All renewable-based dynamic electricity system

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Situation now – Big challenges

Energy consumption rose 2.3% last year – and 70% of that growth was fossil [1].

Coal, Oil and Fossil Gas have roughly equal share.

Fossil fuels represented 80% of global energy production.

Electricity consumption up 4% 2017->18.

Relying on gas and oil makes us dependent on oil and gas producing countries.

We can not go on like this.

1. IEA yearbook 2018

Promising trends

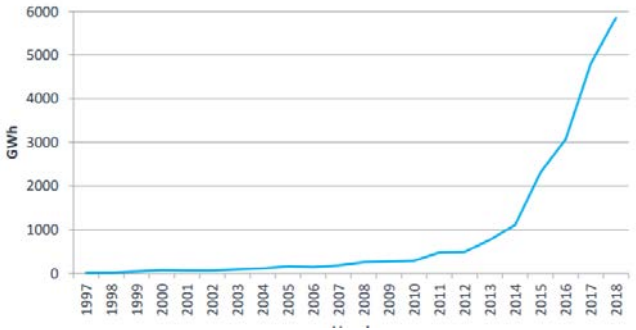
Renewable wind and solar have become economically viable.

- *Average solar and wind auction prices in 2017 USD 50 / MWh[2] and lowest USD 17 in 2018 [2]*
- *In Finland, the first not subsidised wind farms are being built*

New solutions; more affordable technology.

Many people are ready for change.

Windpower production in Finland [GWh p.a., source Energiateollisuus]



Windpower of consumed electricity in Finland

2015	2.6%
2016	3.6%
2017	5.6%
2018	7%

[2] IRENA

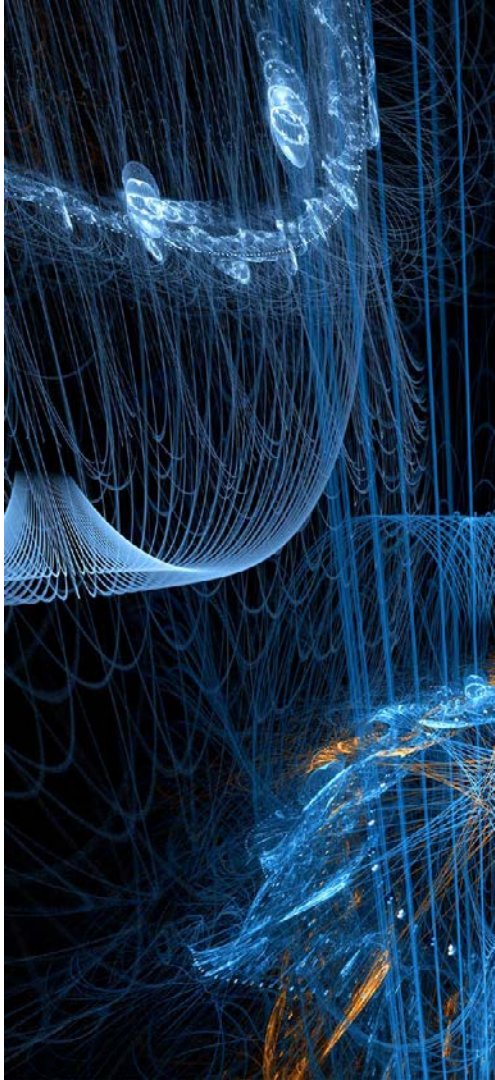
Electricity as primary energy

Electrification: decrease burning of fossil fuels for transport, industry and heating.

- Turn industrial processes coal-free, e.g. steel making.
- Transport: electric and eFuels.

=> Use of electricity doubles, triples, quadruples…

Needed: affordable renewables, storage, flexibility, attitude change



Enablers of the vision

- Low-cost renewable electricity
- P2X2P (storage and eFuels)
- Digitalization => smart energy system
- Active citizen – “power to the people”

Vision and initial roadmap - digitalization view

- Connectivity technologies
- Advanced data analytics
- Data-driven business models

- Peer-to-peer markets
- AI forecasts consumption, production.
- Cybersecurity

- New market models
- Data operator business
- AI automated decision making

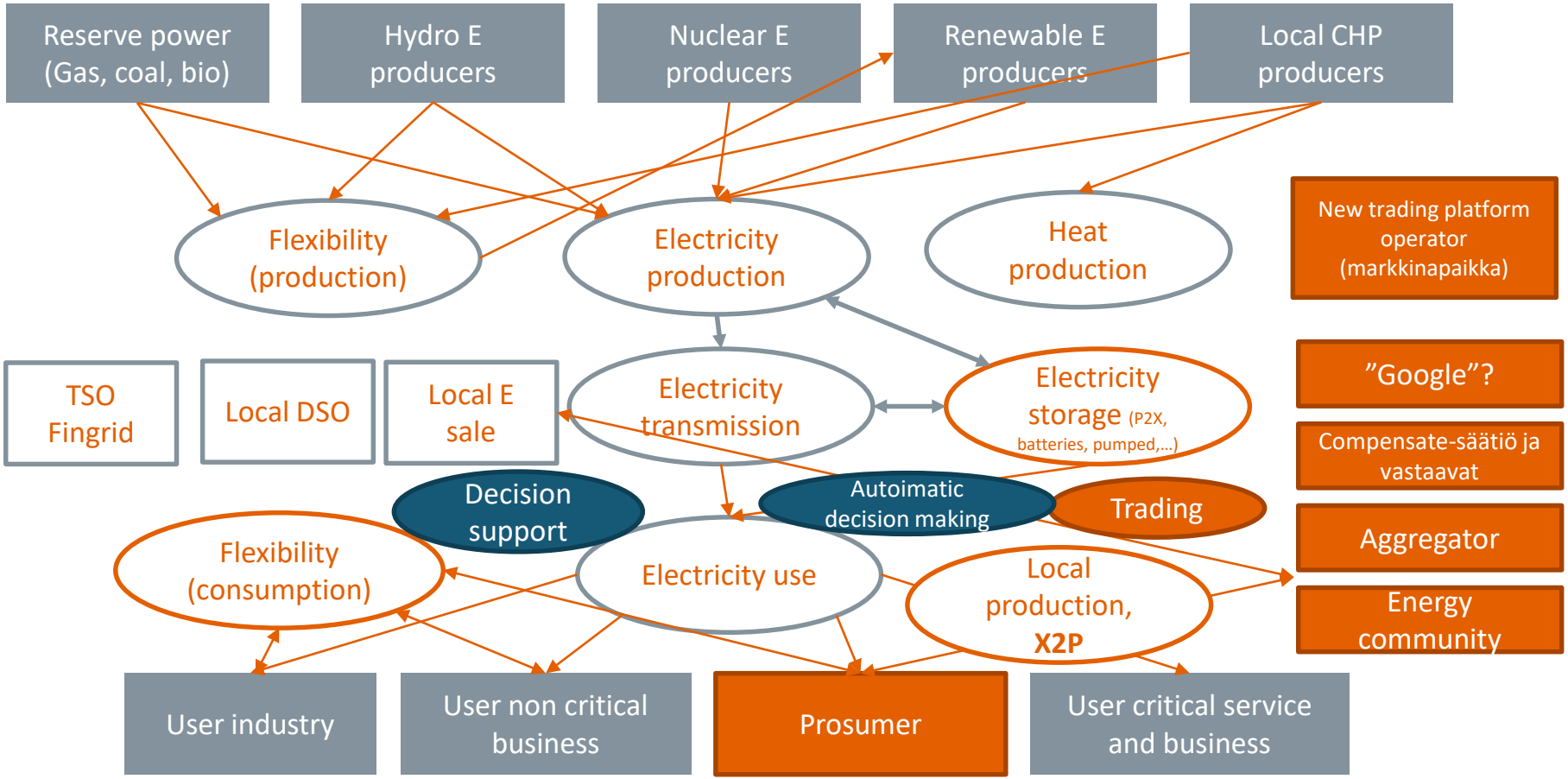
Renewable based energy system

- P2X technology
- Electrification of traffic

- P2X (2P) pilots
- Local flexibility markets

- P2X: fuels, food…
- P2X2P
- Users as actors

Blue Electrification Ecosystem, interactions ”citizen view” (future, ca. 2030)



Levels of Smart Energy System

- Intelligence distributed across system levels
- Widely monitored and controlled
- Efficient communication integrated
- Built on standardized and/or open interfaces
- Stakeholders with fully new roles
- Interoperability becomes essential

Examples of smart energy solutions

“System of systems”

Autonomy for distributed energy system

Need:

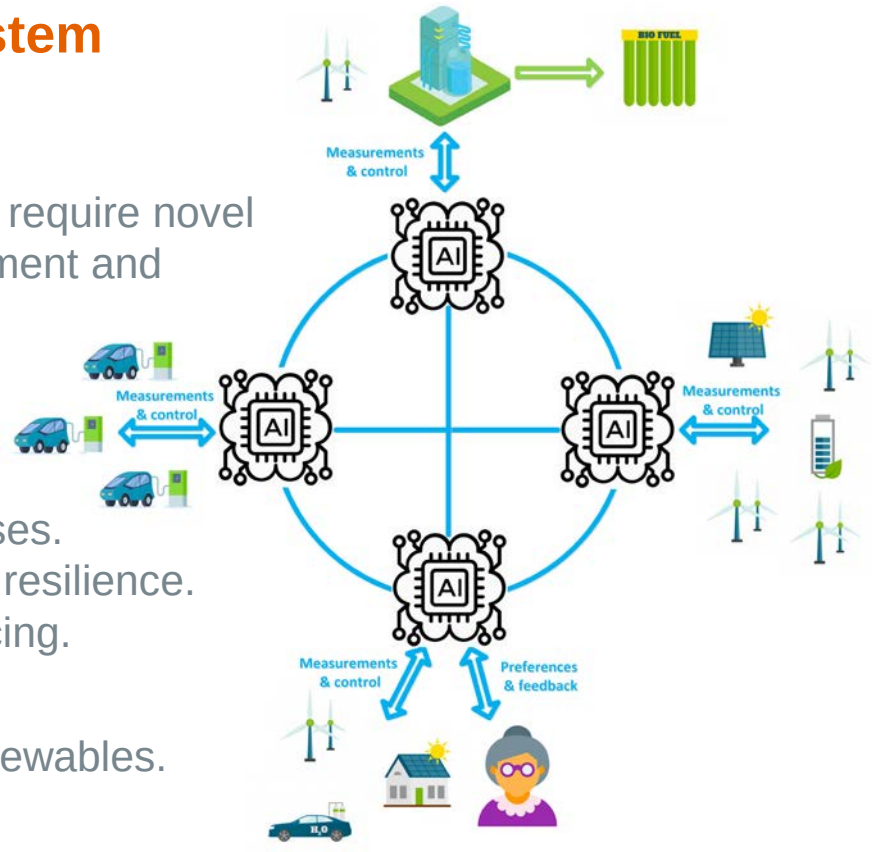
100% renewable and distributed energy systems require novel paradigms and technologies for system management and optimization

Approach:

User-centric energy management with AI.
Management and optimization of P2X2P processes.
System of system approaches for power system resilience.
Multi-agent approaches for power system balancing.

Benefit

Balanced and resilient electricity system with renewables.



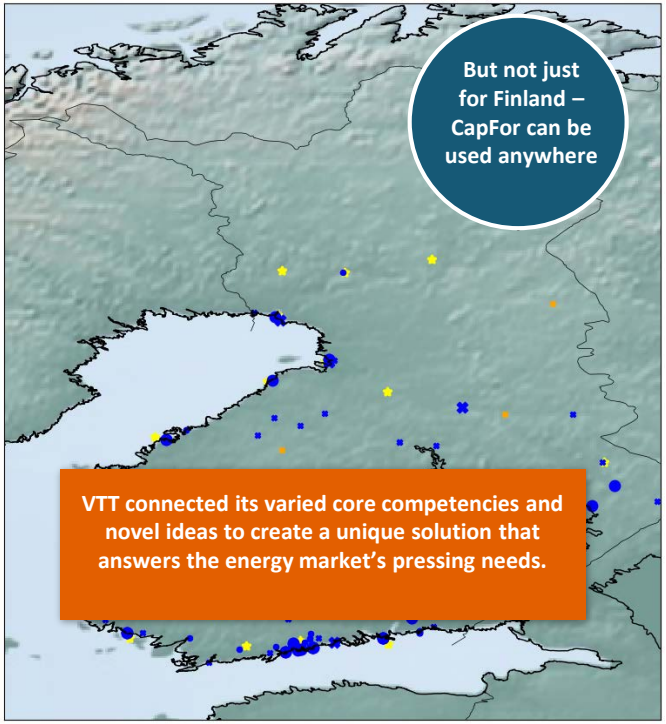
CapFor Online: taking power generation capacity forecasts to a whole new level

CapFor Online software crafted for Fingrid solves a challenge-well known by many grid operators. CapFor precisely forecasts the available capacity of a country's electricity production.

Delivering daily forecasts **up to 7 days in advance**

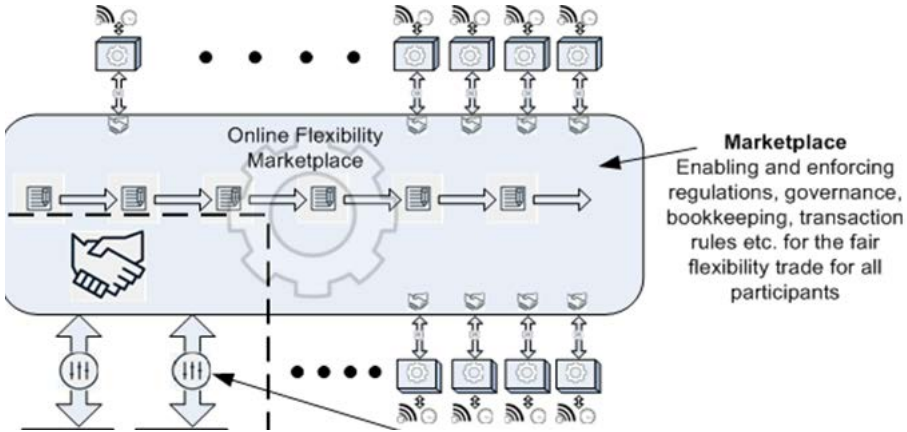
Impressive forecasts with **errors below 5%**

Enables **increased grid reliability**



Fleximar - an online Flexibility Marketplace

Fleximar project aims at improved network stabilty and supply quality as well as transparent and fair trading for users and producers.



Incentives for all actors.

Automation with trading bots.

Regulation coded in trading rules.

Novel methods for metering and controlling power use.

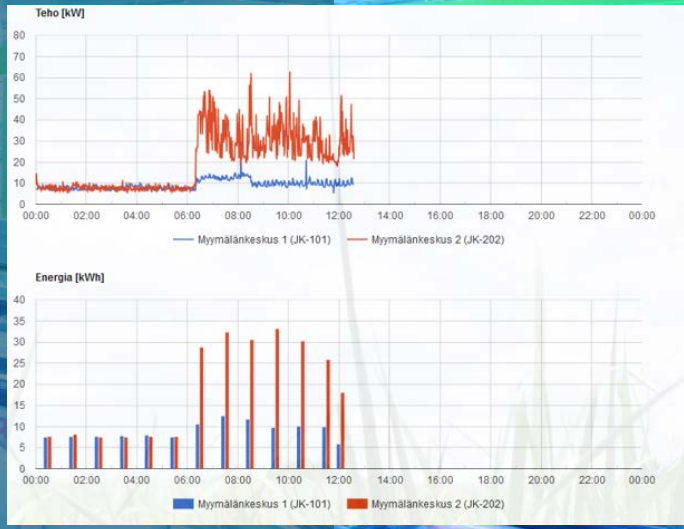
VTT helped save 50% in energy costs of a supermarket

Advanced cooling technology saves up to 50% of energy bill. This is done by two means.

- **Peak load shawing (blue curve)**
- **Installing solar PV**

In single retail store the savings are 230 000 US dollars year, payback time for investment was less than two years.

In Finland one supermarket chain with1800 shops could save 400 M€ per year.



The most energy efficient supermarket in the world.

Next we go for a city neigborhood.

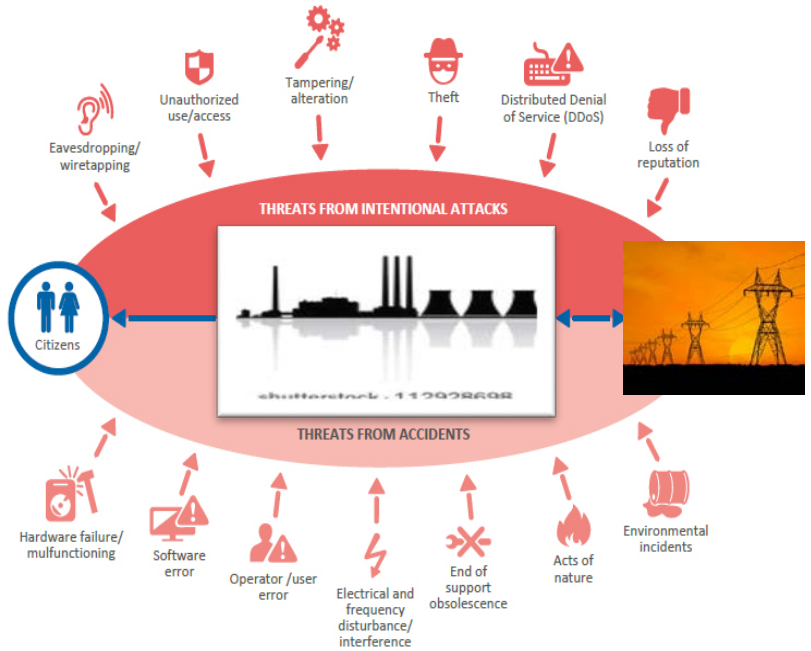
Mitigating cyber threats

Energy systems and grids are becoming more dependent on the internet. There are more remote control and measurement and IoT devices.

This means also vulnerability to cyber attacks, which have already happened in some countries.

We have positive results in cyber threat mitigation with the key-players of energy sector.

Figure 11 Threat landscape



Modified from: ENISA, Cyber security for Smart Cities, An architecture model for public transport, Dec 2015.

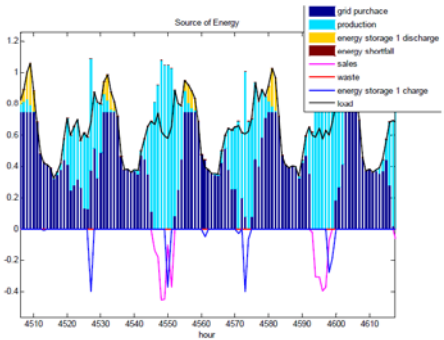
Co-creation

Co-innovation

Co-development

VTT in Smart Energy Systems

- **Extensive coverage on energy system studies (180 py)**
  - Energy system analysis
  - Renewable generation and system integration
  - Energy economics and markets
  - Climate change studies
- **Supporting competences within VTT (200+ py)**
  - ICT (communication, IT, sensors, cybersecurity)
  - Electric mobility, energy storages
  - Smart city, building energy management
  - Data analytics
- **Global co-operation**



New ways of working via piloting platforms and innovation ecosystems

- More dynamic ways of doing
- Key roles for companies
- More iteration and interaction between research and product development
- Combining actors from different sectors
- Testing and piloting of solutions in development phase
- Proof of feasibility for commercial and exportable solutions
- Open ecosystem principles – easy to join and contribute

SMART OTANIEMI

Blue Electrification

LUT University VTT

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Thank you!

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