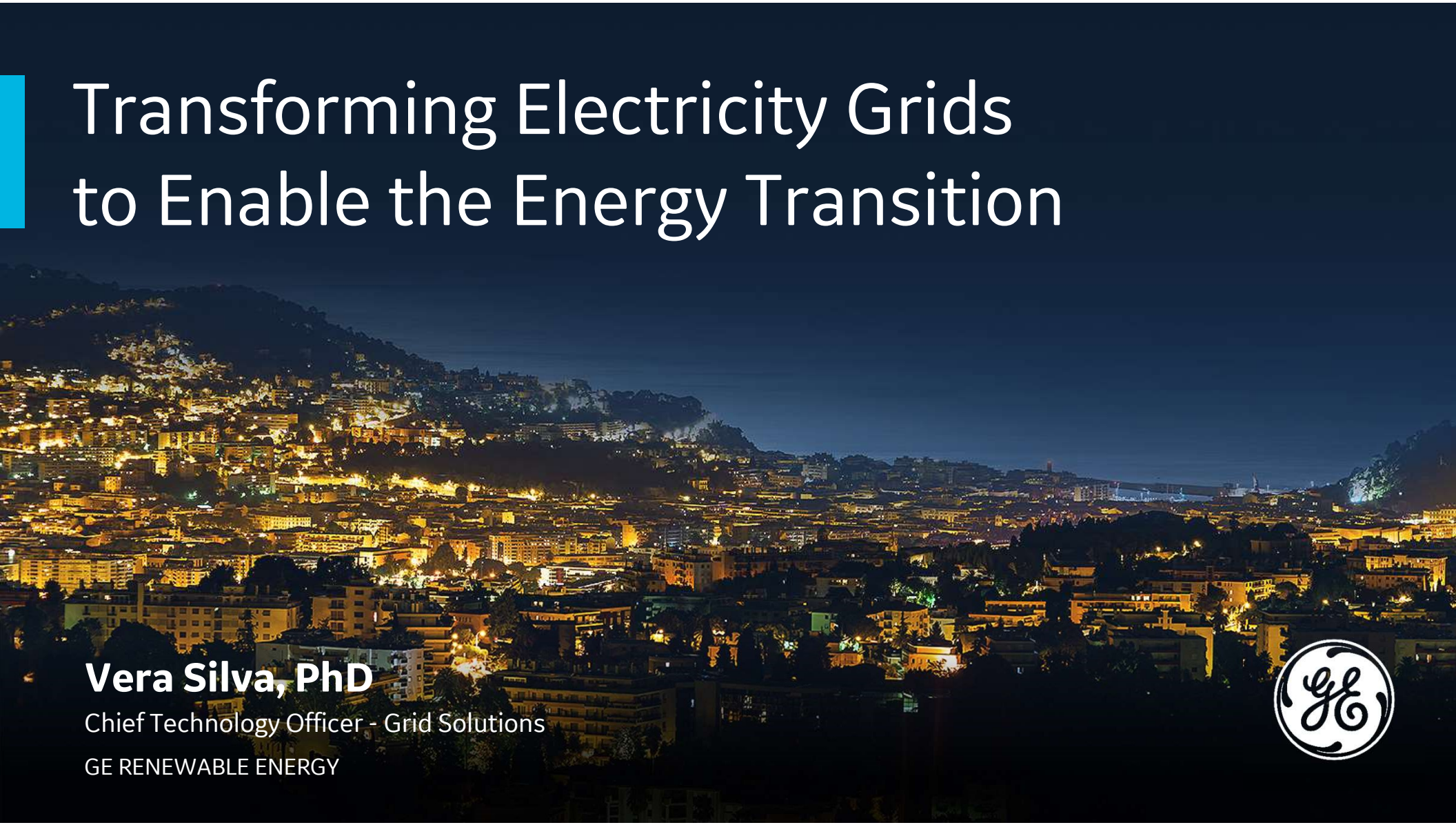
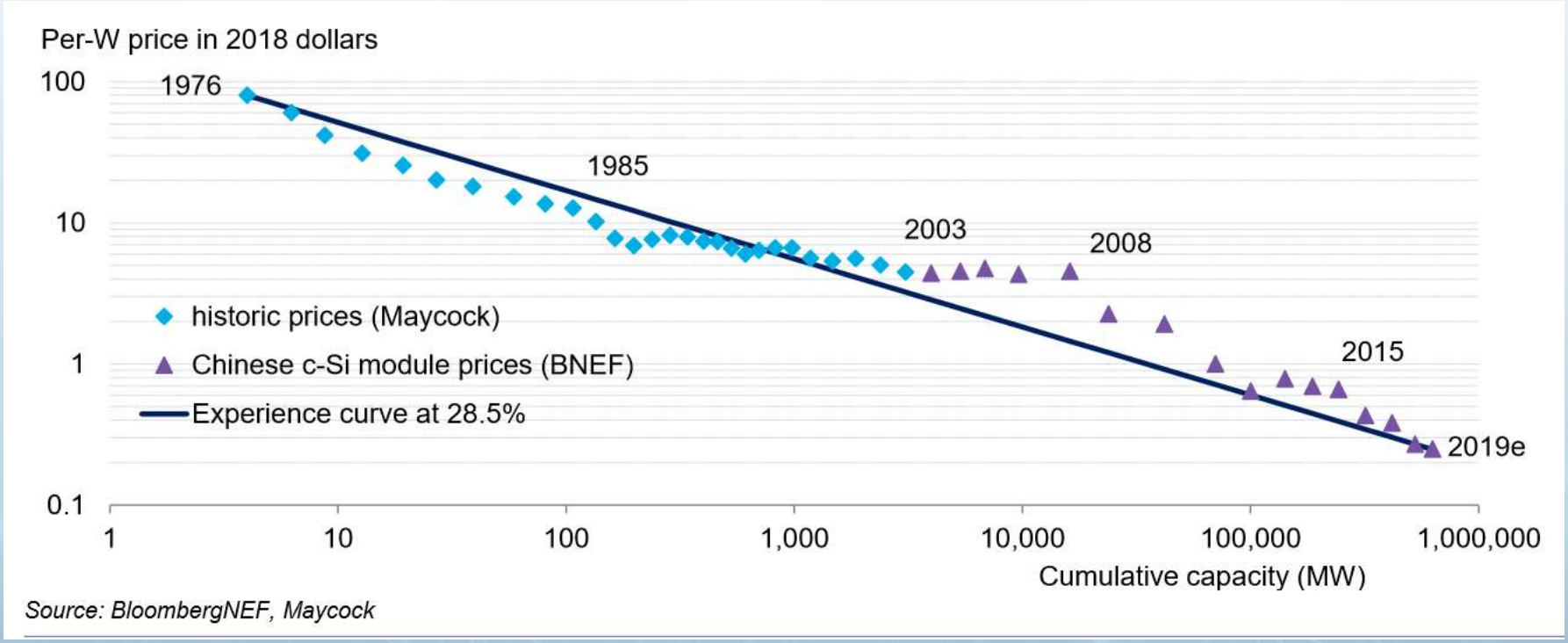
Transforming Electricity Grids to Enable the Energy Transition



Vera Silva, PhD
Chief Technology Officer - Grid Solutions
GE RENEWABLE ENERGY

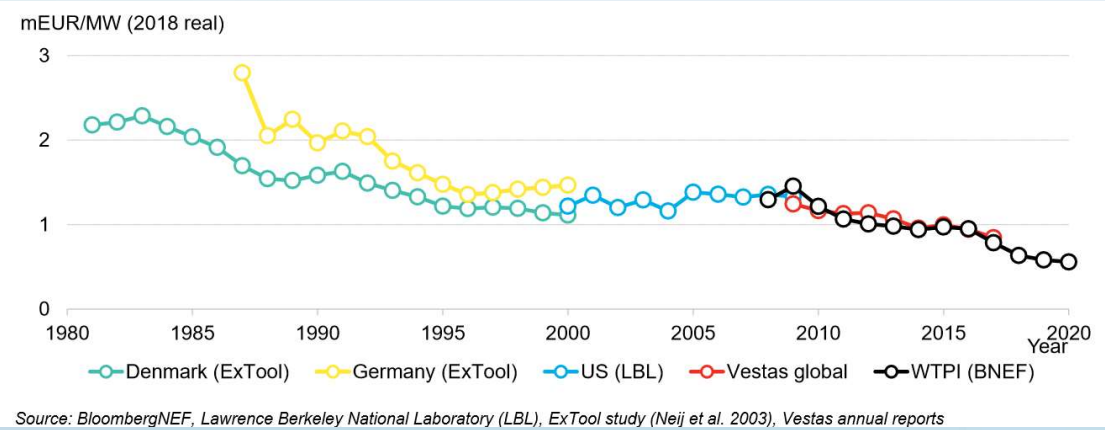
Technology trends in the electricity sector

PV MODULES PRICES DOWN 85% SINCE 2010



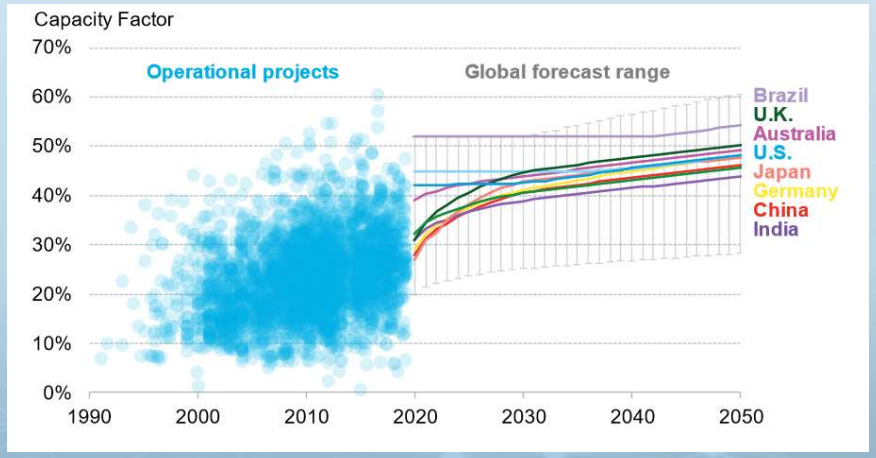
Source: BloombergNEF, Maycock

WIND TURBINE PRICES DOWN 49% SINCE 2010 WITH TURBINES GETTING BIGGER AND BETTER

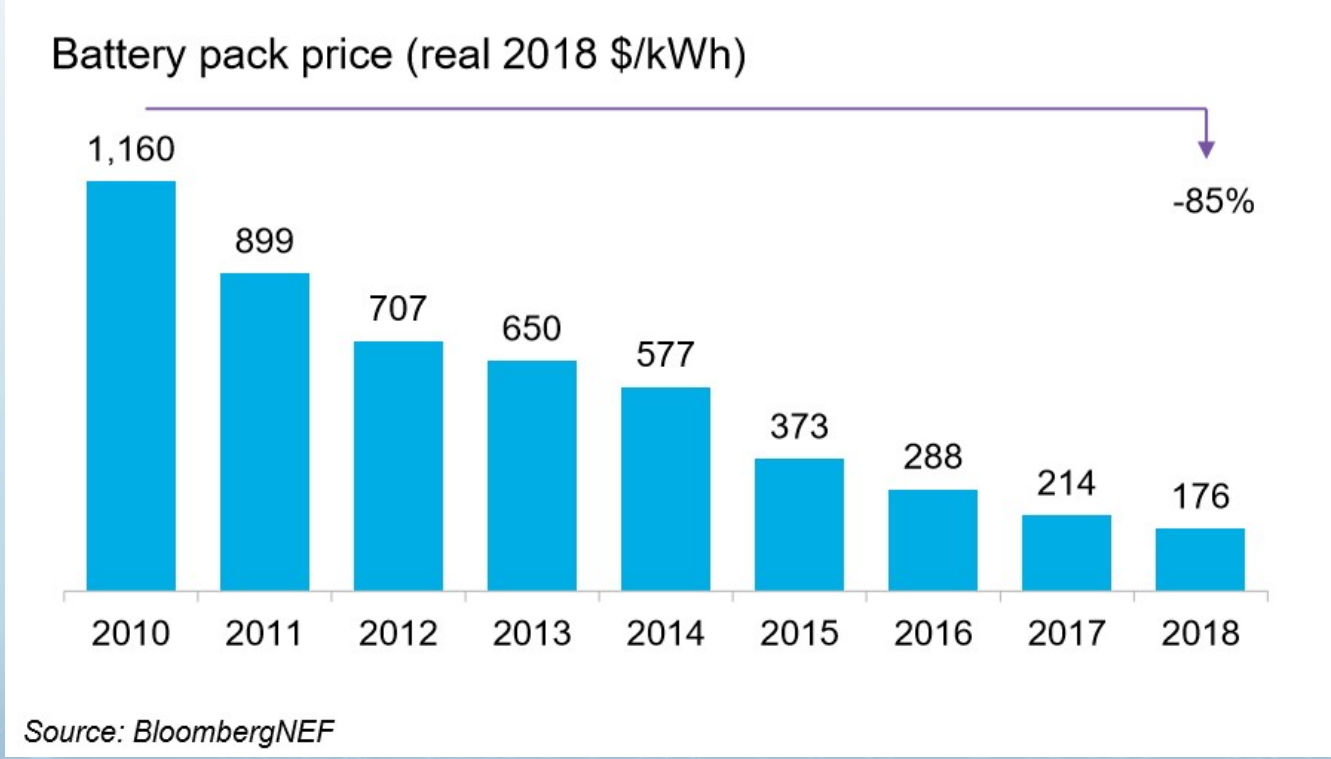


Source: BloombergNEF, Lawrence Berkeley National Laboratory (LBL), ExTool study (Neij et al. 2003), Vestas annual reports

Turbines are getting bigger with 4MW for onshore and 12 GW for offshore in recently commissioned turbines



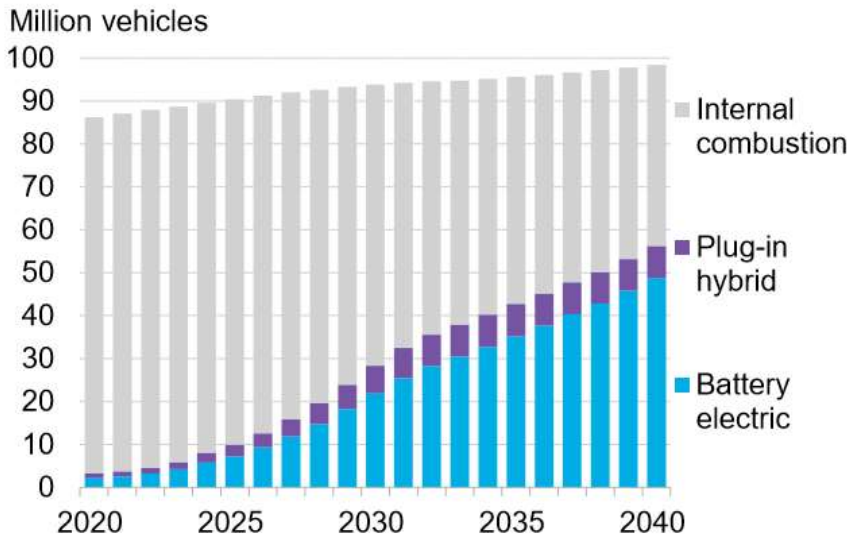
LITHIUM-ION BATTERY PRICES DOWN 85% SINCE 2010



Source: BloombergNEF

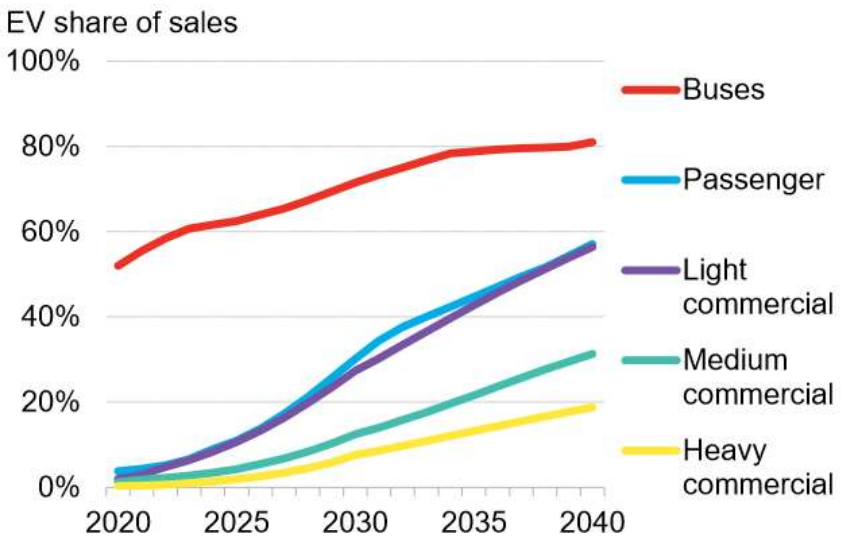
BY 2040, 57% OF NEW VEHICLES HAVE A BATTERY

Global vehicle sales by drivetrain



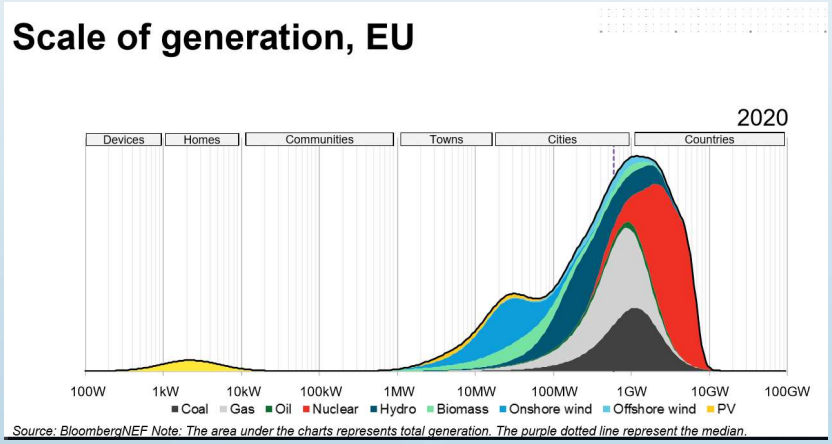
Source: BloombergNEF

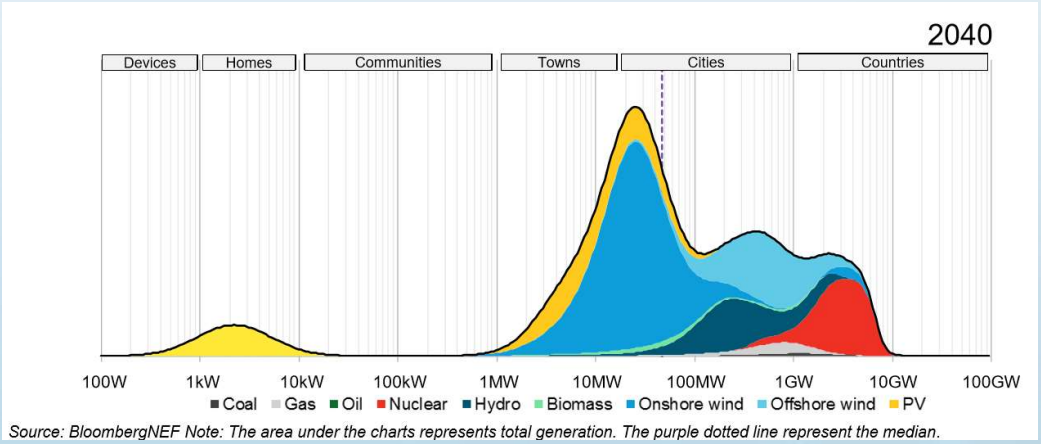
EV share of new vehicle sales by segment



Source: BloombergNEF

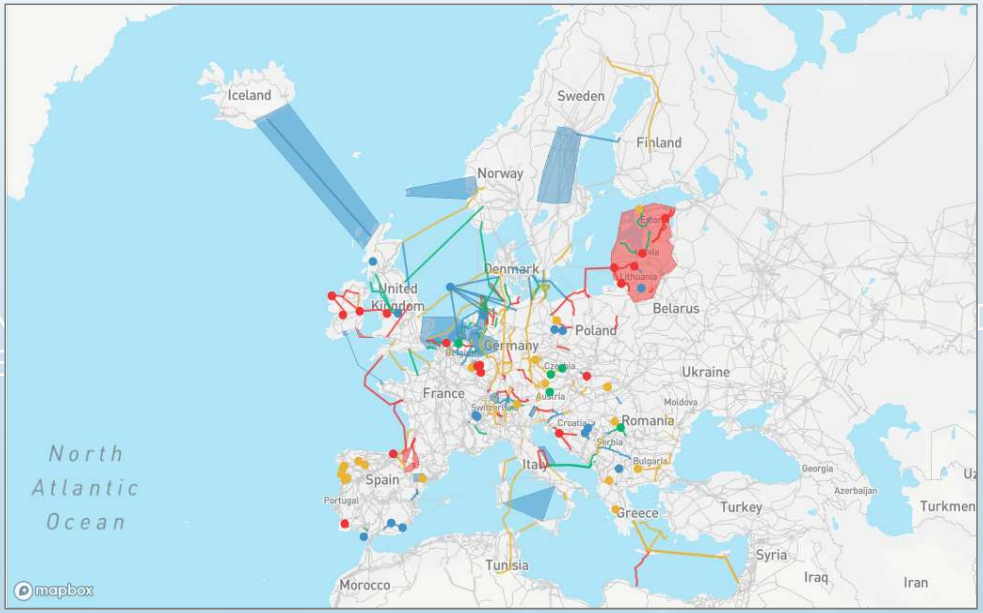
DECENTRALIZATION, NETWORKS AND RENEWABLES
SCALE OF GENERATION, EU





A shift of generation towards lower voltage levels will require a significant transformation of distribution grids

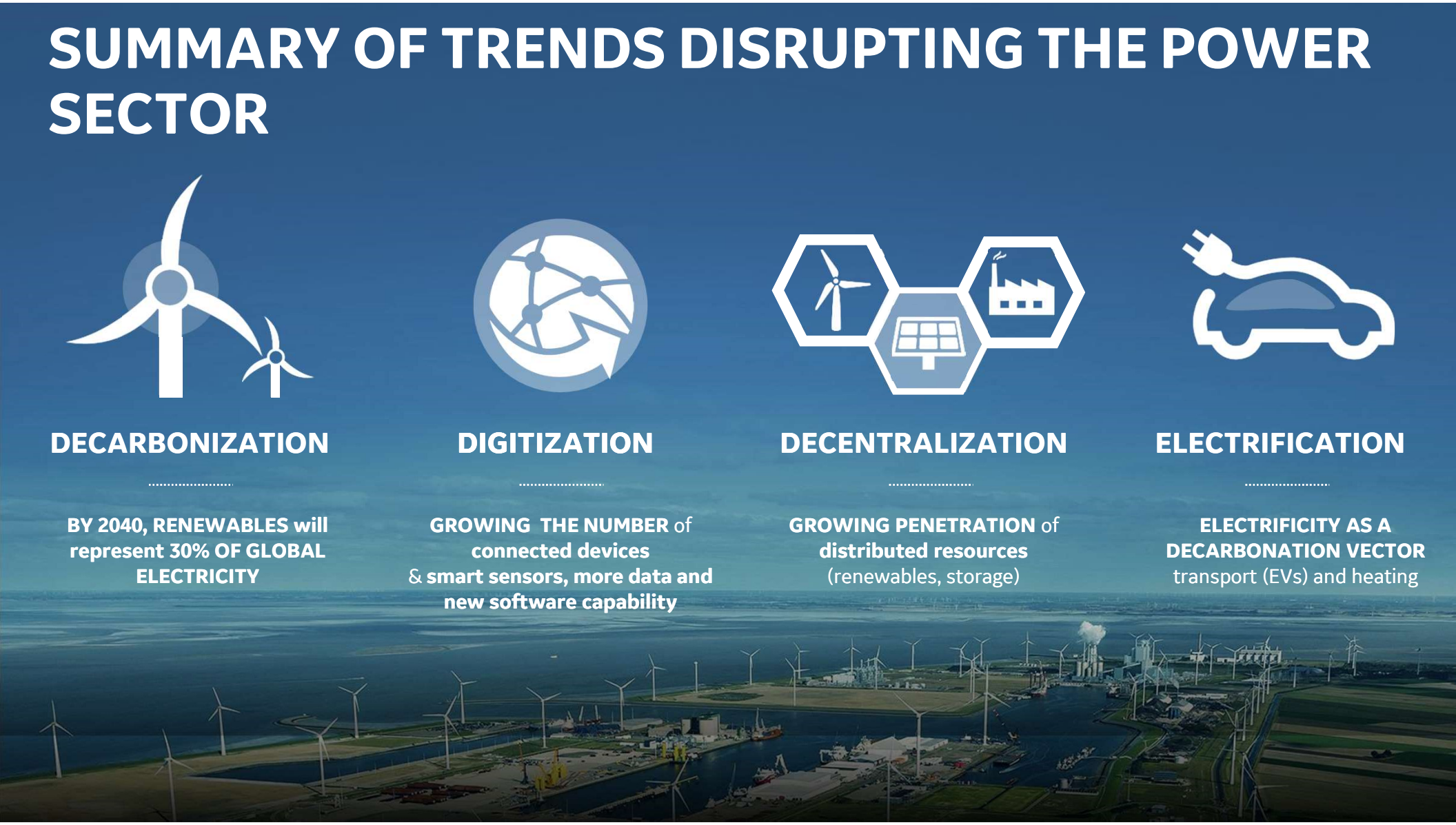
THE CHANGE IN GENERATION MIX AND DEMAND WILL NEED TO BE ACOMPANIED BY GRID TRANSFORMATION



Source: TYNDP 2018, ENSTO-E

According to the European association of transmission system operators (ENTSO-E) the grid integration of more than 50% renewables in electricity in the European system by 2030 will require the reinforcements of interconnections and transmission grids, grid digitalization and coordination with distribution

SUMMARY OF TRENDS DISRUPTING THE POWER SECTOR



DECARBONIZATION

BY 2040, RENEWABLES will represent 30% OF GLOBAL ELECTRICITY

DIGITIZATION

GROWING THE NUMBER of **connected devices** & **smart sensors, more data and new software capability**

DECENTRALIZATION

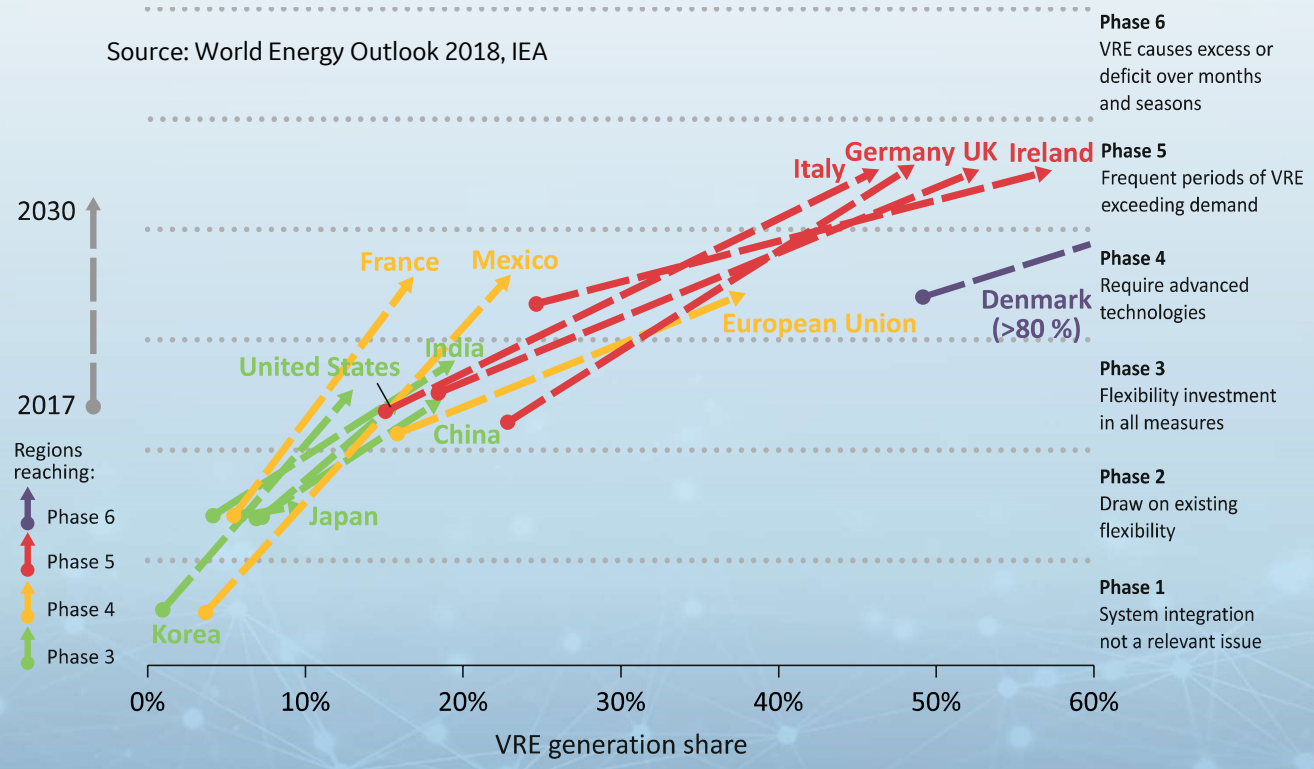
GROWING PENETRATION of **distributed resources** (renewables, storage)

ELECTRIFICATION

ELECTRIFICITY AS A DECARBONATION VECTOR transport (EVs) and heating

Enabling stable and reliable grid operation with high penetration of Renewable Energy

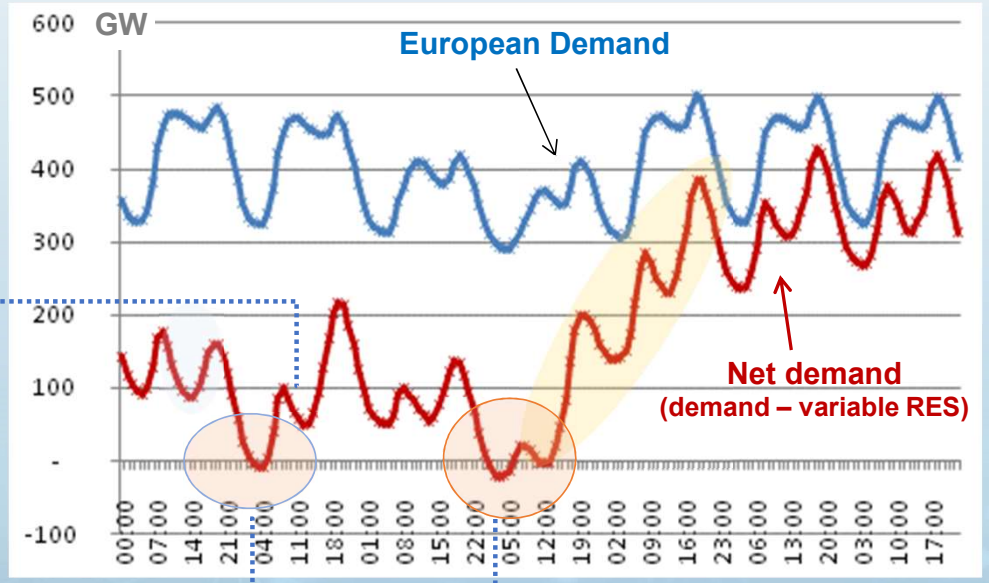
VARIABLE RENEWABLE GENERATION WILL IMPACT SYSTEM SERVICES AND FLEXIBILITY NEEDS BY REGION



Israel: 17% production from renewable energy in 2030

INCREASING VARIABILITY IN DEMAND GENERATION BALANCING

Example from Europe: Meeting the 32% Renewable energy target by 2030 in Europe will lead to having > 50% electricity from renewables in the coming decade



Source: EDF Technical Report

Middle of the day valley

Net demand changes between:
- 100 GW, +500 GW

Demand changes between:
240 GW, 600 GW

Penetration of > 100 % renewables

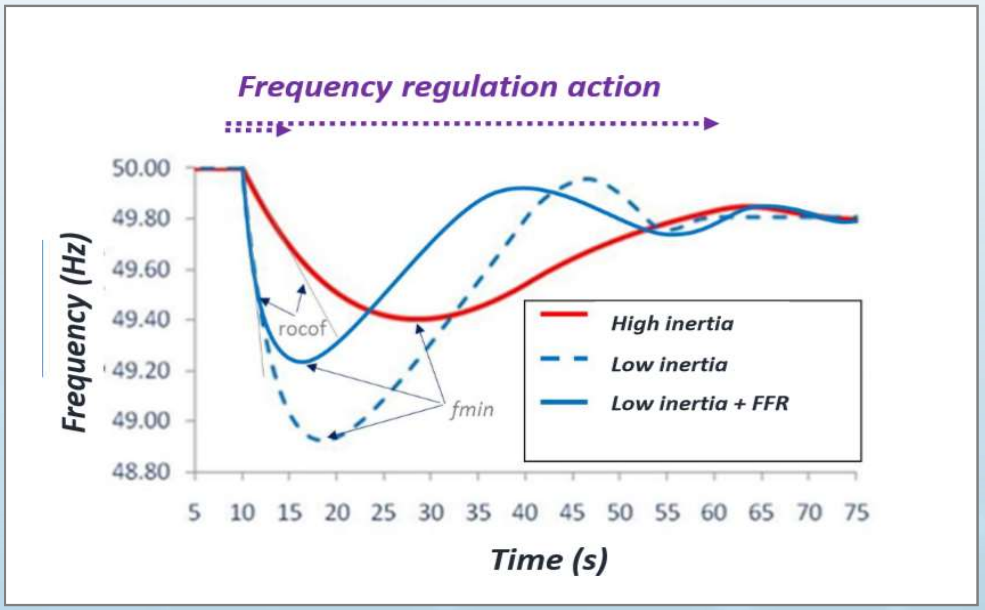
New solutions for flexibility and ancillary services are required to preserve system security

REDUCTION OF SYNCHRONOUS GENERATION

Lower inertia reduces system robustness even in large synchronous systems.

European system with 60% renewables (EDF R&D)

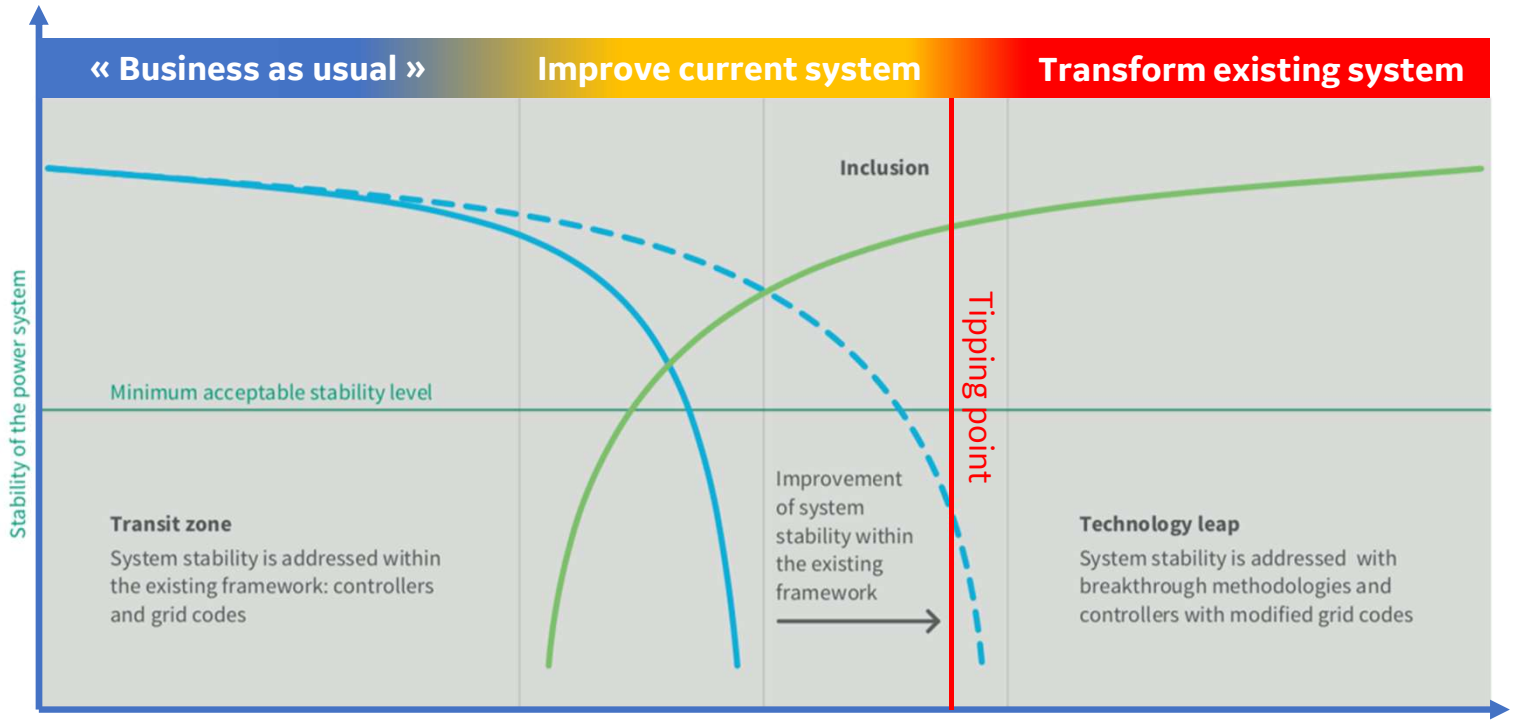
- a risk of load shedding (f< 49 Hz) - 0,8 % of the time
- a violation of ENTSO-E security limit (f< 49,2 Hz) - 25% of the time



RES curtailment during critical periods can only be limited if new technologies are available to stabilize the system and provide fast frequency response

SYSTEM STABILITY – CAN WE STRETCH EXISTING SYSTEMS

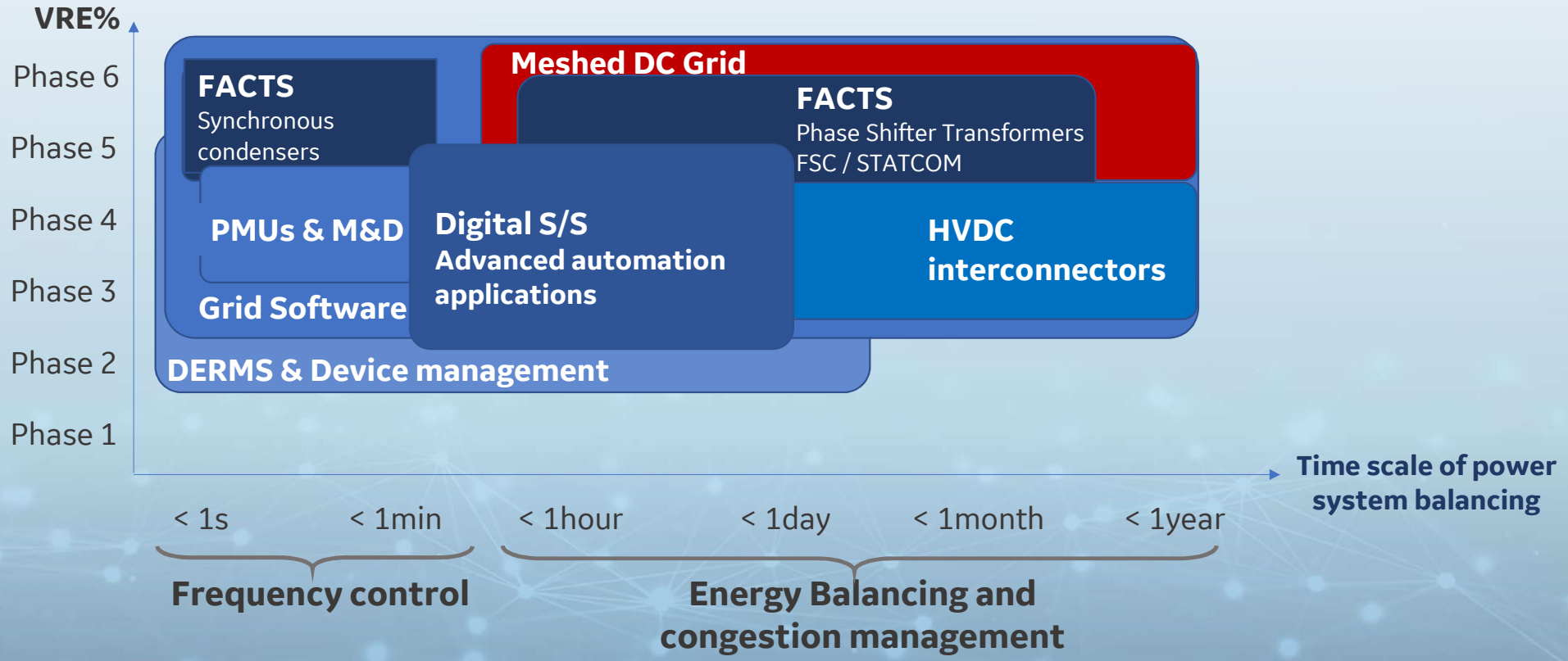
With increasing inverter connected generation/loads, current system will require some enhanced technologies, until we reach the tipping point



Technology supporting the grid of the future

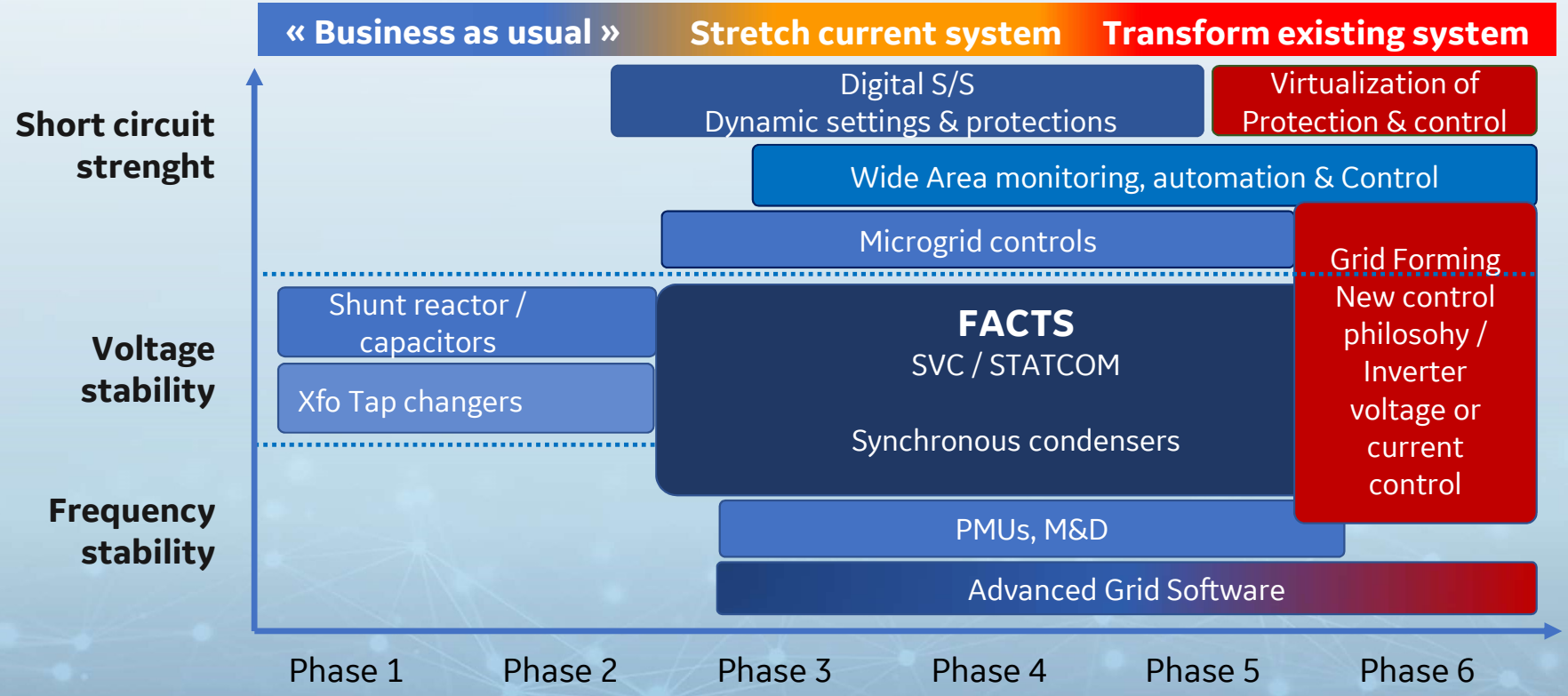
GRID TECHNOLOGY MAP SUPPORTING ENERGY BALANCING

For each balancing challenge, several solutions exist, one should consider the cost of each technology and its resilience to future challenges



GRID TECHNOLOGY MAP SUPPORTING SYSTEM STABILITY

New technologies will maintain system stability until we reach a new paradigm



CONNECTED INTELLIGENCE AND GRID ORCHESTRATION

GRID EDGE

GROWING **OBSERVABILITY:**

- 300,000+ GE critical infrastructure assets connected to remote M&D
- 10,000+ PMUs deployed globally

UTILITY OPERATIONS

GROWING NUMBER OF **CONTROLLED ASSETS:**

- Up to 3X assets in control by EMS, '07-'17
- DERMS/Microgrids market
- Interface with local markets and players (aggregators, micro grid operators)

DATA ANALYTICS

ASSET RM&D BECOMING **MAINSTREAM**

- 10X data volume (MB/day), '07-'17
- Asset Digital Twins & Fleet-based analytics


THE GRID OF THE
FUTURE

The grid of the future...

Will be decarbonised while meeting the energy trilemma: CO2 emissions, security of supply, energy cost

Will leverage new technologies and digital tools to orchestrate a grid that balances the system on a milliseconds resorting to flexibility sources across all the layers of the grid

Will fully exploit the potential of data analytics, artificial intelligence and machine learning to increase the reliability, reduce costs and increate quality of supply

Will be mindful of its environmental impact and fully explore new technology solutions to reduce the full life cycle impact of grid infrastructure.