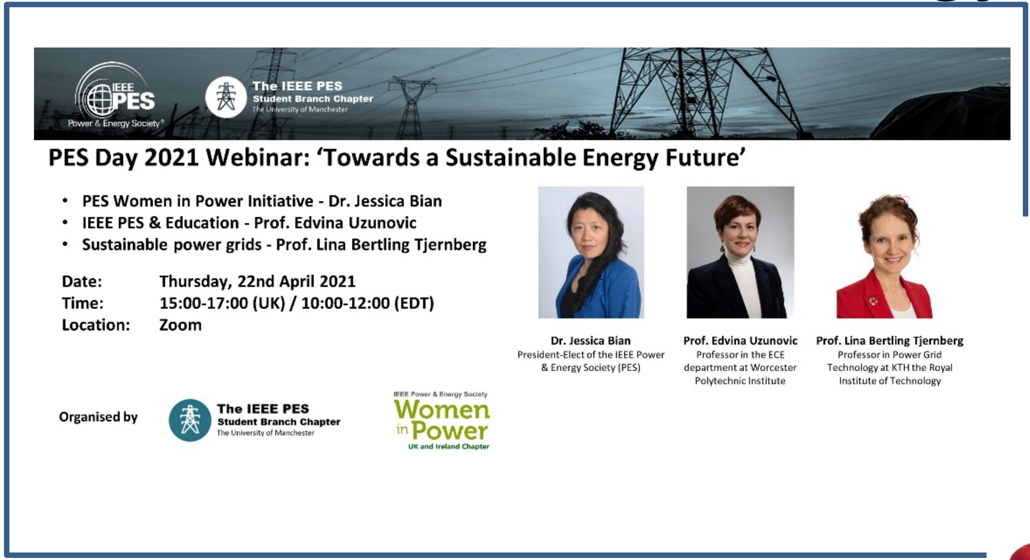
Topic: PES Day 2021 Webinar: Towards a Sustainable Energy Future



Sustainable Power Grids

Dr. Lina Bertling Tjernberg professor in power grid

linab@kth.se www.kth.se/profile/linab @linabertling

April 22 2021

Electric Power grids as enabler for the sustainable society!

Invited talk in panel session in HVDC laboratory, Ludvika, Hitachi ABB Power Grid, 2020.

Thanks for inviting me to this event at the PES Day 2021!

Current and past chair of

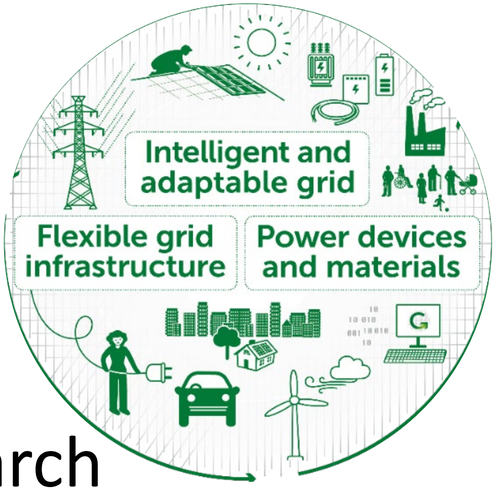
the IEEE Sweden PE/PEL chapter .

Ambra Sannino and Lina Bertling Tjernberg

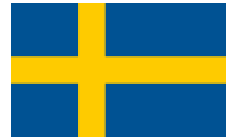
Women in Power Engineering seminar, IEEE PES ISGT Latin America, Brazil 2019.

Summary of the talk

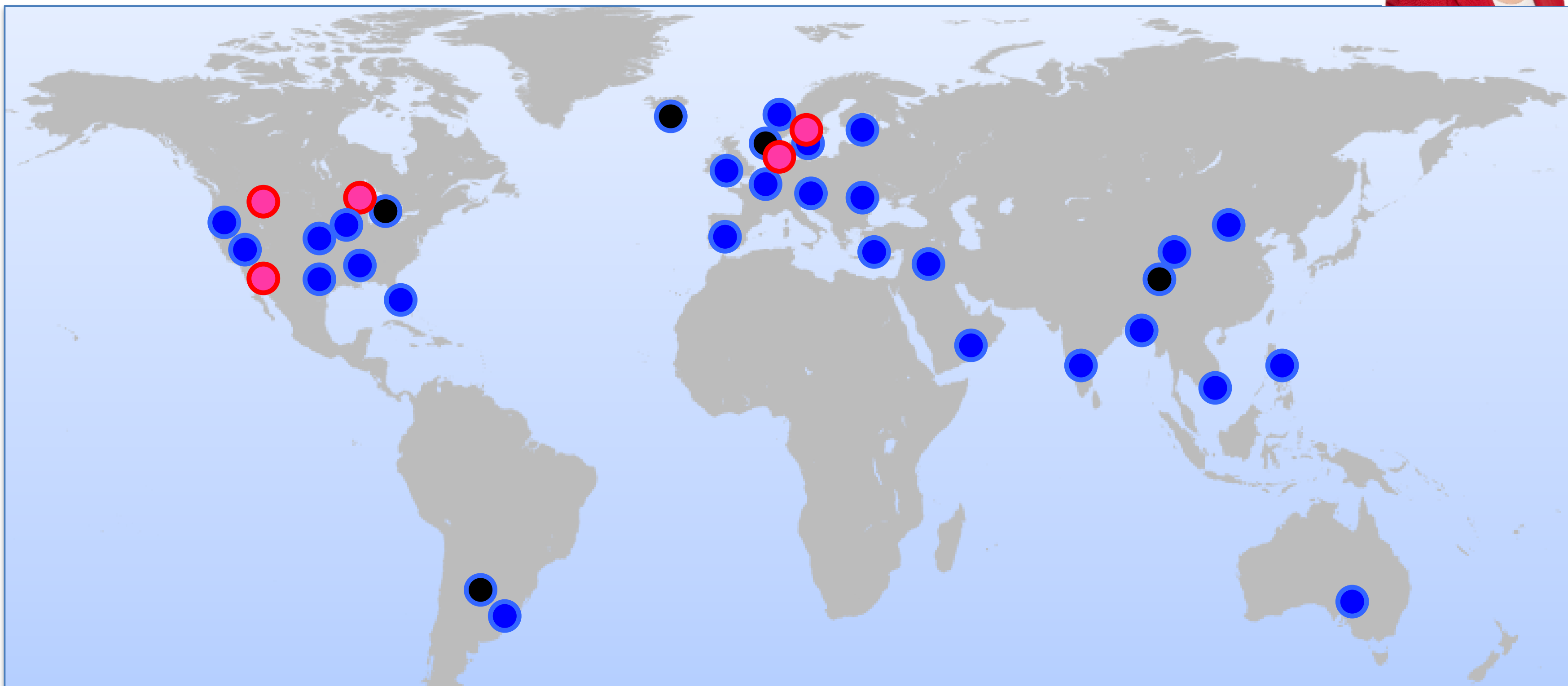
- Brief introduction
- Sustainable developments
  - the EU Green deal package
- Power grid developments
  - trends and topics
- Examples
  - The national grid and ongoing research



Lina Bertling Tjernberg –



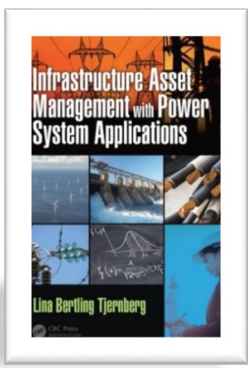
Power Systems, Reliability, Asset Maintenance, Smart Grid, IEEE



- Positions: Stockholm, Saskatoon, Toronto, Gothenburg, Palo Alto
- Top Visits: Iguazu, Niagara, Gullforss, Nordned, Three Gorges
- Key notes: Beijing, Jeju Island, Melbourne, Sarajevo, Gramado

Lina Bertling Tjernberg - in brief

- **Professor in Power Grid Technology**
- Director of Energy platform, Coordinator of Life long learning at the School of Electrical Engineering and Computer Science.
- Docent 2008, PhD 2002 Electric Power Systems, MSc Vehicle Engineering/ Systems engineering 1997, all at KTH.



- *Current:* National expert in the ISGAN Academy of Smart Grid, Member of the National Strategic Council for Wind Power, Vice chair of the Board of Parliament Members and Researchers.
- *Past:* Member of the Swedish Government Coordination Council for smart grid (2012-2014), IEEE Sweden Chapter PE/PEL chair 2009-2019, IEEE PES board Secretary/Treasurer (2012-2016), Editor of the Smart Grid Transaction (2010-2015), the IEEE Reliability Risk and Probability Applications (RRPA) Subcommittee board (chair 2011-2013)
- *Research visits:* Stanford University (2014), University of Toronto (2002/2003), University of Saskatchewan (2000).
- *Author:* more than 100 papers, several chapters and one book *Infrastructure Asset Management with Power System Examples, L. Bertling Tjernberg, CRC Press, Taylor and Francis, April 2018*

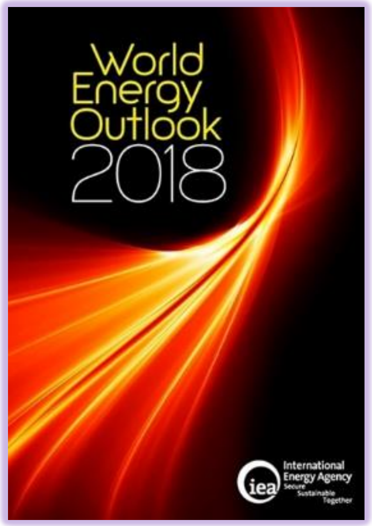
Sustainable developments

Source: https://www.un.org/sustainabledevelopment/sustainable-development-goals/

Sustainable developments

- Three key pillars for the developments of the new energy system:

1. Affordability:
2. Reliability:
3. Sustainability



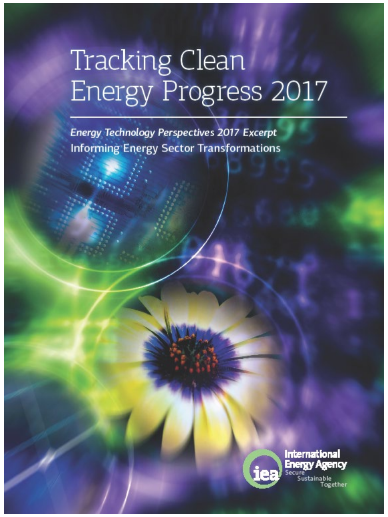
Source: World Energy Outlook, IEA Report November 2018, Available down load from: https://webstore.iea.org/download/summary/190?fileName=English-WEO-2018-ES.pdf

Sustainable developments

1. **Affordability**
   - costs of solar PV and wind continue to fall
   - oil prices climbed above $80/barrel
   - reforms to fossil fuel consumption subsidies under threat
2. **Reliability**:
   - Risks to oil and gas supply remain, as Venezuela's downward spiral shows.
   - One-in-eight of the world's population has no access to electricity and new challenges are coming into focus in the power sector, from system flexibility to cyber security.
3. **Sustainability**:
   - After three flat years, global energy-related carbon dioxide (CO2) emissions rose by 1.6% in 2017 and the early data suggest continued growth in 2018,

Sustainable development goals

- **Three key areas on track**
  1. A new historic record with over 750 000 EVs
  2. Storage technologies reaching almost 1GW
  3. Strong annual capacity growth continued for both solar PV and onshore wind record low long-term contract prices in Asia, Latin America and the Middle East.

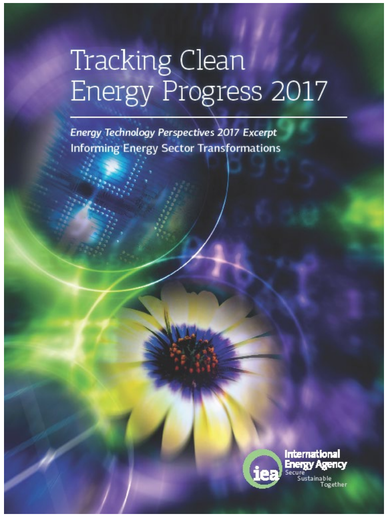


Source: Tracking Clean Energy Progress 2017, IEA Report 2017, Available to down load from: https://www.iea.org/publications/freepublications/publication/TrackingCleanEnergyProgress2017.pdf:

Sustainable developments

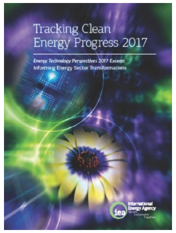
Worrying progress with slow progress for several key areas

- ✓ Nuclear power saw 10 GW of capacity additions (the highest rate since 1990)
- ✓ Coal continues to dominate global power generation, share of over 40%
- ✓ Large-scale CCS projects stalled due to lack of new investment decisions.
- ✓ Advanced biofuels need a 25-fold scale-up in production volumes by 2025



Sustainable developments

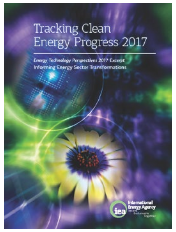
- With the rise of renewables in much of the world, understanding and managing flexibility is becoming a cornerstone of energy markets.
- Energy storage played a much greater role in providing flexibility in 2016, with important deployments in both short-term and long-term balancing markets, particularly in Europe and the United States.



Source: Tracking Clean Energy Progress 2017, IEA Report 2017, Available to down load from: https://www.iea.org/publications/freepublications/publication/TrackingCleanEnergyProgress2017.pdf :

Sustainable developments

- Strong deployment of storage technologies continued to be driven by policy, technological developments and a better appreciation by regulators of the value of storage.
- Lithium-ion batteries are positioned as the main storage technology due to cost reductions and rapid scale-up of manufacturing capacities.
- Storage is on track with 2DS due to positive market and policy trends, but an additional 21 GW of capacity is needed by 2025.
- Further policy action is, therefore, required to tackle challenges to deployment



Source: Tracking Clean Energy Progress 2017, IEA Report 2017, Available to down load from: https://www.iea.org/publications/freepublications/publication/TrackingCleanEnergyProgress2017.pdf :

Sustainable developments

- European Green Deal Call: €1 billion investment to boost the green and digital transition (launched 22 Sept. 2020)

Sustainable developments

The European Green Deal provides an action plan to

- boost the efficient use of resources by moving to a clean, circular economy

- restore biodiversity and cut pollution
- The plan outlines investments needed and financing tools available. It explains how to ensure a just and inclusive transition.

Sustainable developments

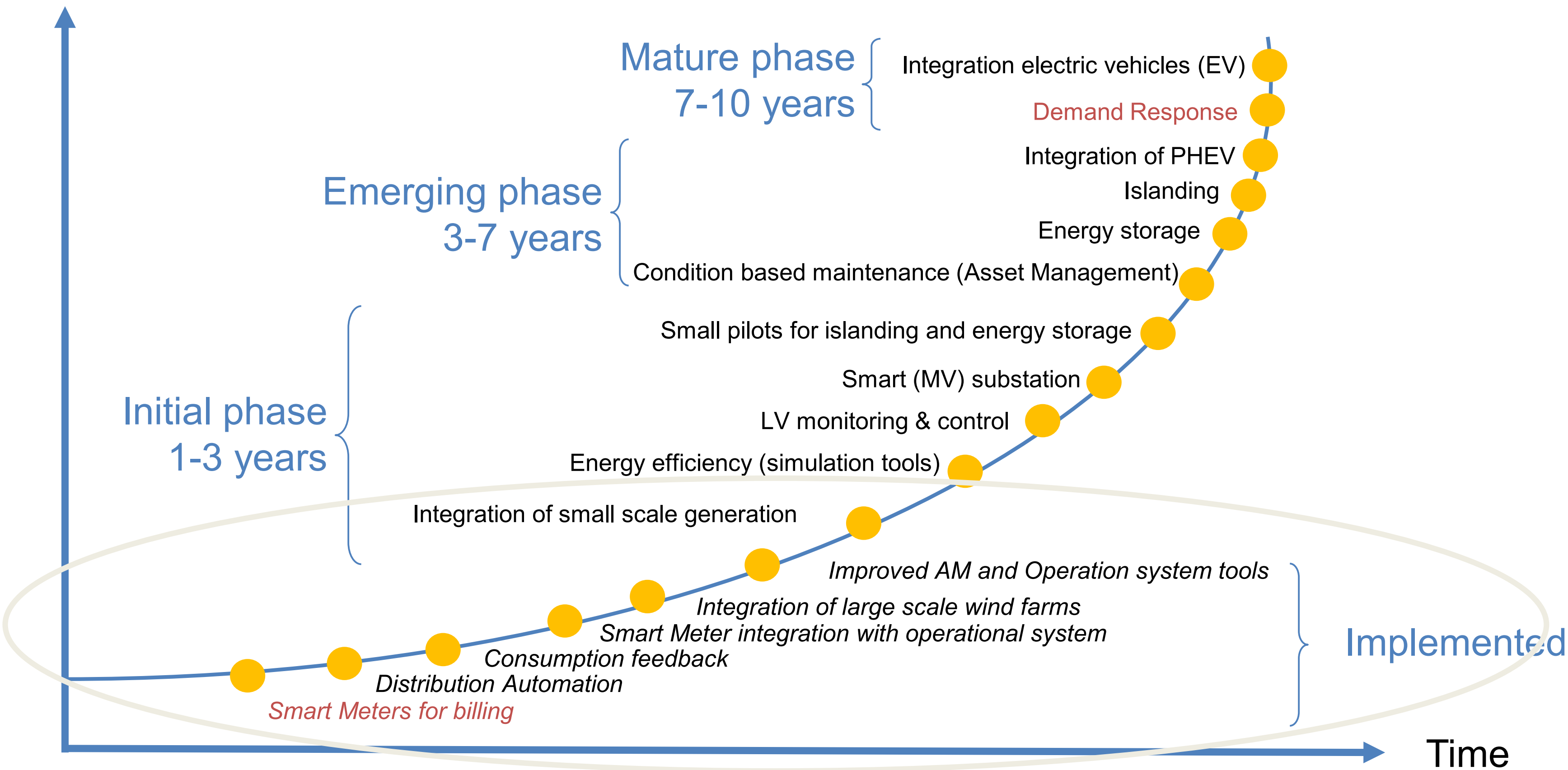
The European Green Deal provides an action plan to

- “Climate change and environmental degradation are an existential threat to Europe and the world. To overcome these challenges, Europe needs a new growth strategy that will transform the Union into a modern, resource-efficient and competitive economy, where
  - there are no net emissions of greenhouse gases by 2050
  - economic growth is decoupled from resource use
  - no person and no place is left behind”

Towards a sustainable society

- Energy – transformed and transported
- Electric power grid as an energy infrastructure
- Electricity replacing fossil fuel in transportations and industry
- Trends
  - Electrification
  - Digitalization
  - Circular economy

Power Grid Developments



VATTENFALL

IEEE

IEEE PES Power & Energy Society®

Power Grid Developments

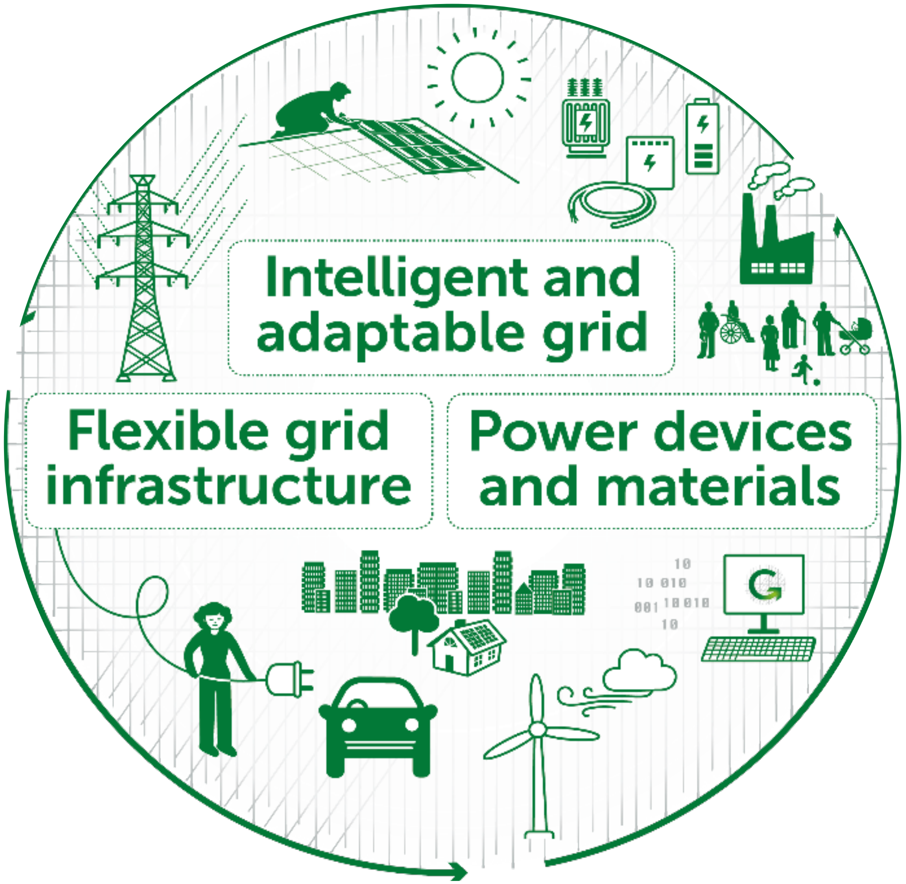
Vattenfall use batteries from BMW to back up wind power

- up to 1,000 lithium-ion batteries with a capacity of 33 kilowatt-hours (kWh) each from BMW's plant in Dingolfing.
- build the first 3.2 MW battery storage facility at its 122 MW Princess Alexia wind farm near Amsterdam.

Source; Reuters, March 14, 2017.

Power Grid Developments

- For a sustainable society with 100% renewables
- Key areas:
  - Intelligent (software)
  - Flexible (hardware)
  - Circular economics with battery storage



•Research in these field are performed within the national research center [SweGRIDS | KTH]

Power Grid Developments

- The electric power system is being modernized to enable a sustainable energy system.
  - New developments include possibilities and challenges with generation, delivery and usage of electricity as an integrated part of the energy system.
  - This involves new forms of usage of electricity, e.g. for transportation and demand response, and to the updating of existing electricity infrastructures.

Power Grid Developments

- For electricity generation the trend is toward new large-scale developments, like offshore wind farms, as well as small-scale developments like rooftop solar energy.
- At the same time, digitalization of society is creating new opportunities for control and automation as well as new business models and energy related services.

Power Grid Developments

- The overall trend for technology developments are the new possibilities for measurement and control.
  - PMUs which provide measurements of voltage and current up to 30-120 times per second.
  - Smart Meters placed with the end consumer, which enables integration of private small-scale electricity production from solar cells, or energy storage from electric vehicles and general distributed control of energy use

Power Grid Developments

- Another trend is the development of diagnostic measurement techniques
  - assessing the insulation condition,
  - prediction of lifetime of physical assets
  - resulting in new methods for condition monitoring.

The Swedish national grid

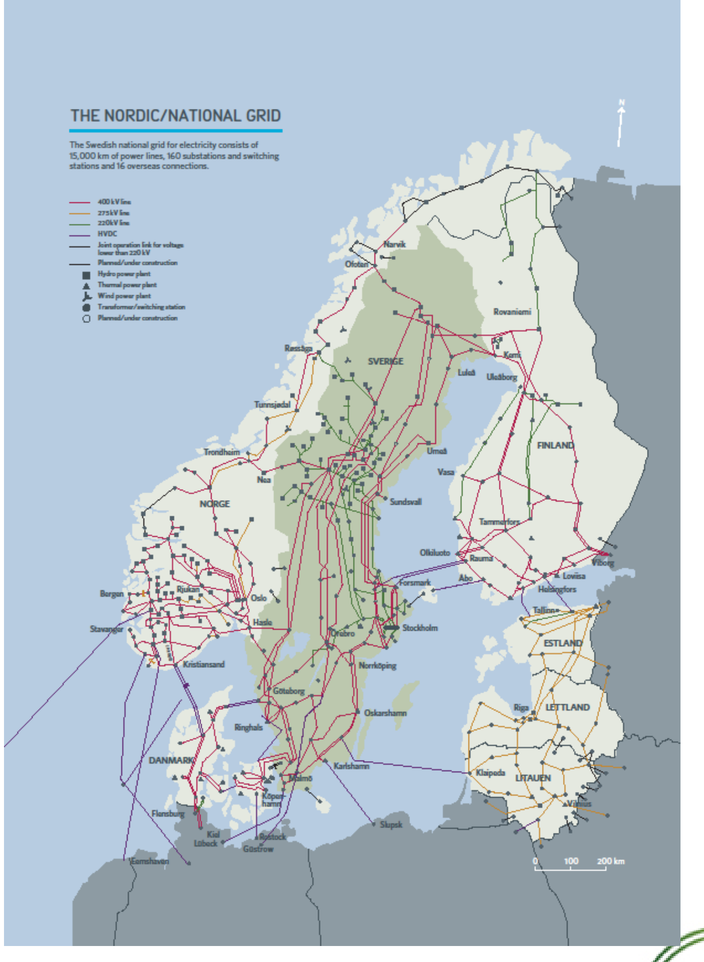
- Swedens Energy policy and target

50 per cent more efficient use of energy in 2030, compared with 2005	70 per cent less emissions from transports 2030 compared with 2010	100 per cent renewable electricity to 2040	No net emissions of greenhouse gases to 2045

Three pillars for Sweden’s energy policy

The Swedish national grid

- The Swedish national grid for electricity consists of
  - 15 000 km of power lines
  - ~160 substations and switching stations and
  - 16 overseas connections



The Swedish national grid

2021-03-08 7.00

- Total production
  - 21 820 MW
- Total consumption
  - 21 849 MW
- Importing 29 MW

The flow of electricity

Electricity trading in the Nordic and Baltic regions occurs in the Nordic power exchange Nord Pool Spot. The flow of electricity is from an electricity area with lower price to an area with higher price. Both the flow of electricity and the price are controlled by supply and demand. The price is valid for the current hour.

› Read more about the national grid

Flows updated today 7:08
Prices updated today 7:00

Total exports / imports

SWEDEN	Importing	29 MW
DENMARK	Importing	1 904 MW
NORWAY	Exporting	4 044 MW
FINLAND	Importing	2 919 MW
ESTONIA	Importing	772 MW
LATVIA	Exporting	230 MW
LITHUANIA	Importing	867 MW

Electricity is a Swedish export. Sweden's electricity consumption is about 140 TWh a year and in recent years, net exports have been 10-30 TWh. We have many important electricity connections to neighbouring countries.

Data source: Statnett

The connections enable Sweden to export electricity when there is a surplus while import capability strengthens the Swedish security of supply. The map shows the flow right now and is updated every minute.

Data source: Statnett

The Swedish national grid

- Electricity production March 8, 2021, 0700

Electricity generation	Power [MW]	Power [%]
Nuclear	6363	29.2
Thermal	1535	7
Not specified	698	3.2
Wind	1770	8.1
Hydro	11453	52.5
Total production	21 820	

The Swedish national grid

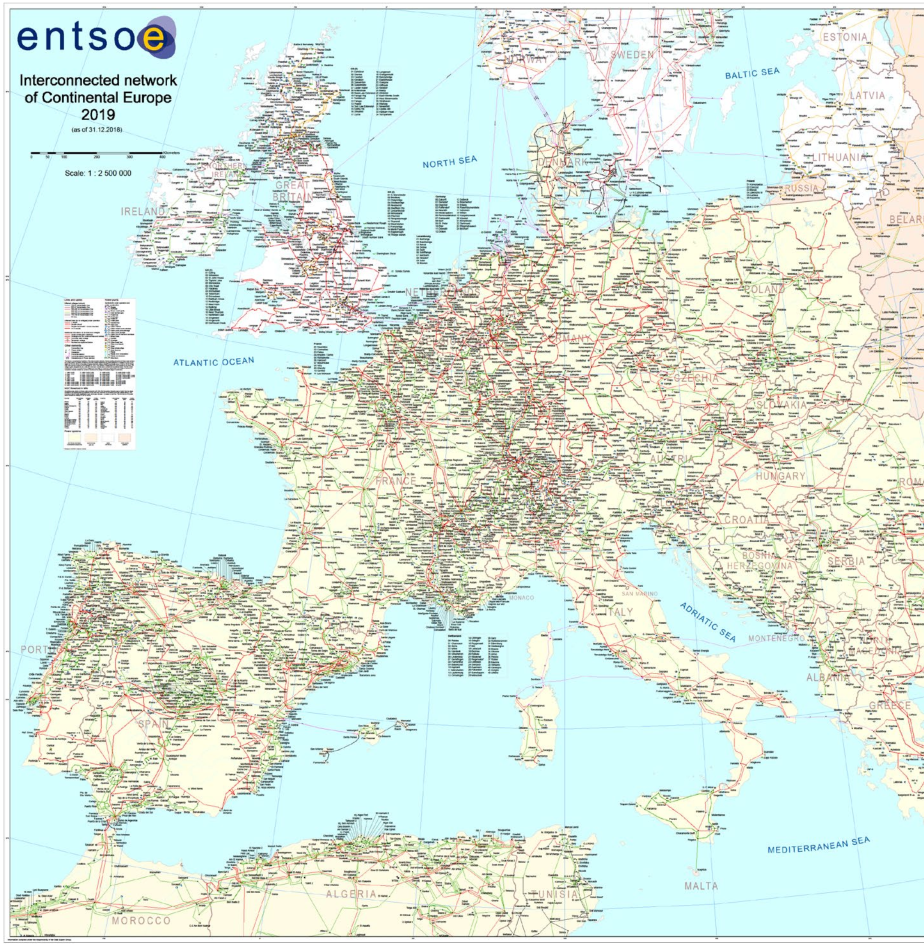
Power reserve for 2020-2025

- The Power Reserve has an agreement of 562 MW until winter 2024/2025, then the Power Reserve Act is deleted as decided by the Parliament on May 12, 2016 (Business Committee's bet 201516:NU19)

Owner	Area	Power [MW]	Station
Sydkraft thermal power	SE4	562	Karlshamn

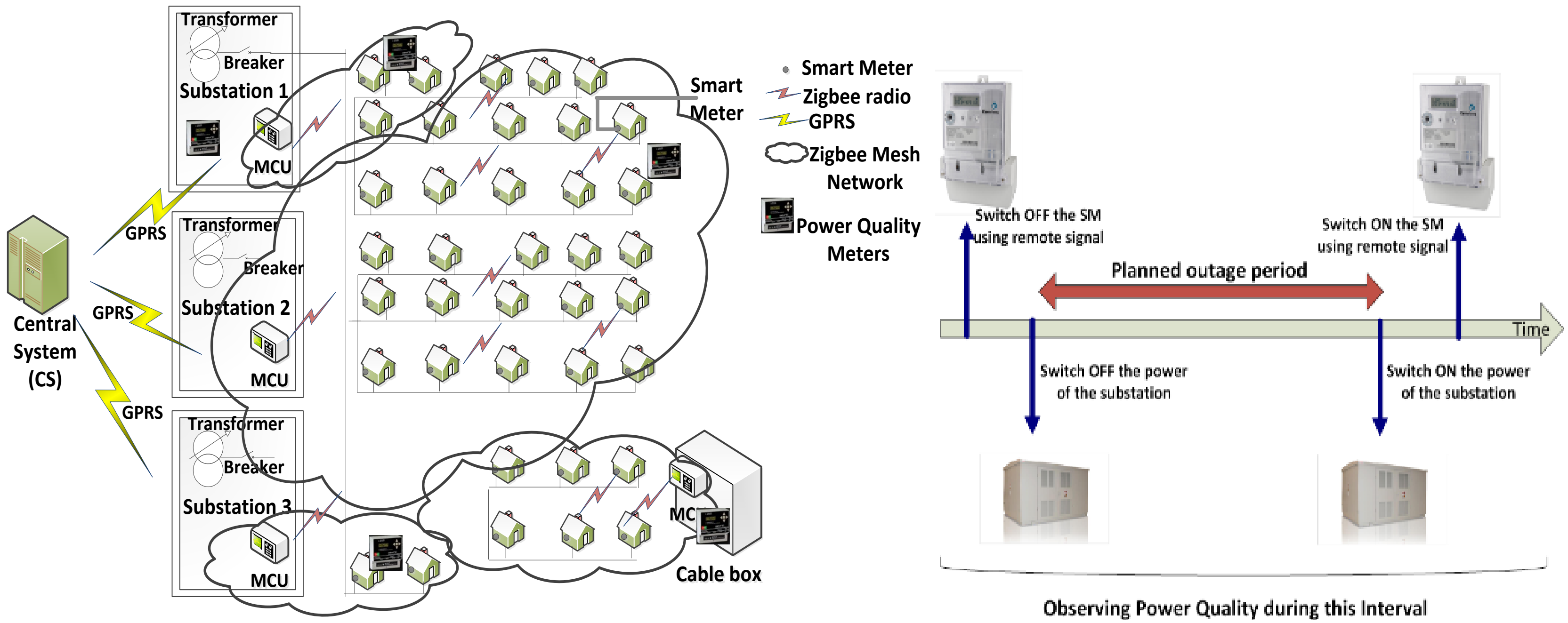
The Swedish national grid

Interconnected with Europe



Power Grid Developments

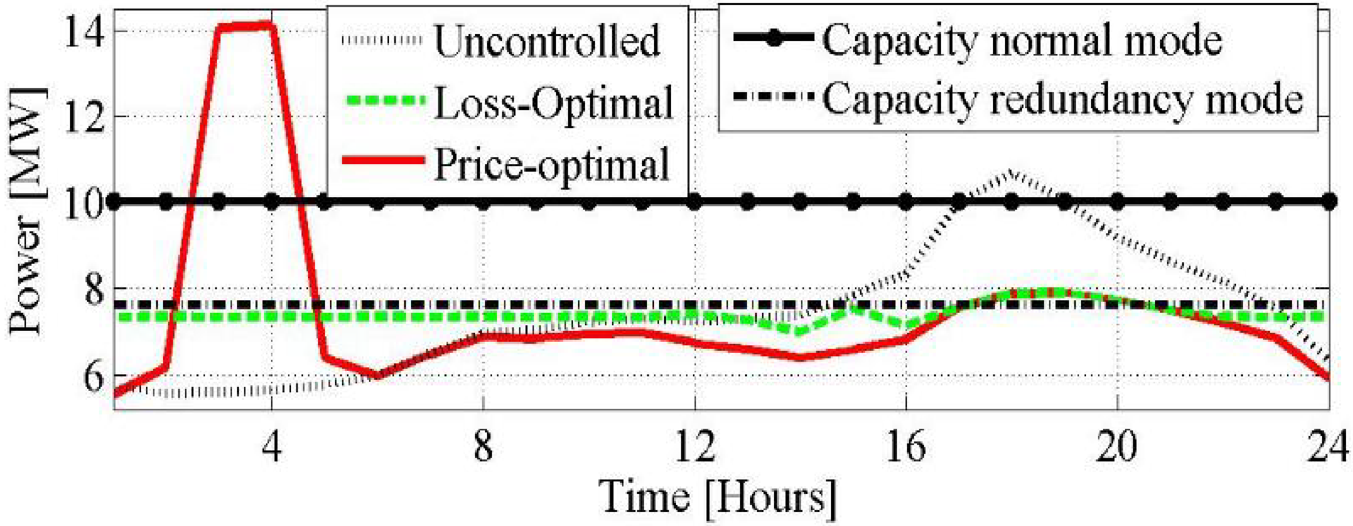
Example study: remote switching with Smart Meters



Remote switching of multiple Smart Meters and steps to check the effect on the grid's power quality, Y. Arafat, L, Bertling Tjernberg, P. A. Gustavsson, IEEE PES T&D conference, April 2014.

Power Grid Developments

Example: effects of policies on charging of EVs



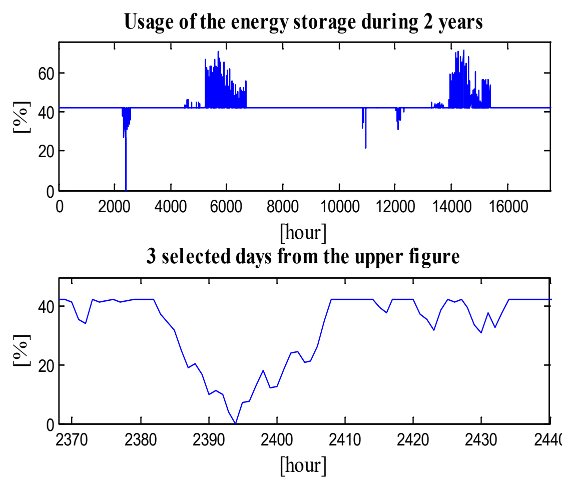
- Conclusions: different strategies reduces the need for reinforcement of the grid and contributes to lower losses

Assessment of Electric Vehicle Charging Scenarios Based on Demographical Data, Steen D., Tuan L., Carlson O. Bertling Tjernberg L. IEEE Transaction on Smart Grid, September 2013.

Power Grid Developments

Example: Smart Grid Gotland

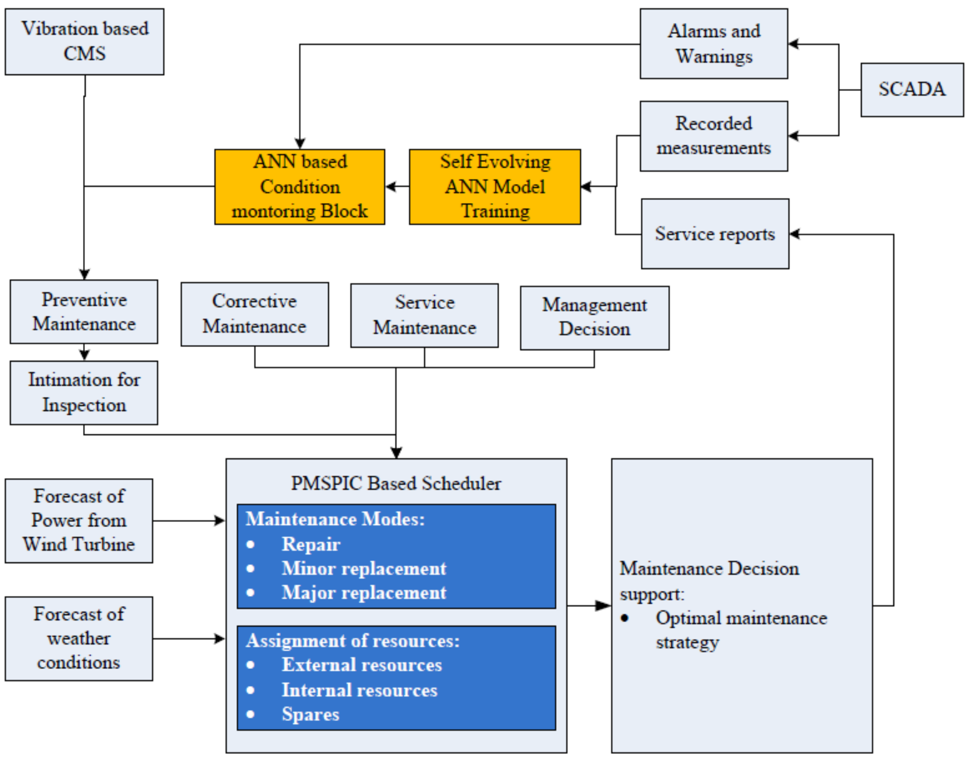
✓ Investigating impact of smart technologies in an existing power grid: wind and solar integration, energy storage, dynamic rating, etc.



Reference: Application of Smart Grid Technologies Case Studies in Saving Electricity in Different Parts of the World, Elsevier, Academic Press, Pages 373–393, June 2018. J. Wallnerström, L. Bertling Tjernberg

Power Grid Developments

Example: Predictive maintenance



ANN: Artificial Neural Networks

PMSPIC: Preventive Maintenance Scheduling Problem with Interval Costs

SCADA: Supervisory Control And Data Acquisition system

Smart Grid Handbook, , John Wiley & Sons, Ltd., August 2016. Chapter on: Condition Monitoring and Asset Management of Smart Grid, Bangalore P., Bertling Tjernberg L.
DOI 10.1002/9781118755471.sgd061

Power Grid Developments

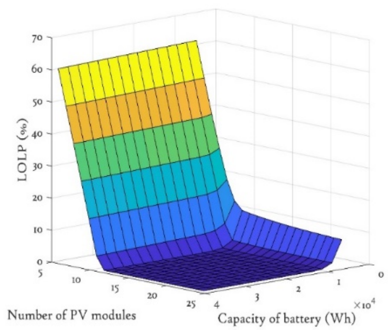
Example: Reliability and Life Cycle Cost Analyses of PV system in Zambia

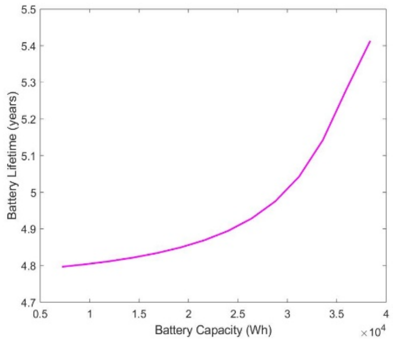
Step 1
Determine set of possible configurations with desired **reliability** using an energy management strategy (Loss of Load Probability < 5%)

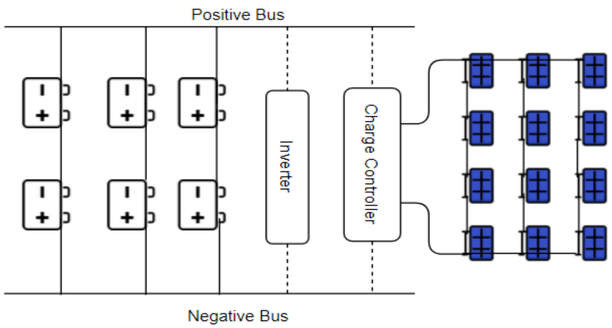
Step 2
Battery lifetime estimation using the overall usage method / Average DoD (depending on the battery profile in Step.1)

Step 3
Evaluate all the possible solutions in terms of **Life Cycle Cost** to find the most cost-effective solution (Net Present Value)

Optimum Design with lowest LCC
3 kW PV array
7.2 kWh battery capacity





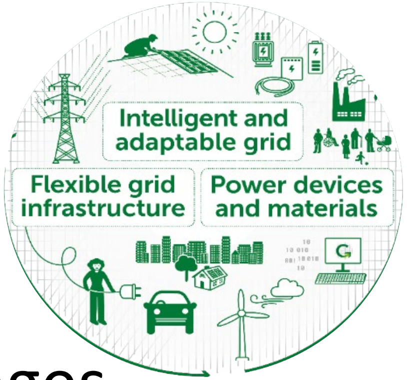


P. Alikhani, A. Mrad, H. Louie, and L. B. Tjernberg, “On the Reliability and Life Cycle Cost Analyses of Small-scale Standalone Solar Systems in Rural Areas,” p. 5, presented in IEEE ISGT NA 2021.

Summary of the talks

- Sustainable development
  - the EU Green deal package for 2050

- Power grid developments
  - Electrification, digitalization, battery storage, circular economics
  - Intelligent, flexible grid,



- Examples
  - Swedish national grid – capacity challenges
  - Research - numerous of topics!

THANKS & WELCOME!

- ***Dr. Lina Bertling Tjernberg***
- Professor in Power Grid Technology
- KTH Royal Institute of Technology
- School of Electrical Engineering and Computer Science
- Email: linab@kth.se
- Web: www.kth.se/profile/linab/
- LinkedIn: www.linkedIn.com
- Twitter: https://twitter.com/LinaBertling

society news

meet the candidates

Society elections

BEGINNING IN AUGUST, ELECTIONS will be held for the positions of IEEE Power & Energy Society (PES) president-elect, secretary, and treasurer. The candidates are as follows:

- ✔ president-elect: Lina Bertling Tjernberg and Edvina Uzunovic
- ✔ secretary: Sri Niwas Singh and Jonathan Sykes
- ✔ treasurer: Juan Carlos Montero and Nirmal K.C. Nair.

The successful candidates will serve for the term of 2022–2023. To learn more about the candidates before casting your ballot, read the biographies and candidate statements that follow. Visit the PES website (https://www.ieee-pes.org) for the most up-to-date information.

Candidates for President-Elect

Lina Bertling Tjernberg

Dr. Lina Bertling Tjernberg is a professor in power grid technology at KTH Royal Institute of Technology. She is the director of the energy platform and coordinator of lifelong learning at the School of Electrical Engineering and Computer Science. She was previously a professor at Chalmers University of Technology (2009–2013) and with the National Grid (2007–2009). She completed her Ph.D. degree in electric power systems at KTH in 2002. Her research and teaching are focused on the development of the future sustainable electric power grid with a special interest in reliability analysis, predictive maintenance, and asset management. She is actively involved as an advisor and expert in various professional organizations. Her current appointments include the Program Committee of the World Energy Council, National Strategic Council for Wind Power, ISGAN Academy of Smart Grid, and National Committee of CIRED; in addition, she is part of the expert pool for the EU commission.

Digital Object Identifier 10.1109/MPE.2021.3070946
Date of current version: xxxxxxx

IEEE Activities and Accomplishments

- ✔ Distinctions
  - 2016: Appointed as Distinguished Lecturer of IEEE PES
    - Giving an IEEE tutorial on asset management with power system applications
    - Giving DLP lectures and keynotes on the topics "Sustainable Power System Developments," "Predictive Maintenance Methods," and "Power System Reliability Assessment"
    - Frequent keynote speaker at ISGT conferences, Women in Power events, and Women in Engineering affiliations.
  - 2008: Senior Member of IEEE.
- ✔ Committees/Boards:
  - Secretary, IEEE PES Governing Board (2014–2016)
  - Treasurer, IEEE PES Governing Board (2012–2014)
  - Editorial board member, *IEEE Transactions on Smart Grid* (2010–2015)
  - Chair, IEEE PES ISGT Europe Steering Committee (2010–2014)
  - Officer of the board, IEEE PES Subcommittee on Risk, Reliability, and Probability Applications (RRPA) (2007–2013)
  - Member of the committee, IEEE PES Uno Lamm High Voltage Direct Current Award (2013–2020)
  - Member of the committee, IEEE PES Ramakumar Family Renewable Energy Excellence Award (2014–2020)
  - Past member of several technical committees and working groups within Methods for Power Systems and Transmission and Distribution
  - Currently a member of the committees of the IEEE Smart Grid, IEEE PES Awards and Recognition Committee, IEEE PES Industry Technical Support Leadership Committee, IEEE PES ISGT Europe Steering Committee, and Ad Hoc Committee for Patrick Ryan Award
- ✔ Region
  - Region 8
- ✔ Sections/Chapters
  - Chair, IEEE Sweden Chapter (2009–2019)
  - Officer of the board, IEEE Sweden Section Board (2006–2008)

2 IEEE power & energy magazine july/august 2021

Candidate for the IEEE PES President Elect 2022 – welcome to vote!