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14

2. "Is the Electrical Distribution Ready for a Revolution?" by Dr. Pablo Arboleya, Associate Professor, University of Oviedo, Spain.

LEMUR ELECTRICAL ENERGY RESEARCH

Universidad de Oviedo
Universidá d'Uviéu
University of Oviedo

Is the Electrical Distribution Ready for a Revolution?

Pablo Arboleya (arboleyapablo@uniovi.es)

CÁTEDRA MILLA DEL CONOCIMIENTO
GIJÓN SMART CITIES

¿Why change somethig that works?

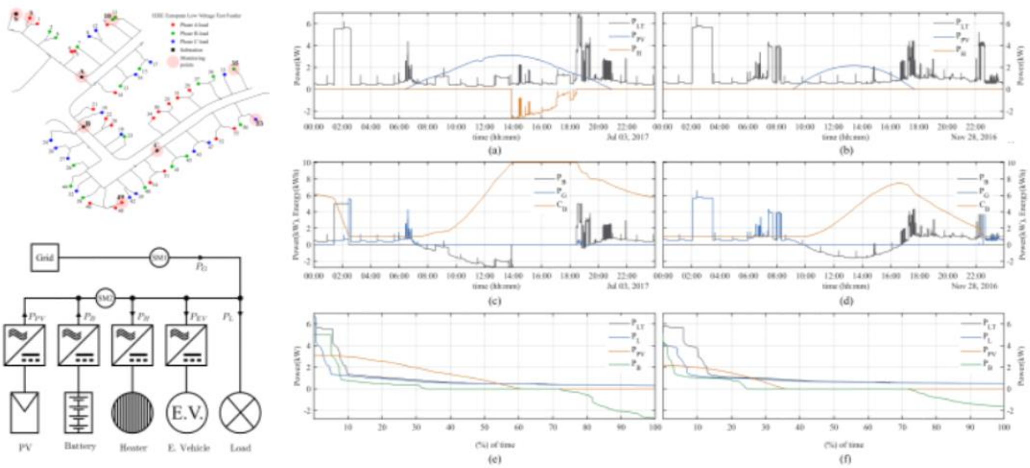
1. The forecasts indicate a very significant **increase in load** on the network in the short/medium term as a result of an unstoppable **electrification** process that not only includes technologies related to **electric mobility** but also includes **other technologies** such as heat pumps or other air conditioning equipment.

2. An **increase** in the installation of **distributed resources**, mainly solar photovoltaic energy in many cases combined with accumulation systems, is expected.

3. The **uncoordinated** use of the above resources may cause **congestion** in the network in the short/medium term.

[redacted]

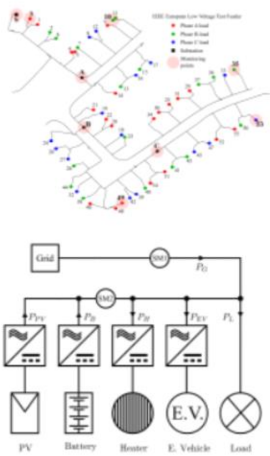
Case of Study (Self-consumption without surplus):

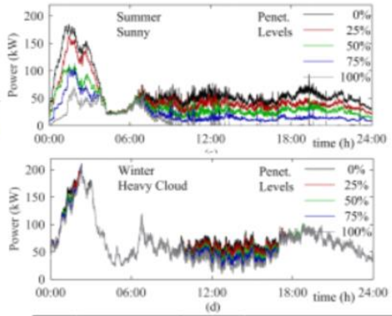


[redacted]

[redacted]

Case of Study (Self-consumption without surplus):





	Summer	Winter
P_{LT} (Average) (W)	737.8	897.4
P_{LT} (Max) (W)	6902.7	5230.8
P_L (Average) (W)	987.9	1203.7
P_L (Max) (W)	6902.7	6638.1
P_G (Average) (W)	158.6	698.1
P_G (Max) (W)	5640.8	6638.1
P_{PV} (Average) (W)	1118.2	505.5
P_{PV} (Max) (W)	3107.6	2150.2
P_B when ($P_B > 0$ (Average) (W)	442.4	229.7
P_B when ($P_B < 0$ (Average) (W)	-418.6	-229.7
E_{LT} (kWh)	23.7	28.9
E_L (kWh)	17.7	21.5
E_G (kWh)	3.8	16.7
E_{PV} (kWh)	26.8	12.1
E_B when ($P_B > 0$) (kWh)	10.6	7.2
E_B when ($P_B < 0$) (kWh)	-10.1	-7.2
E_H (kWh)	7.5	0

Season	Summer				Winter				House
Weather Scenario	Load	Sunny Load+Sys	Cloudy Load+Sys	Heavy Cl. Load+Sys	Load	Sunny Load+Sys	Cloudy Load+Sys	Heavy Cl. Load+Sys	
Net Energy (kWh)	27,2	5,4	6,8	11,9	26,1	10,9	14,0	17,7	Node 3
Maximum Power (kW)	8,5	4,0	8,5	6,1	6,8	6,8	8,3	6,7	
Average power (kW)	1,1	0,2	0,3	0,5	1,1	0,5	0,6	0,7	
Net Energy (kWh)	19,4	2,5	5,0	9,0	66,3	51,5	56,9	56,3	Node 10
Maximum Power (kW)	6,6	6,1	6,1	6,1	11,3	11,3	10,8	11,3	
Average power (kW)	0,8	0,1	0,2	0,4	2,8	2,1	2,4	2,3	

[redacted]

Why change something that works?

4. The **problem** of **congestion** in the distribution network can be avoided by **investments** in the distribution network (basically increasing the power of transformers and increasing the section of conductors).

5. On the other hand, **regulators** are **reducing** the **remuneration** of distribution operators, which generates a **low return** on network **investments**.

Changes in regulation, a few examples:

European Commission Energy Efficiency Directive 2012/27/EU (Art. 15. 4) requires Member States to: "Ensure the **removal** of those **incentives** in transmission and **distribution tariffs** that are **detrimental** to the overall **efficiency** (including energy efficiency) of the generation, transmission, distribution and supply of electricity or those that might hamper **participation** of **Demand Response**, in **balancing markets** and **ancillary services** procurement".

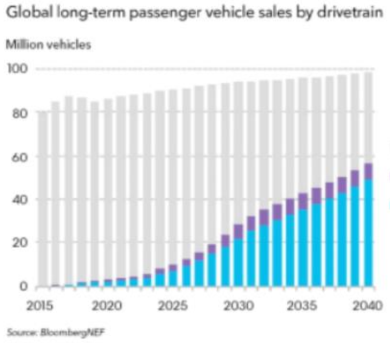
"Ensure that network operators are incentivized to **improve efficiency** in infrastructure design and operation, and, within the framework of Directive 2009/72/EC, that tariffs allow retailers to **improve consumer participation** in system efficiency, including **Demand Response**, depending on national circumstances".

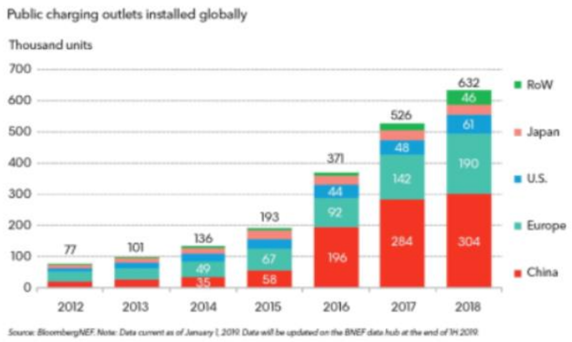
Why change something that works?

6. The only way to **manage** a **massive penetration** of electric vehicles and other resources distributed in the network is through their **coordinated installation**, which makes it possible to **limit investment** in **infrastructure** and to **manage distributed resources** and increase overall efficiency through their active participation.

¡¡¡ FLEXIBILITY !!!

Electrical Vehicles



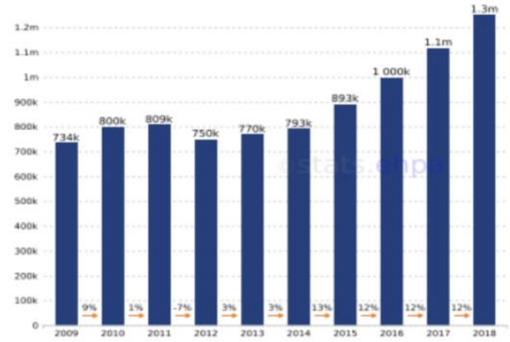


- Electric vehicles in Spain (63,000) less than half are cars.
- Average daily travel is 45km
- Average consumption of an EV is 15kWh/100km
- Average daily consumption of a car 6.75kWh/day -> 2.5MWh per year
- For 100,000 electric vehicles the consumption would be 250GWh, (1% of the global energy consumption).
- Average consumption of a Spanish home (3.5MWh per year) -> EV would increase consumption by 70%

Climate control heat pumps and air conditioning

Figure 28 HEAT PUMPS INSTALLED IN EHPA MEMBER COUNTRIES IN 2018

Source: EHPA

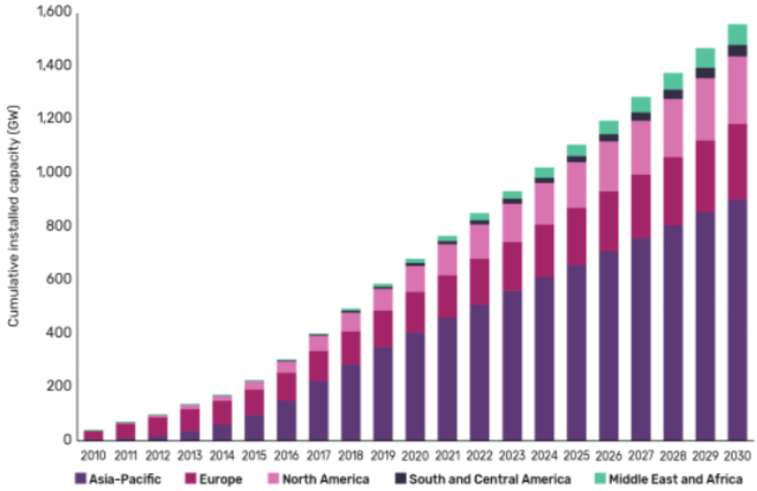


Webinar: EHPA market report and statistics outlook 2019 | Thomas Nowak | 24.06.2019

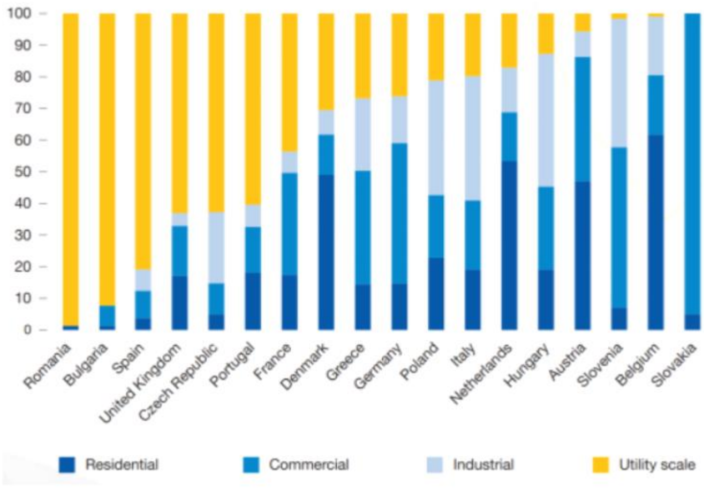
Case of Study:

- **100m² house with Energy Label E in Climate Zone D**
- Energy demand data:
  - Heating: 102 kWh/m² year -> 10.200kWh/year (thermal consumption)
  - Refrigeration: 14.53 kWh/m² year -> 1453kWh/year (thermal consumption)
- Seasonal yields for heating and cooling
  - SCOP aerothermal energy A+: 6.2 -> 10200kWh/6.2 = 1645.16kWh heating (electricity consumption)
  - SEER cooling A+: 5.7 -> 1453kWh/5.7= 254.91kWh cooling (electricity consumption)
- Total electricity consumption for climate control = 1900.07kWh -> 1.9MWh
- Annual electricity consumption of the average Spanish home 3.5MWh
- Annual energy consumption of the average Spanish home (gas + electricity) 10MWh per year
- Electrification would bring this consumption down to 1.9+3.5 = 5.4MWh (down 46%).
- Consumption of heat pumps installed in Spain (1100GWh -> 0.5% of total).
- Without distributed generation, congestion in the distribution network would increase by 54% due to heat pumps alone.

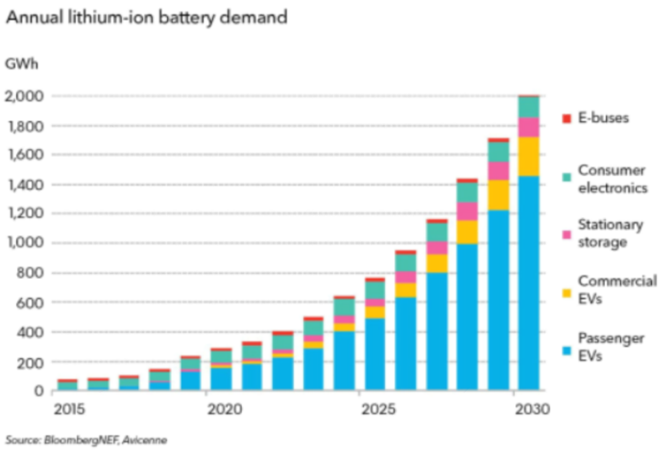
PV Generation



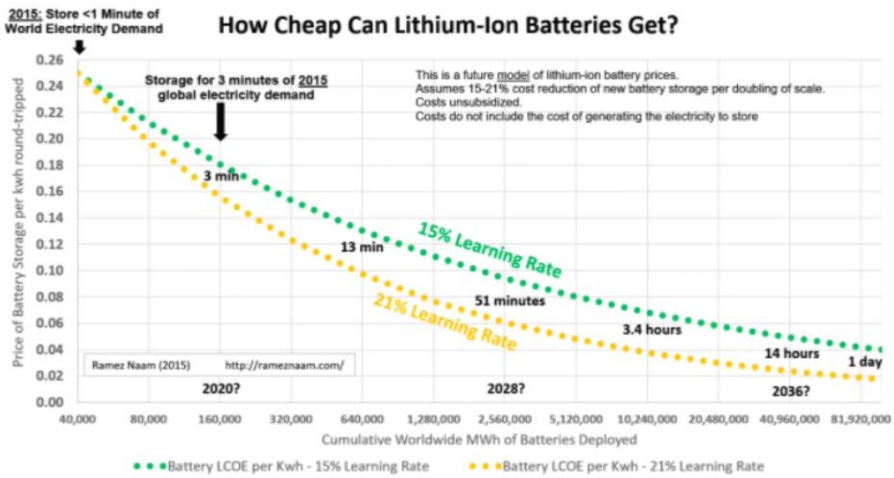
PV Generation



Energy Storage:



Energy Storage:



What we researchers have done over the last 20 years?

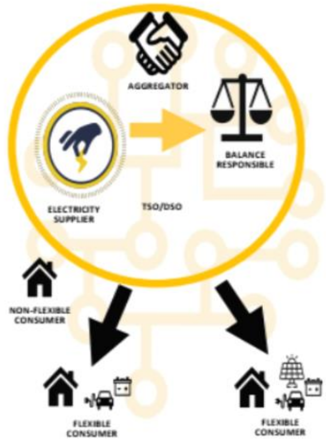
- **Microgrid**: Solution for the coordination of different distributed resources in a portion of the network connected through a coupling point.
- **SmartGrids**: Relaxation of topological restrictions and automatic or semi-automatic network management that allows the implementation of **Demand Response** systems or **flexibility** management.
- **Transactive Energy**: Application of economic techniques in conjunction with conventional network management techniques, giving rise to new roles or business models such as the **Aggregator**.

Which Aggregator models do we have? Are they "deployable"?

- There is a vast catalogue of aggregation models that depend mainly on the following factors:
  - Regulation
  - Available technology
  - Regulation
- In this presentation we will see two models that represent the two "extremes" but there are many proposals and solutions in between.
- Model 1:
  - Consume and generate energy in a coordinated way.
  - One more agent in the system
  - No responsibility for the energy supply to the customer

Which Aggregator models do we have? Are they "deployable"?

- There is a vast catalogue of aggregation models that depend mainly on the following factors:
  - Regulation
  - Available technology
  - Regulation
- In this presentation we will see two models that represent the two "extremes" but there are many proposals and solutions in between.
- Model 4:
  - Integrated management with the TSO, DSO or energy supplier.
  - It optimises the management of resources to the maximum and increases efficiency.
  - It can be a role within an agent or an agent itself

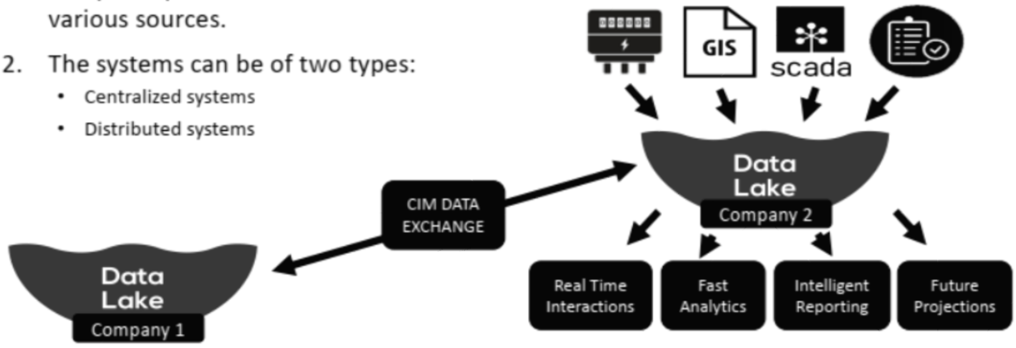


What is the reality in utilities?

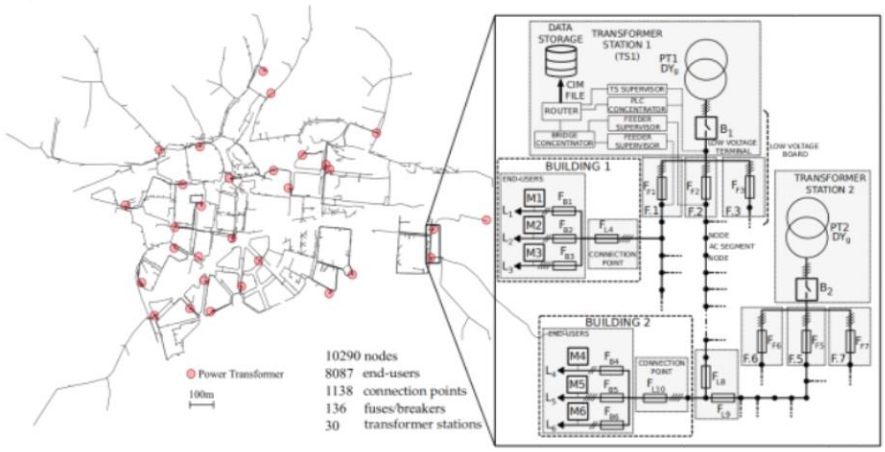
1. The **utilities** have made a tremendous effort in **digitalization** generating an immense **volume** of **invaluable data**.
2. **Data** is the oil of the 21st century, but data collection and storage **does not directly means** the generation of **knowledge**.
3. In many cases, **data** is in **separate, non-intercommunicating** systems, making it **difficult** to manipulate and **extract knowledge** from it.

Which is the path we must follow?

1. Create data storage and management systems that enable ultra-fast, highly complex queries with cross data from various sources.
2. The systems can be of two types:
   - Centralized systems
   - Distributed systems

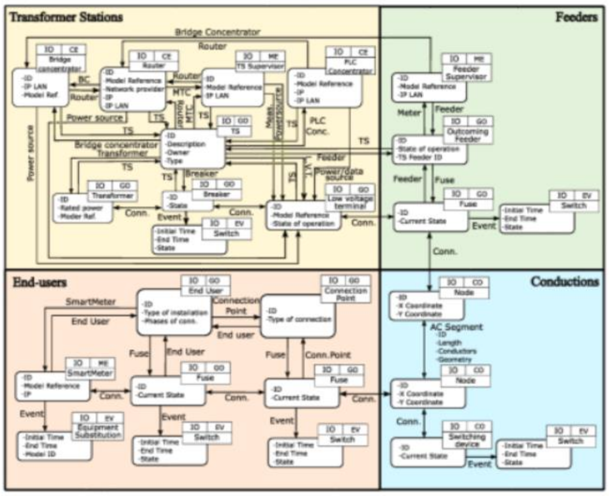


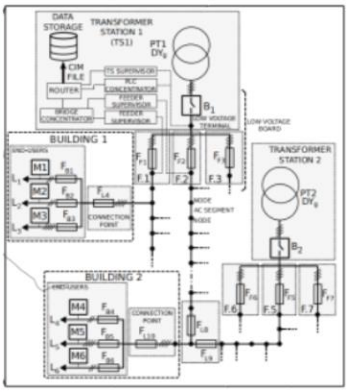
Development of data models is a critical task



Arpan Koirala, Lucía Suárez-Ramón, Bassam Mohamed, Pablo Arboleya, *"Non-synthetic European low voltage test system"*, International Journal of Electrical Power & Energy Systems, Volume 118, 2020.

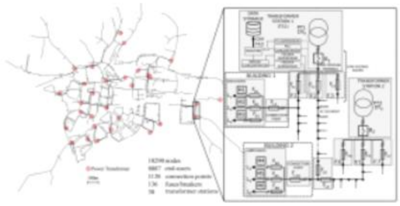
Development of data models is a critical task



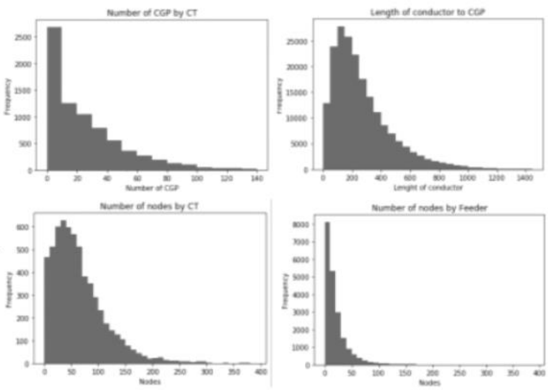


A Specific data model for each case of application

The parallelization of data processing systems



	Case	Min	Percentile 5	Average	Percentile 95	Max
0	Nodes by CT	2	6.0	67.303422	163.0	590
1	Nodes by Feeder	2	2.0	19.958337	63.0	258
2	CGP by CT	0	0.0	25.797784	82.0	465
3	Length to CGP	0	41.0	269.575146	683.0	3027



In distribution, it is essential to break down the problem.
A natural grouping element is the power transformer station.
Knowing the dimensions of the problem to optimize the algorithms is fundamental.

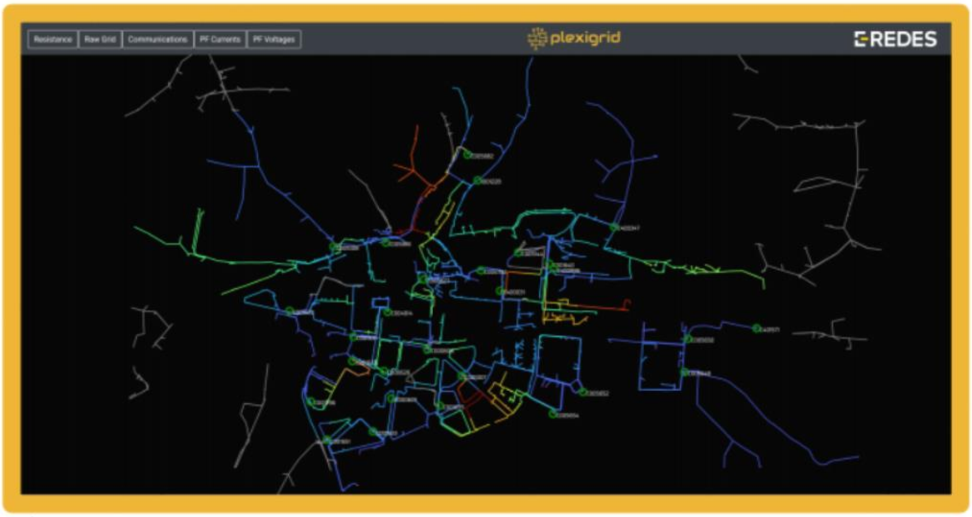
Case of study, complex query

The real-time calculation of the network impedance map involves the generation of real-time networks that That allow to reach from each point to its corresponding transformer.

Case of study, complex query

Impedance map

Case of study, complex query



Voltages map

Case of study, complex query

Currents map

[redacted]

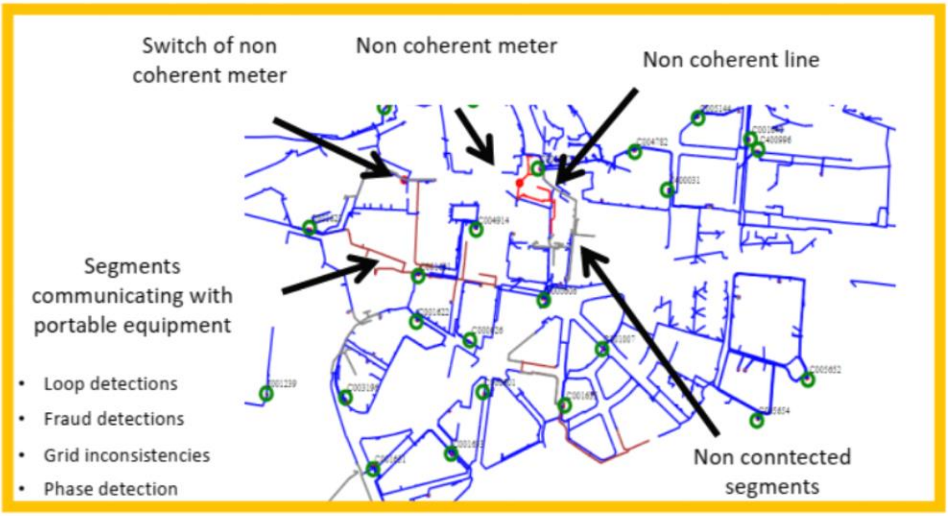
Is it posible to run a real-time state estimation?

- Again the key is in data acquisition and management and parallelization of operations.
- The technology used in Spanish smartmeters is PLC technology.
- As the main advantage of PLC technology we could indicate the elimination of the dependence on third party communication networks.
- PLC technology allows us to obtain a lot of topological information and the configuration of network resources.
- The bandwidth is very limited.

[redacted]

[redacted]

Is it posible to run a real-time state estimation?



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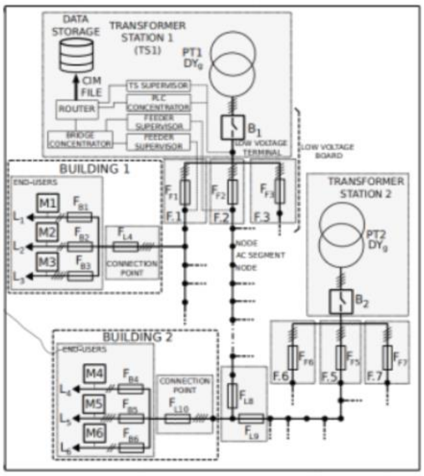
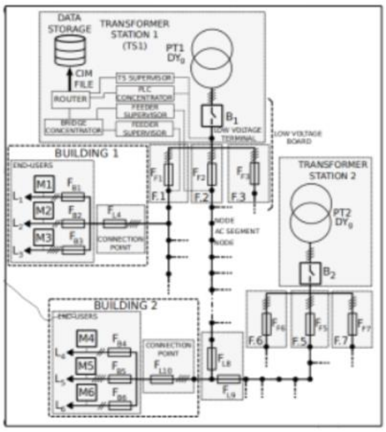
Is it posible to run a real-time state estimation?

- The **state estimation** algorithms in four-wire systems are **developed**.
- Once the problem of topological estimation is solved, everything depends on the **acquisition** of **measurements** that allow the **observability** of the system.
- The **advanced measurement infrastructure** consisting of smartmeters, line supervisors and advanced supervisors at the transformer station level is capable of **providing sufficient information**.
- It is **essential** to **understand the sampling** process and the delays generated by it in obtaining the information.



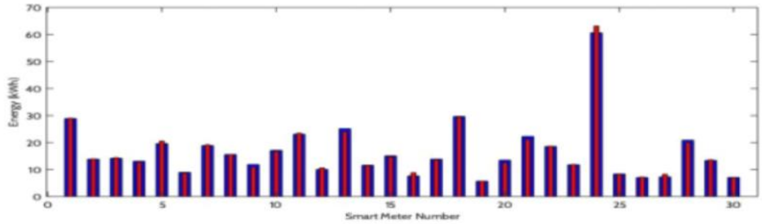
Is it posible to run a real-time state estimation?

- What is the delay in requesting data from a SmartMeter?
  - Injection phase
  - Distance to the concentrator
  - Network saturation
  - Electromagnetic interference
- Example request active power to smartmeter:
  - Request time: 30-Nov-2019 17:27:36
  - Answer received: 30-Nov-2019 17:28:10
  - Value (active power W): 599.9
  - Value timestamp: 30-Nov-2019 17:27:57
  - Total delay: 34 seconds



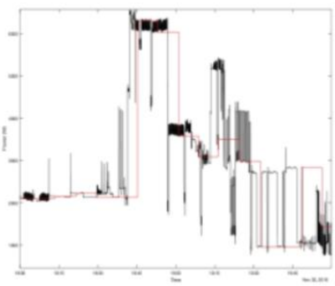
Is it posible to run a real-time state estimation?

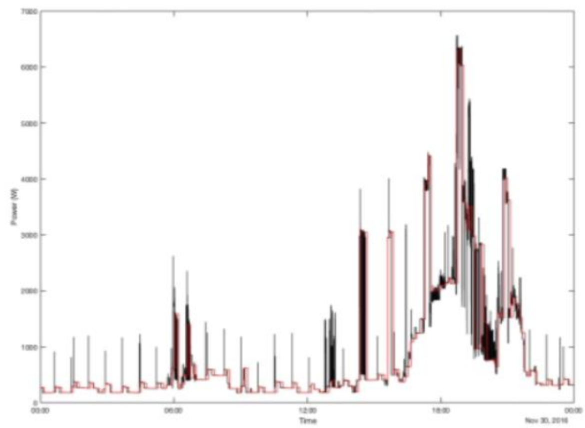
- Data obtained with a sampling emulator in a system of 30 dwellings divided into 5 connections located in the same feeder and distributed in 3 phases.
- Distance of the connections in meters [25 37 52 91 103].
- Initial curves obtained with recorders and sampled with a frequency of 1 second.
- The average delay in the slowest smartmeter was 19.73 seconds, in the fastest one 7.81 seconds. The number of records obtained by each meter was 181, in this case only active power was sampled. This implies that a data could be obtained from each smartmeter every 7 minutes and 57 seconds.

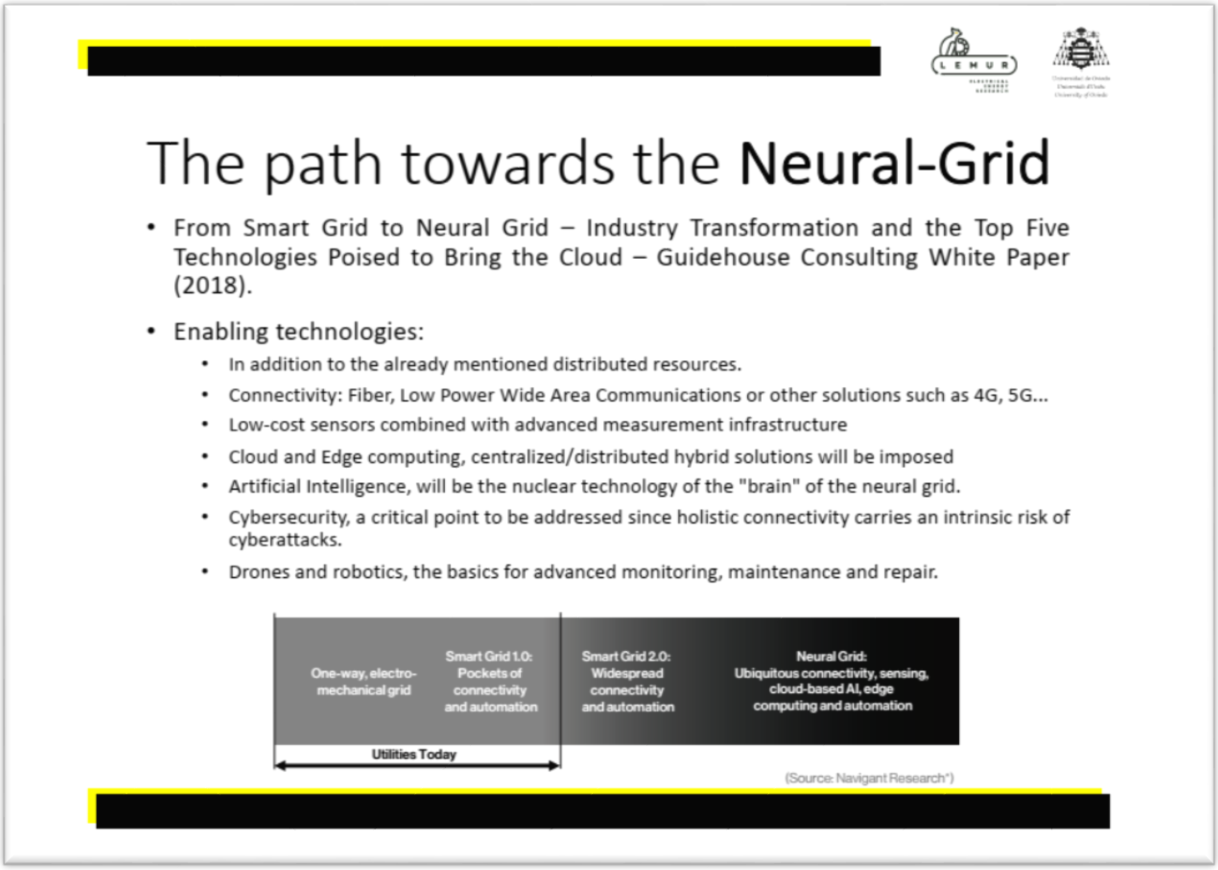


Is it posible to run a real-time state estimation?

- Difference between real signal and sampled signal on smartmeter number 7
- The definition of the sampling strategy is fundamental.
- The measurements have to be used together with prediction techniques and AI algorithms.






The path towards the Neural-Grid
From Smart Grid to Neural Grid – Industry Transformation and the Top Five Technologies Poised to Bring the Cloud – Guidehouse Consulting White Paper (2018).
Enabling technologies:
In addition to the already mentioned distributed resources.
Connectivity: Fiber, Low Power Wide Area Communications or other solutions such as 4G, 5G...
Low-cost sensors combined with advanced measurement infrastructure
Cloud and Edge computing, centralized/distributed hybrid solutions will be imposed
Artificial Intelligence, will be the nuclear technology of the "brain" of the neural grid.
Cybersecurity, a critical point to be addressed since holistic connectivity carries an intrinsic risk of cyberattacks.
Drones and robotics, the basics for advanced monitoring, maintenance and repair.
One-way, electro-mechanical grid
Smart Grid 1.0: Pockets of connectivity and automation
Smart Grid 2.0: Widespread connectivity and automation
Neural Grid: Ubiquitous connectivity, sensing, cloud-based AI, edge computing and automation
Utilities Today
(Source: Navigant Research)