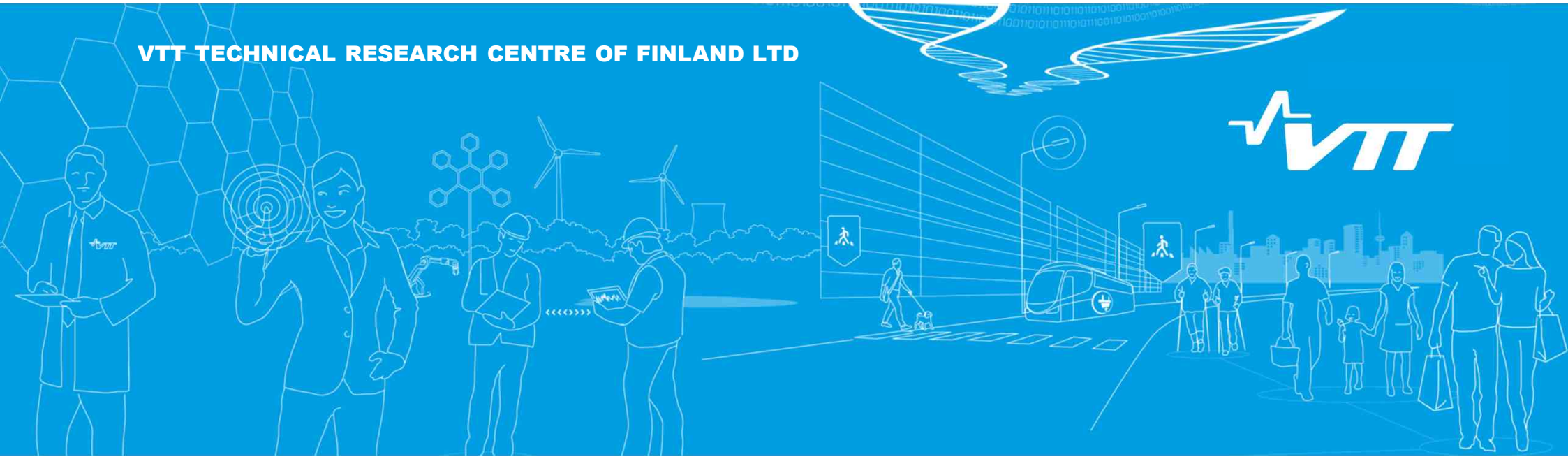


Energy storage in future energy systems

Pyhäjärvi Energy Storage in Mine

2018-04-05, Vantaa

Matti Paljakka, VTT

VTT – impact from excellence

VTT is one of the leading research and technology organisations in Europe. We use our scientific and technological excellence to provide innovation services for our domestic and international customers and partners.

Our vision

A brighter future is created through science-based innovations.

Our mission

Customers and society grow and renew through applied research.

Strategy

Impact through scientific and technological excellence.

Established in
1942

269 M€
Net turnover and other operating income (VTT Group 2016)

2,368
Total of personnel (VTT Group 2017)

Owned by
Ministry of Economic Affairs and Employment

27%
Doctorates and Licentiates (VTT Group 2017)

33%
from abroad (VTT Group 2016)

VTT's R&D services on smart energy and smart city

Towards a sustainable low carbon society

RENEWABLE ENERGY

Waste to Energy, Bioenergy
- From waste and biomass to fuel, heat and power
- Integrated concepts

Wind and solar
- Concentrated Solar Power integration
- Grid integration of wind power and photovoltaics

New technical opportunities
- Fuel cell technology
- Power to Gas, P2X

SMART ENERGY SYSTEM

Technology and business foresight

Energy efficiency solutions
- Transport
- Industry
- Buildings and districts

Holistic concept development

Data analytics

SMART CITY

- Smart mobility systems
- Key Performance Indicators
- Visualization, Augmented Reality
- Smart buildings
- Smart governance

NUCLEAR POWER

- Reactor safety and licensing support
- Plant life management
- Spent fuel management and disposal
- Next generation nuclear technologies

Drivers for storage units in flexible energy systems

Amount of intermittent RES generation

- Storage enabling more efficient integration

Need for better service reliability

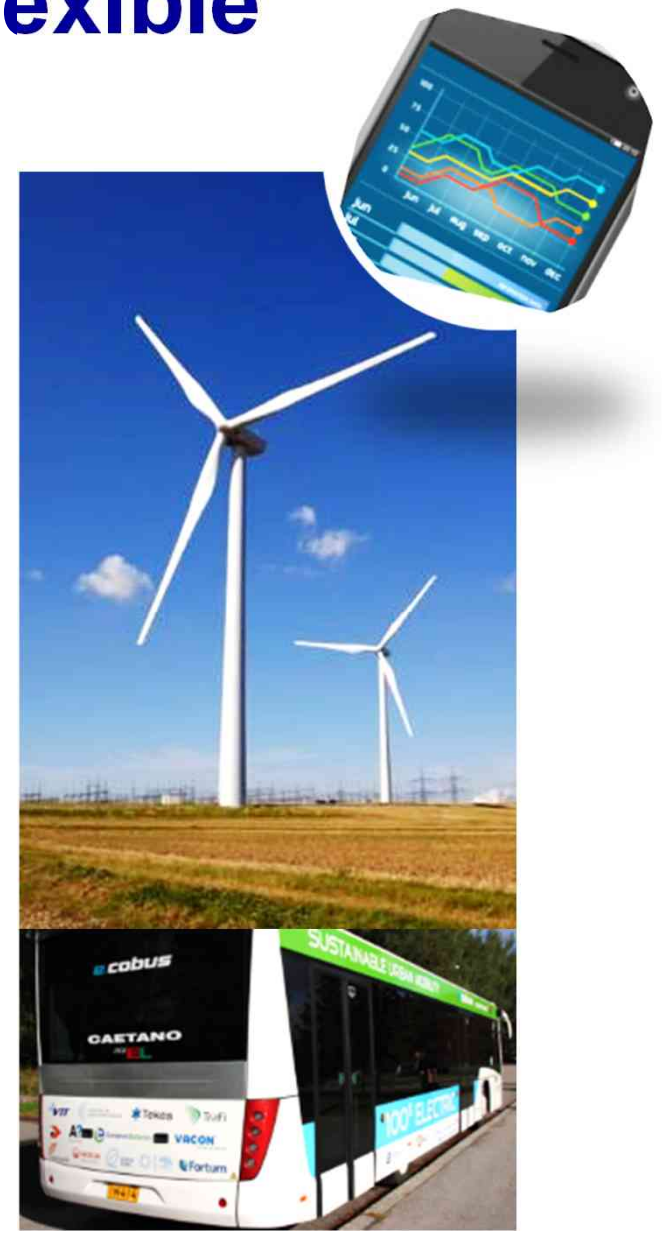
- Avoiding service interruptions
- Improving customer power quality

Amount of electric vehicles

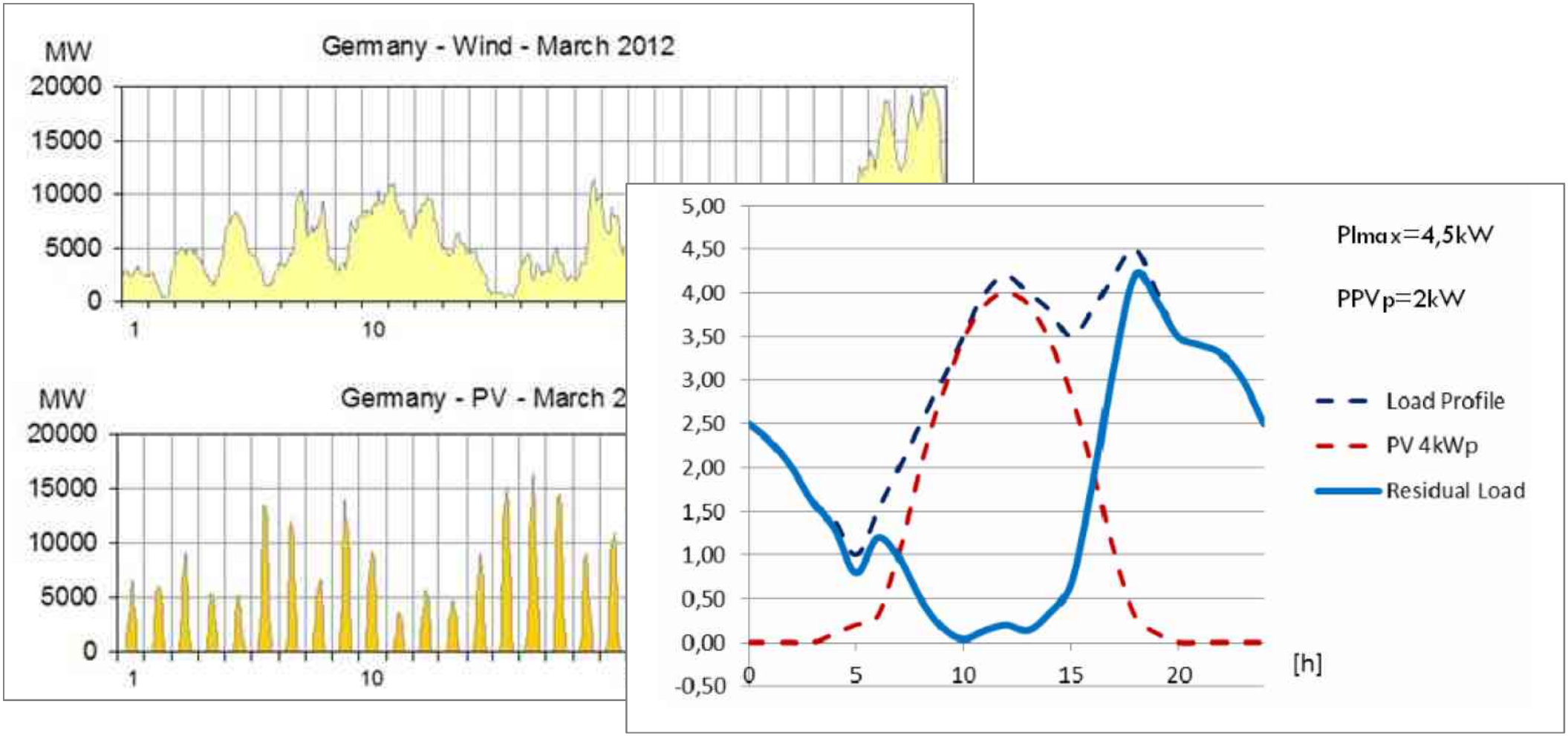
- Potential for smart charging and vehicle to grid (V2G) integration

Customer-level applications

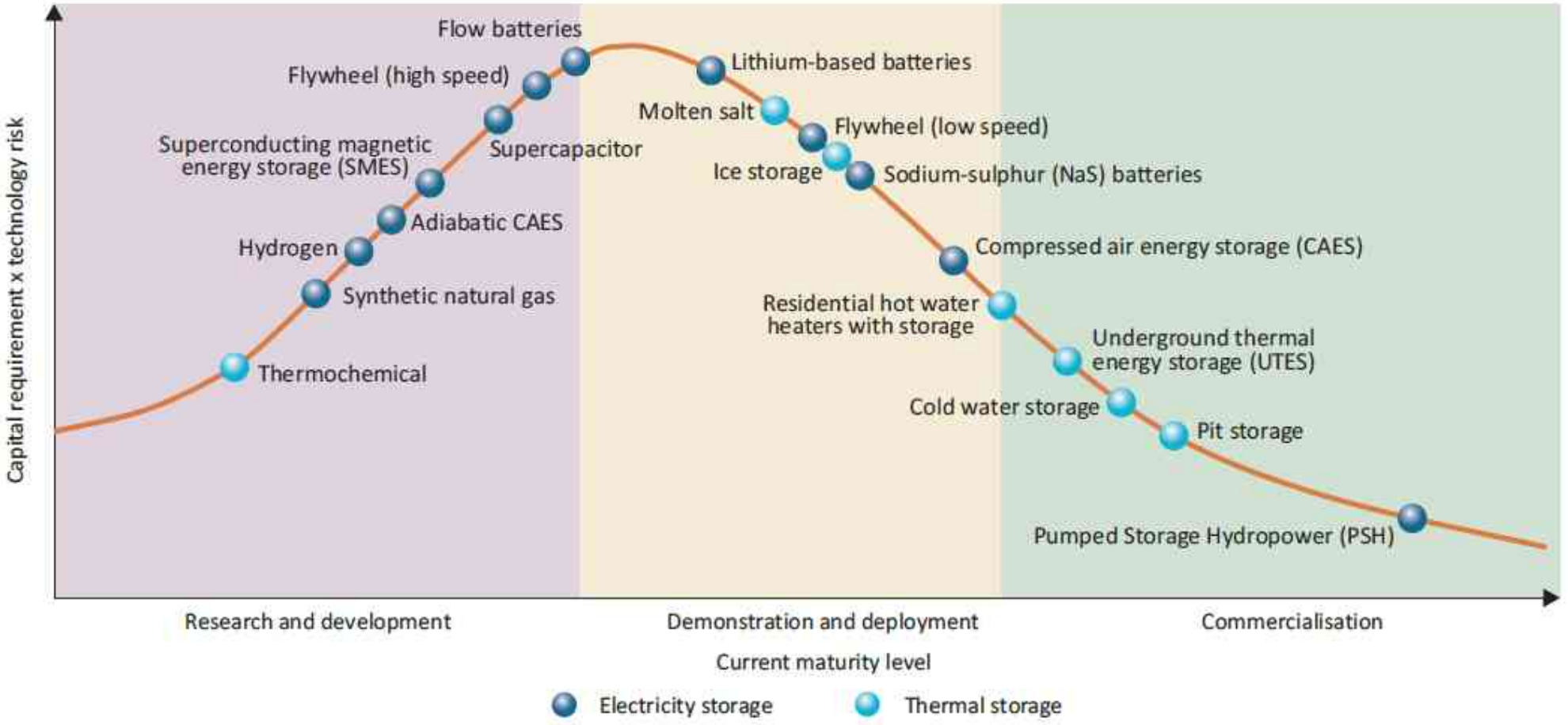
- Economical use of dynamic tariffs
- Optimization of microgeneration
- Microgrids and local back-up power



Intermittent generation

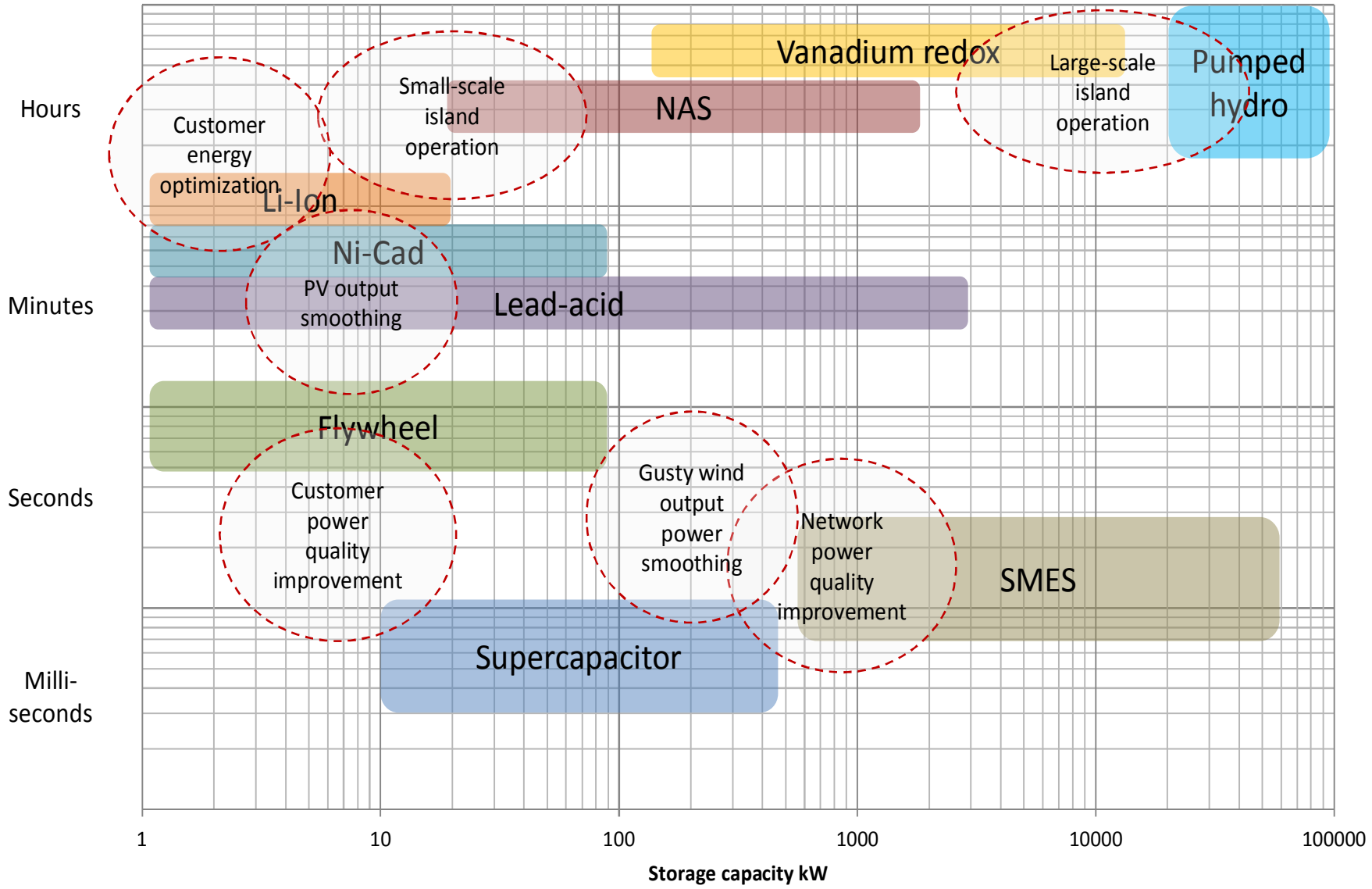


Maturity of energy storage technologies

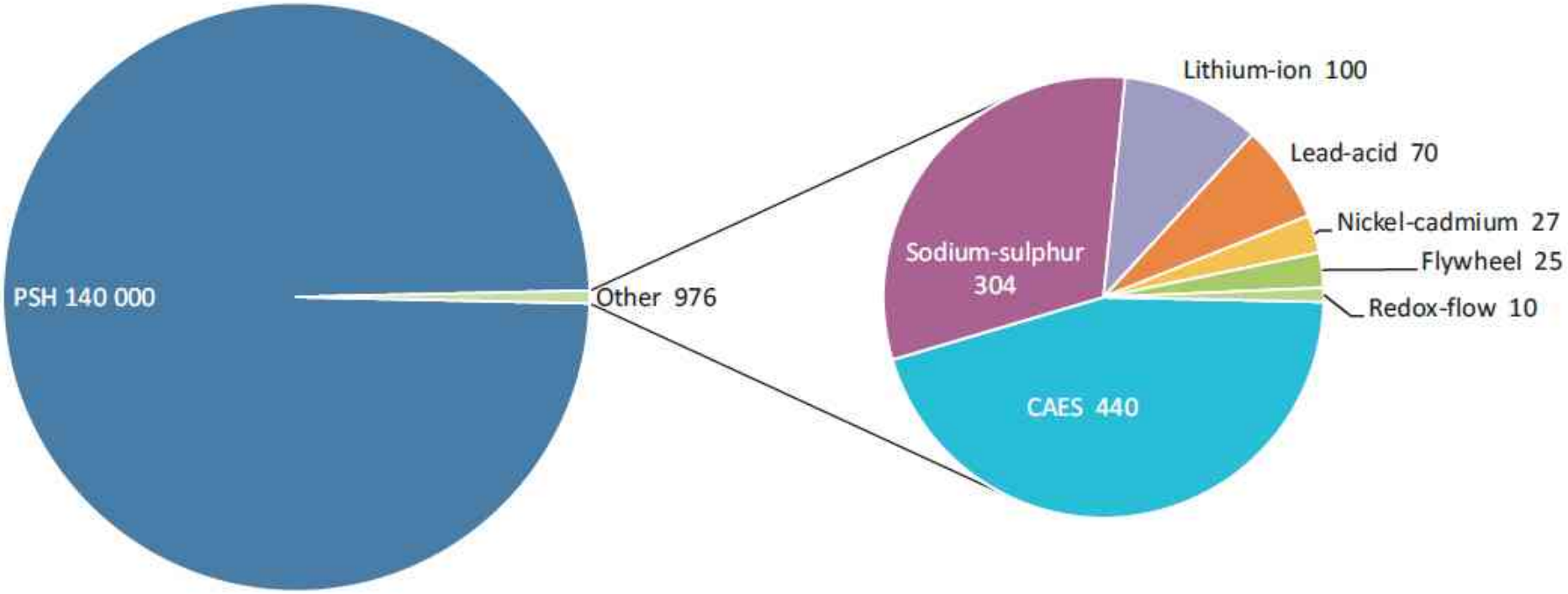


Source: Decourt, B. and R. Debarre (2013), "Electricity storage", *Factbook*, Schlumberger Business Consulting Energy Institute, Paris, France and Paksoy, H. (2013), "Thermal Energy Storage Today" presented at the IEA Energy Storage Technology Roadmap Stakeholder Engagement Workshop, Paris, France, 14 February.

Technologies by time scale and capacity



Energy storage technologies

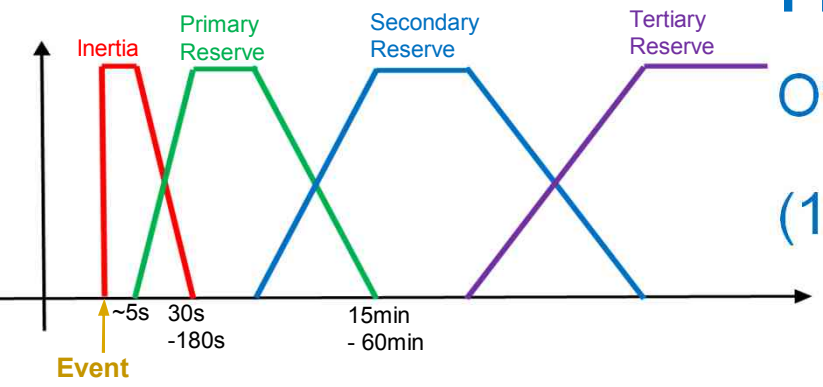


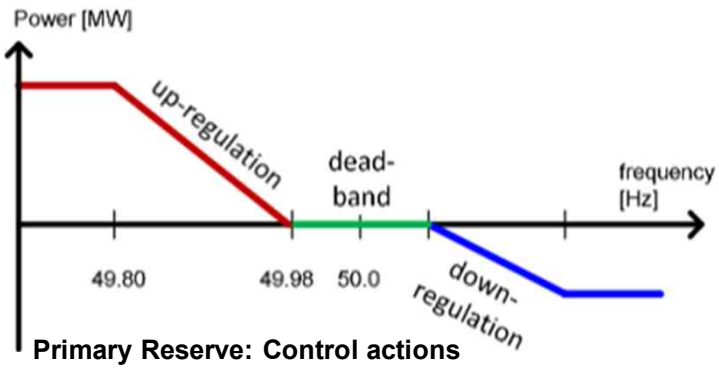
Source: IEA analysis and EPRI (Electric Power Research Institute) (2010), "Electrical Energy Storage Technology Options", Report, EPRI, Palo Alto, California.

Key grid challenges

- Security of supply
  - access, and operation reliability/security
- Reserve provision
  - mitigation of imbalances of load/generation
- Voltage control
  - maintaining proper voltage levels and phase balance
- Current congestion mitigation
  - overloading of network element
    - Transformer, line or cable

Use Cases of a Storage – System level





Primary Reserve: Control actions

Predefined reserve products

Offered to the transmission system operator (TSO)

(1) Reserves activated by changes in grid frequency

Dedicated local controller

I. Inertia replacement: Ultrafast Frequency Control

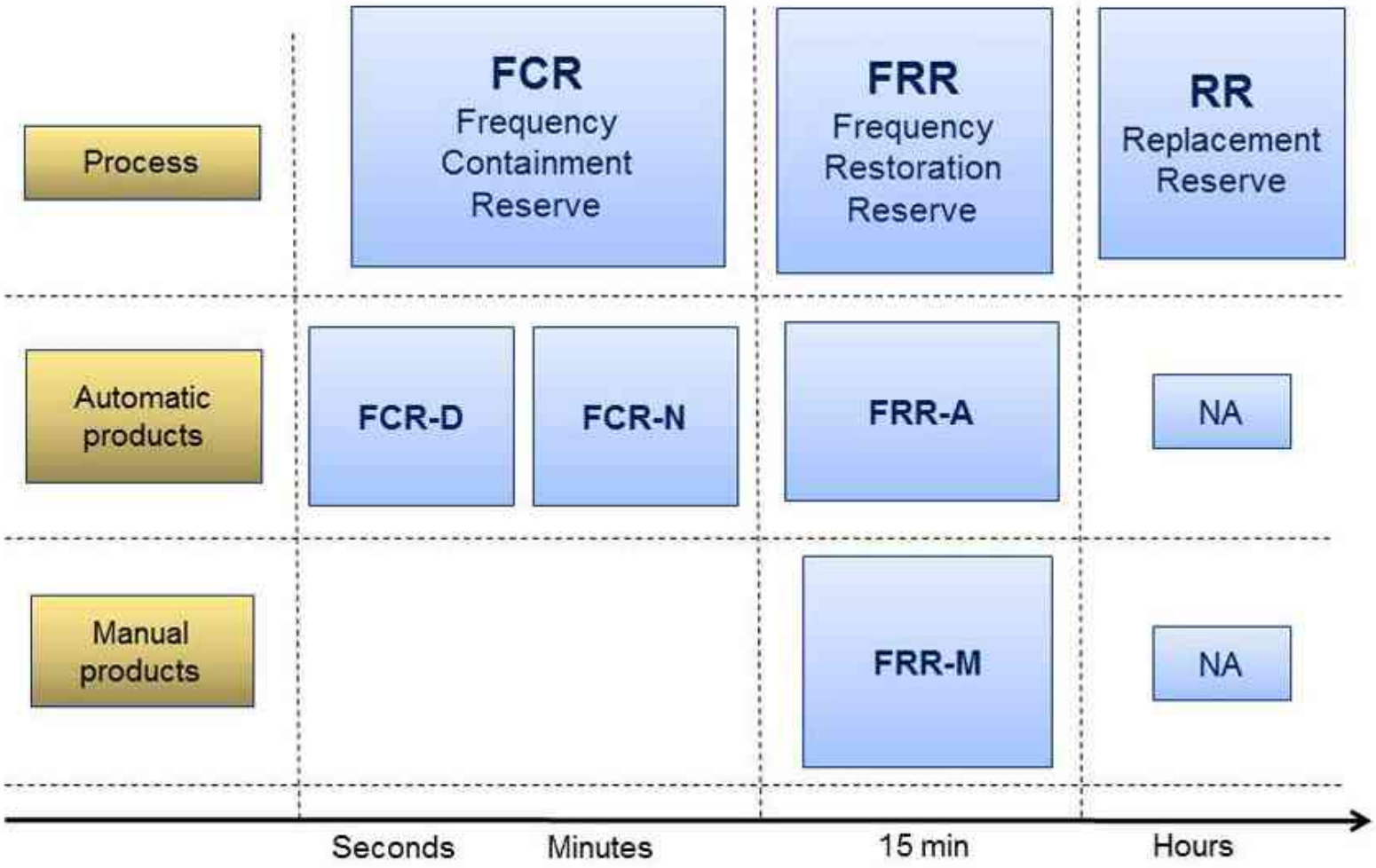
II. Primary Reserve: FCR-N, PRL

(2) Reserves activated by remote signal from TSO

III. Secondary Reserve (automatic): A-FRR, SRL

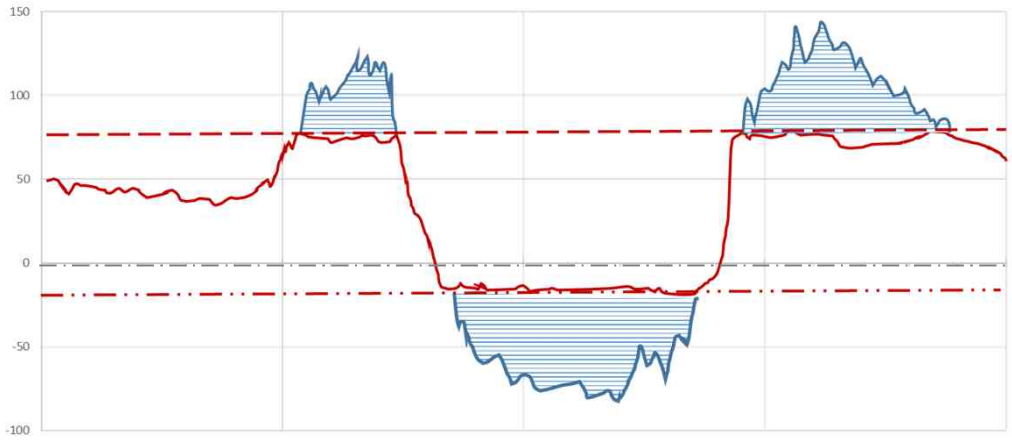
IV. Tertiary Reserve: M-FRR, Minute Reserve

Evolving markets for flexibility



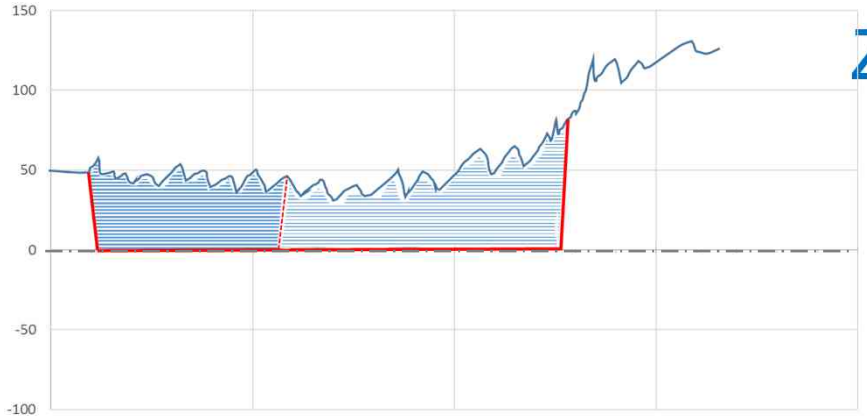
Fingrid reserve types

Use cases of a storage – Local level



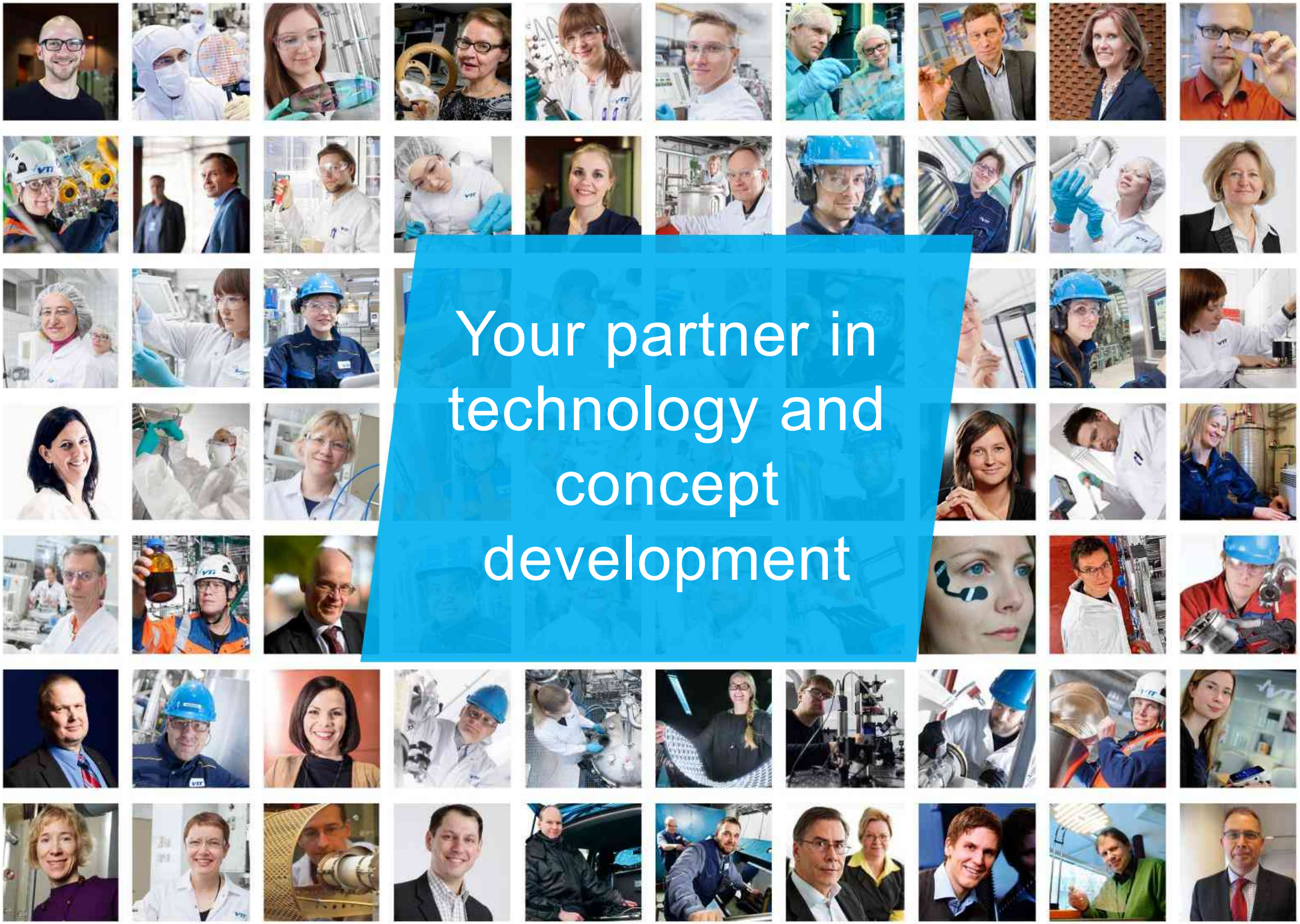
Peak demand control

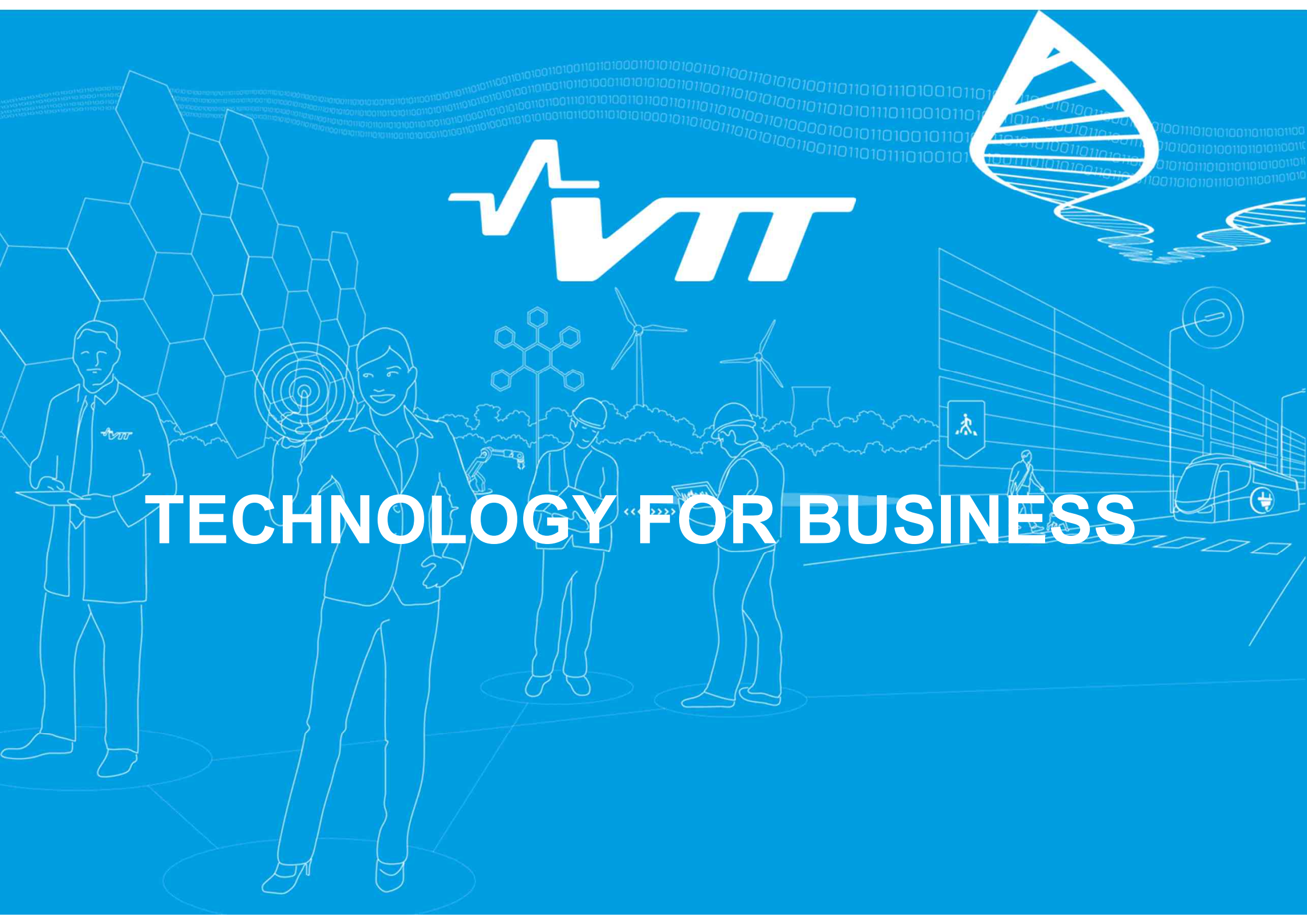
- Reduction of peak consumption and peak production
- To meet needs from e.g.
  - PV solar production
  - Electrical vehicle charging peaks



Zero load provision

- State of local network is close to an island
- Due to e.g. high price of electricity


Your partner in technology and concept development


TECHNOLOGY FOR BUSINESS