

Next steps in optimal utilization of grid-capacity

Across levels of scale and modalities

Kristian Helmholt | Digital Energy Systems '25

11 December 2025

Agenda



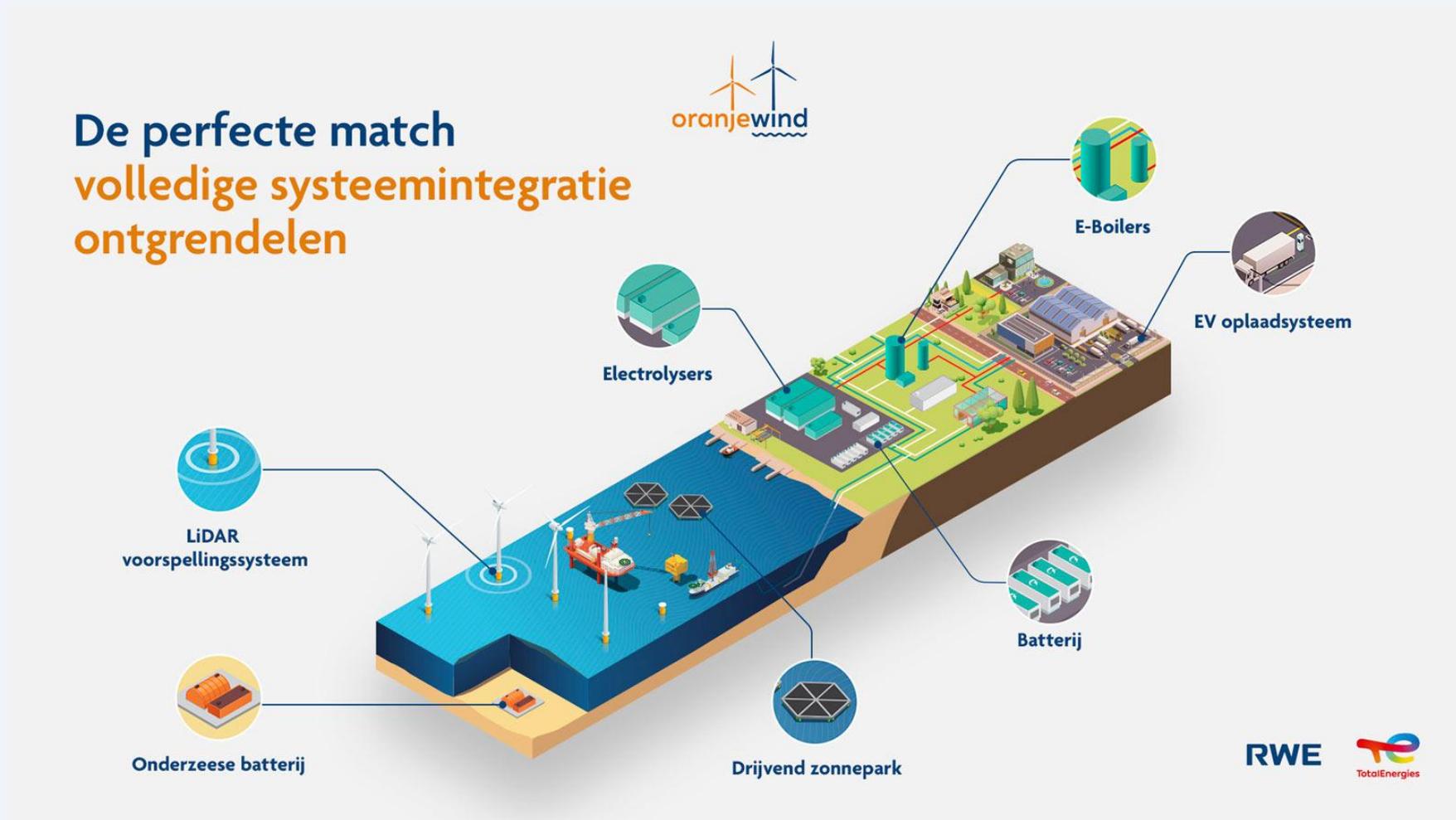
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5. Take aways

Position

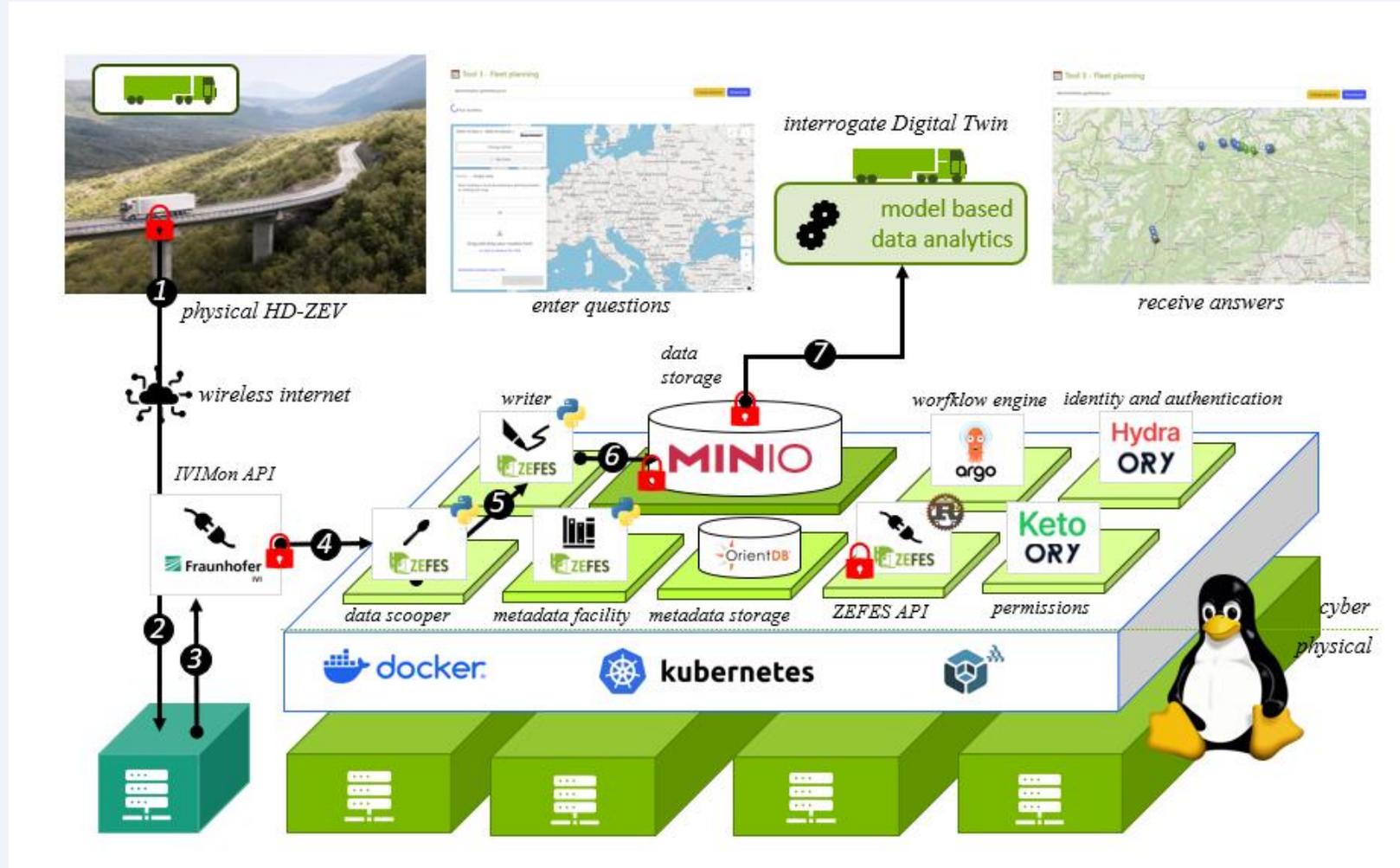
- General mission and vision at TNO: we create impactful innovations for the sustainable wellbeing and prosperity of society.

More specific: design & First-time Engineering to understand the impact of architectural choices when applying information and communication technology

Data, information & knowledge sharing



Zero Emission Heavy Duty Vehicles



Charging Energy Hubs

Sycada
yeco
Vlootmanagement Platformen

heliox
AME
Megawatt laadinfrastructuur en vermogenselektronica

ZERO EMISSION SERVICES
DENS
DAF
Batterijopslag (inclusief second use)

SCHOLTenergy
MAXEM
yeco
Energie & Trade Management Platformen

Shell Recharge
van Kessel
TAN Green
(Snel)laadlocaties van de toekomst

Firan
Elaadnl
Interoperabiliteit, standaarden en cyber security

Elektrificatie van Voer- en vaartuigen
DAF xyz
DAMEN

Ontwerp en realisatie DC-microgrid
dønning
SYSTEMS

Testfaciliteiten en certificering
KEMA Labs
CONNECTR
energy innovation

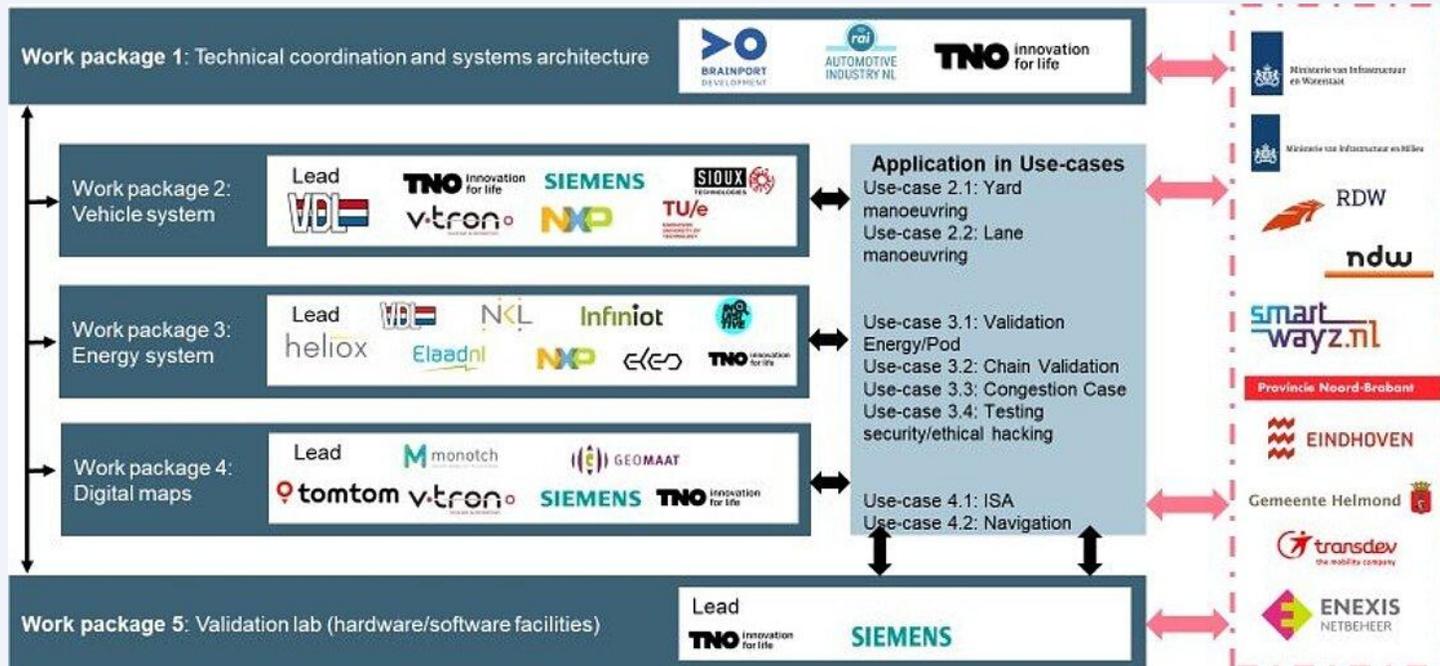
Automatische robot laadsystemen
PRODRIVE
TECHNOLOGIES
ROCSYS

Simulatie & systeemanalyses
TNO
EINDHOVEN UNIVERSITY OF TECHNOLOGY
TU/e

Kennisontwikkeling en Human Capital
HAN
ACE
automotive center of expertise
SECE
Fontys
NKL
CONNECTR
energy innovation

Projectcoördinatie en disseminatie
BRAINPORT DEVELOPMENT
economische ontwikkelingsmaatschappij
INDUSTRIE
AUTOMOTIVE INDUSTRY NL
NKL
AEZ

Digitale infrastructuur voor Toekomstbestendige Mobiliteit (DITM)

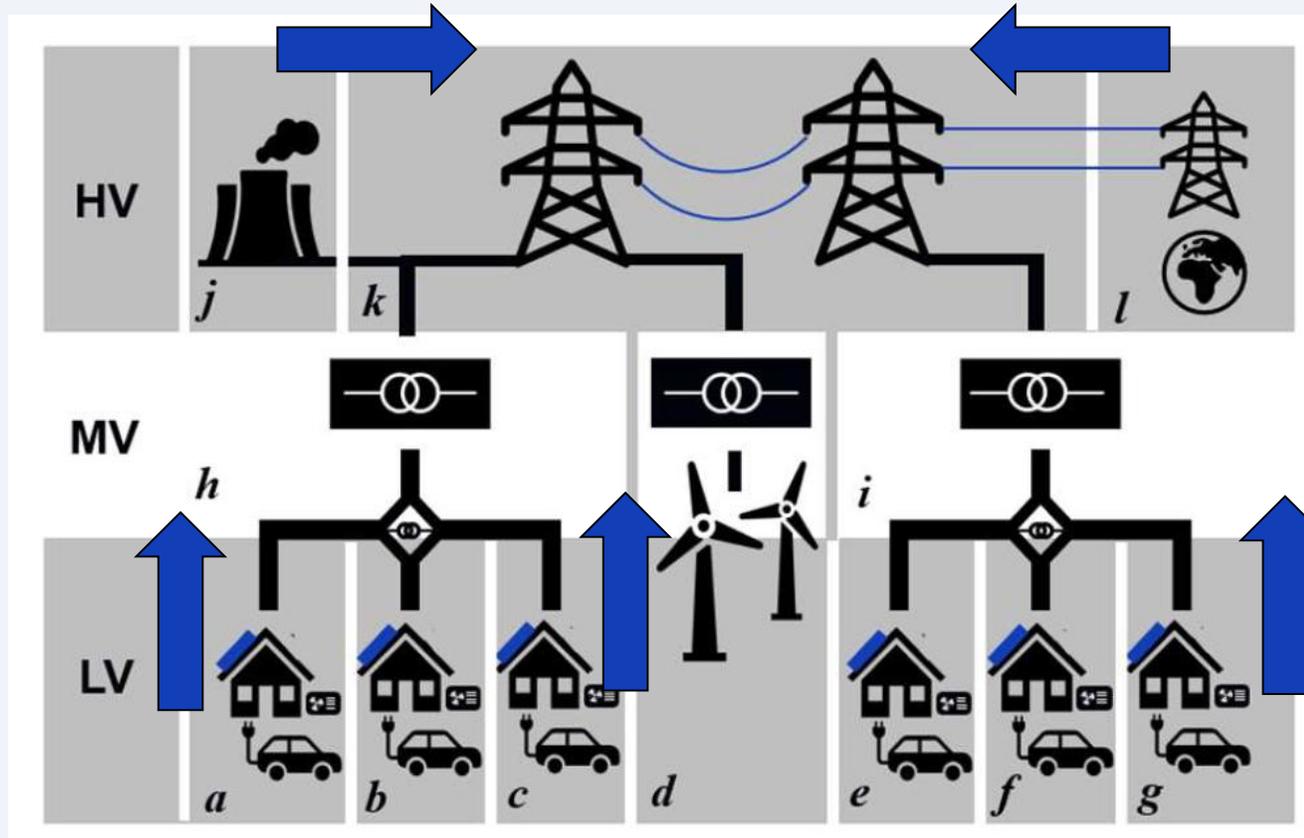


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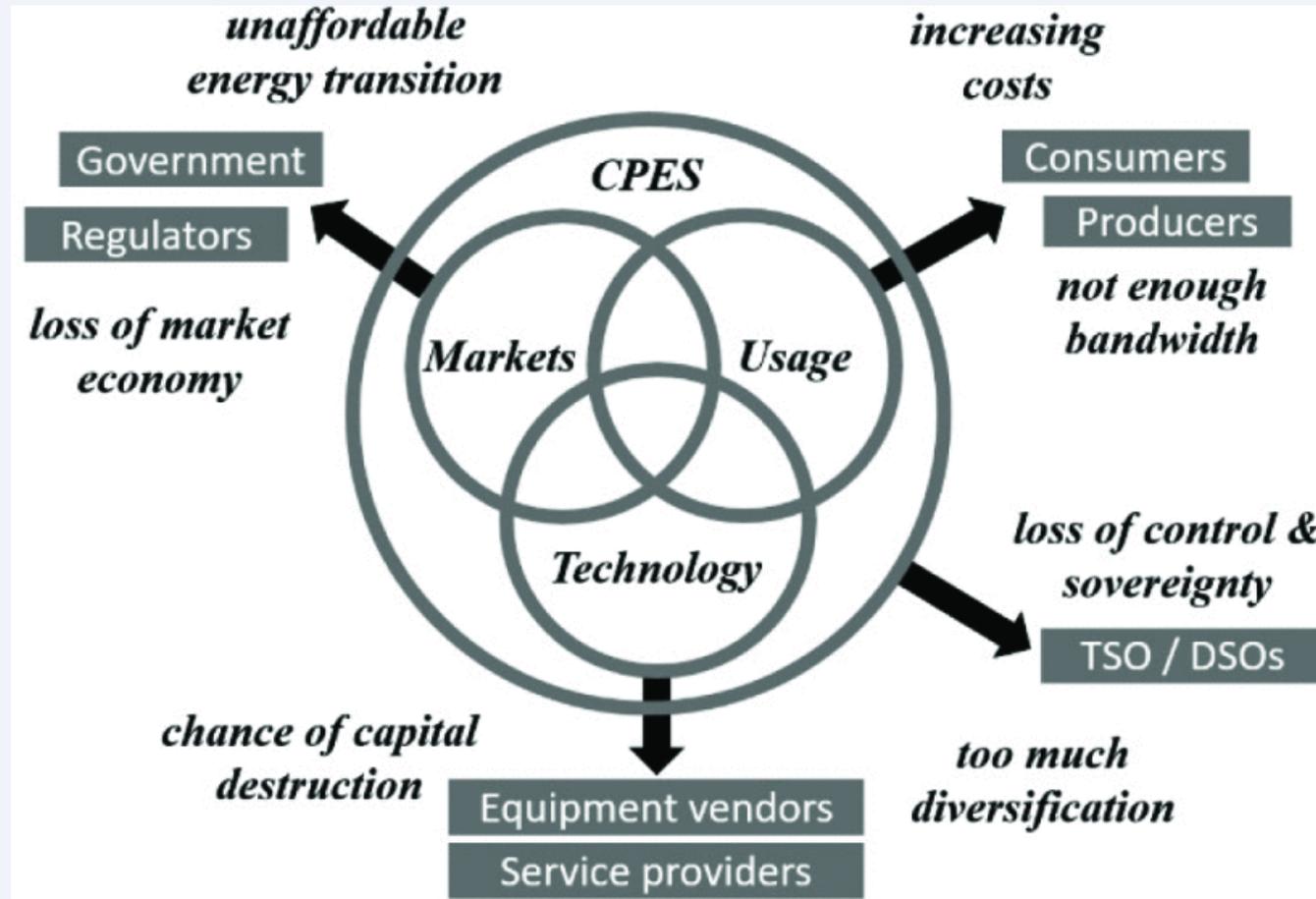
What is the technical landscape?



PowerTech Kiel 2025

Future state is influenced by dynamic states elsewhere

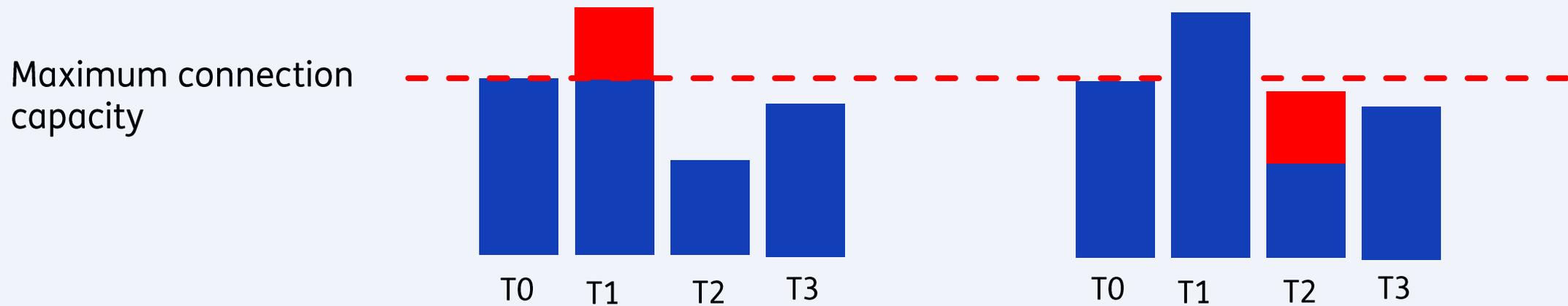
The wicked problem to avoid



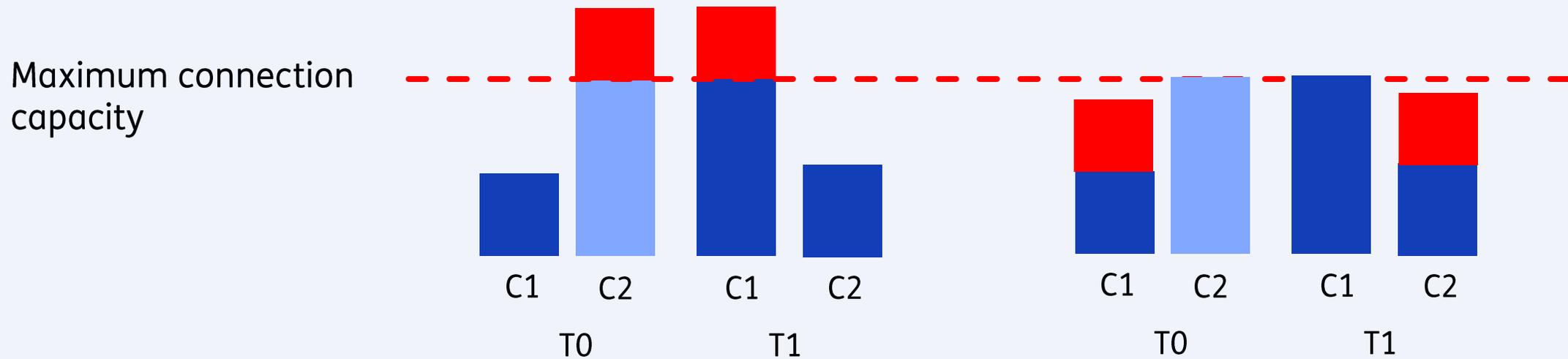
- lack of agreement on the definition of the problem.
- no single clear solution to the problem, but there are several, each with their own (dis)advantages
- no single problem owner that has the authority to decide on the solution.

The Wickedness of Making Smarter Use of the Electricity Grid," 2024 IEEE International Systems Conference (SysCon),

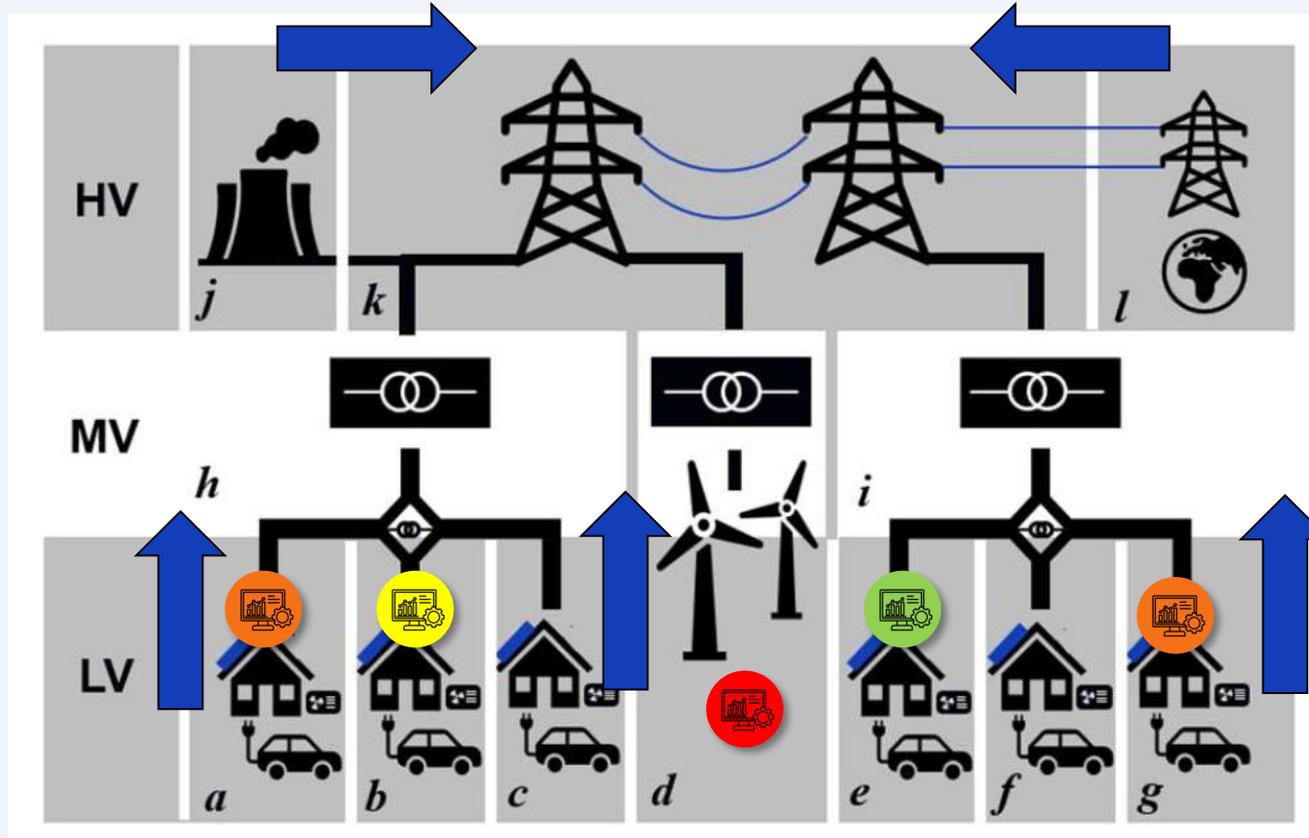
Firm capacity increase – shift own connection in time



Non-firm capacity increase – shift to other connection

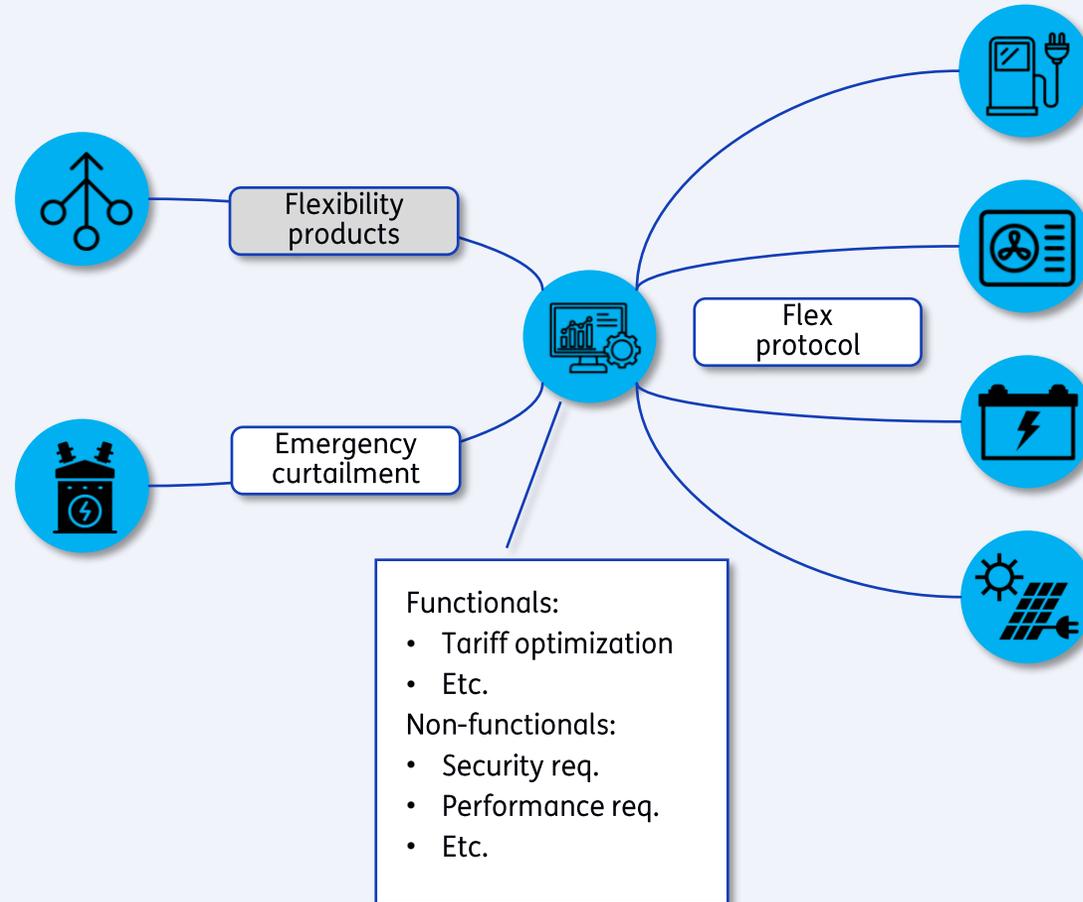


Increasing capacity by adding intelligence at nodes

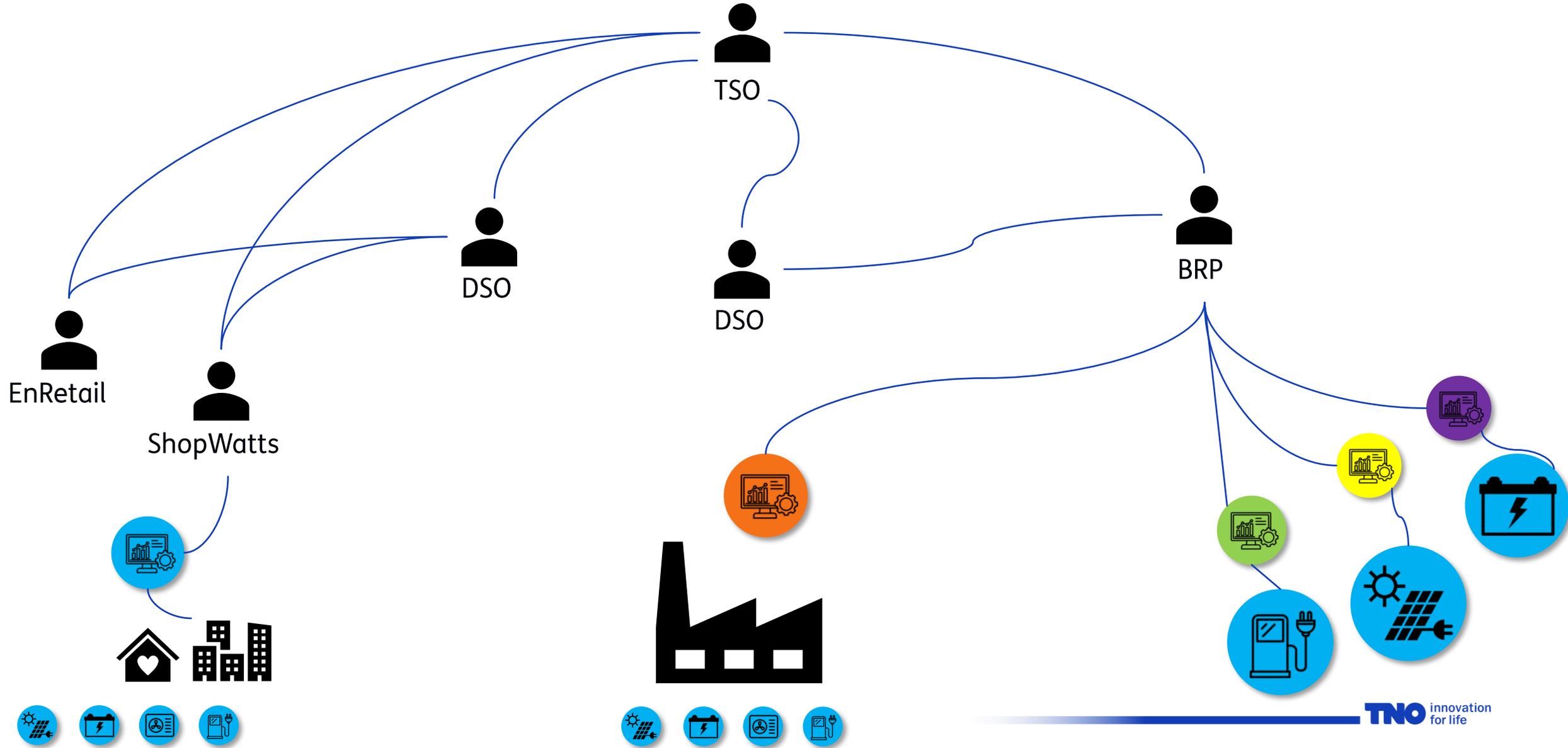


Smart components manage 'traffic'

Energy Management Systems at nodes



The Story 2) Current solution: add EMSs to provide flexibility (2/2)



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Risks involved in application of ICT

- **Arcanization**
 - Technology is rapidly evolving, so systems are built that might not be understood in a decade.
- **Amberization**
 - System of interdependent (sub)systems that becomes too complex to change
- **Over-Openness**
 - Too open: cybersecurity issues and too much information (enabling gamification)

Potential issues in 'firm land'

- **Keeping an open and level playing field**
 - Risk of vendor or service provider lock impeding customers from switching between service providers and product manufacturer
- **Multi market model support**
 - Can the logic in the distributed control nodes be replaced quickly and reliably when changes to the market occur?

Potential issues in 'non-firm land'

- **Organizing multiparty distributed control**
 - Distributed control by parties with different interests (TSO, BRP, BSP, DSO, etc.) may clash and provide emergent behaviour
- **Resilience**
 - Do the EMS support curtailment procedures and can it handle black starts?
- **Trusting forecasts and request compliance**
 - Can DSOs and (thus) TSOs really trust the forecasts and promised flex from the nodes?

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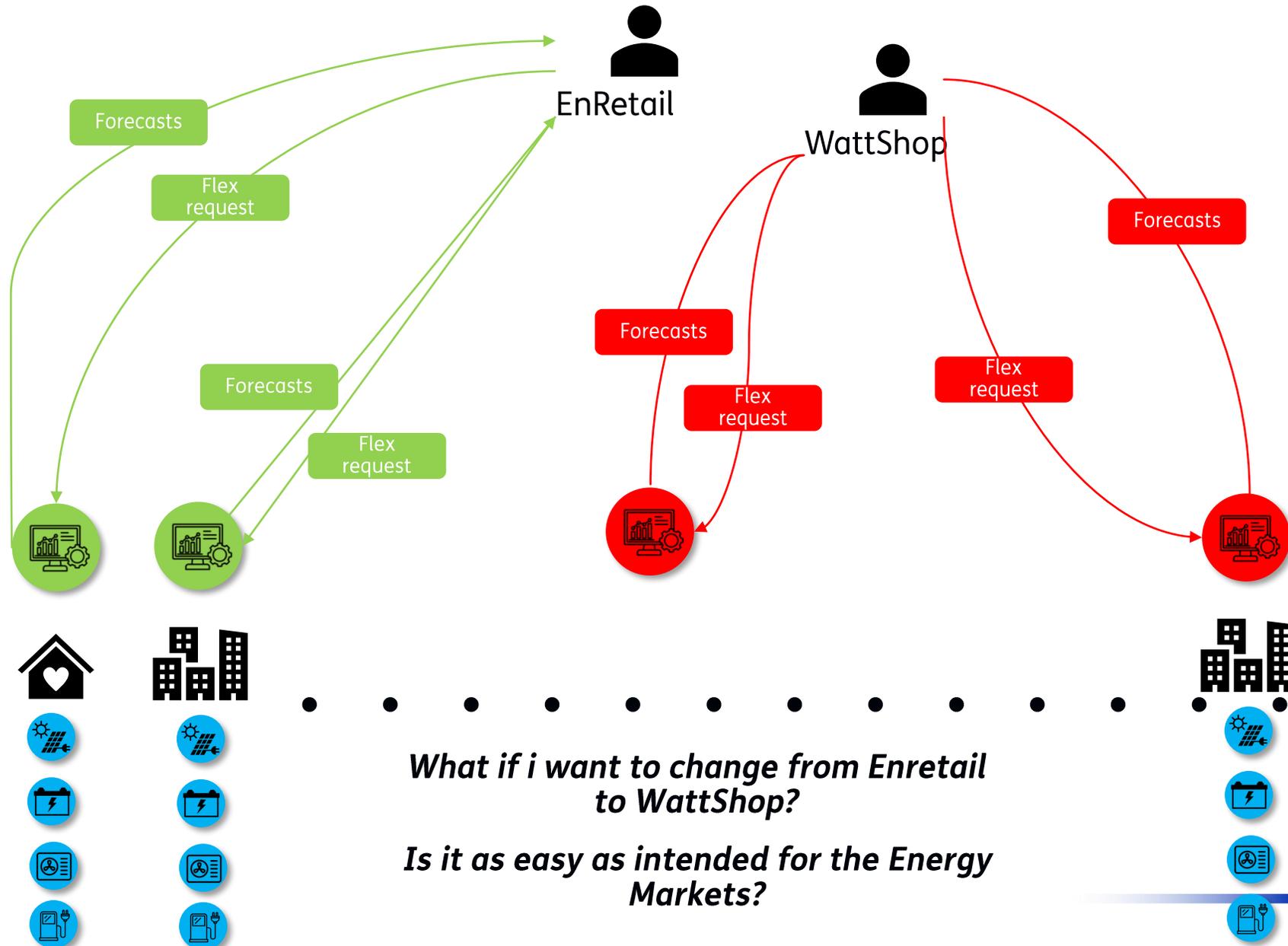


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Harmonize – like S2



Steps to take Visual examples of switching between energy retailers and BRPs



Forecasts

- Demand or supply forecast (MWh)
 - 1Hr or 15min interval
- % Accuracy of the forecast

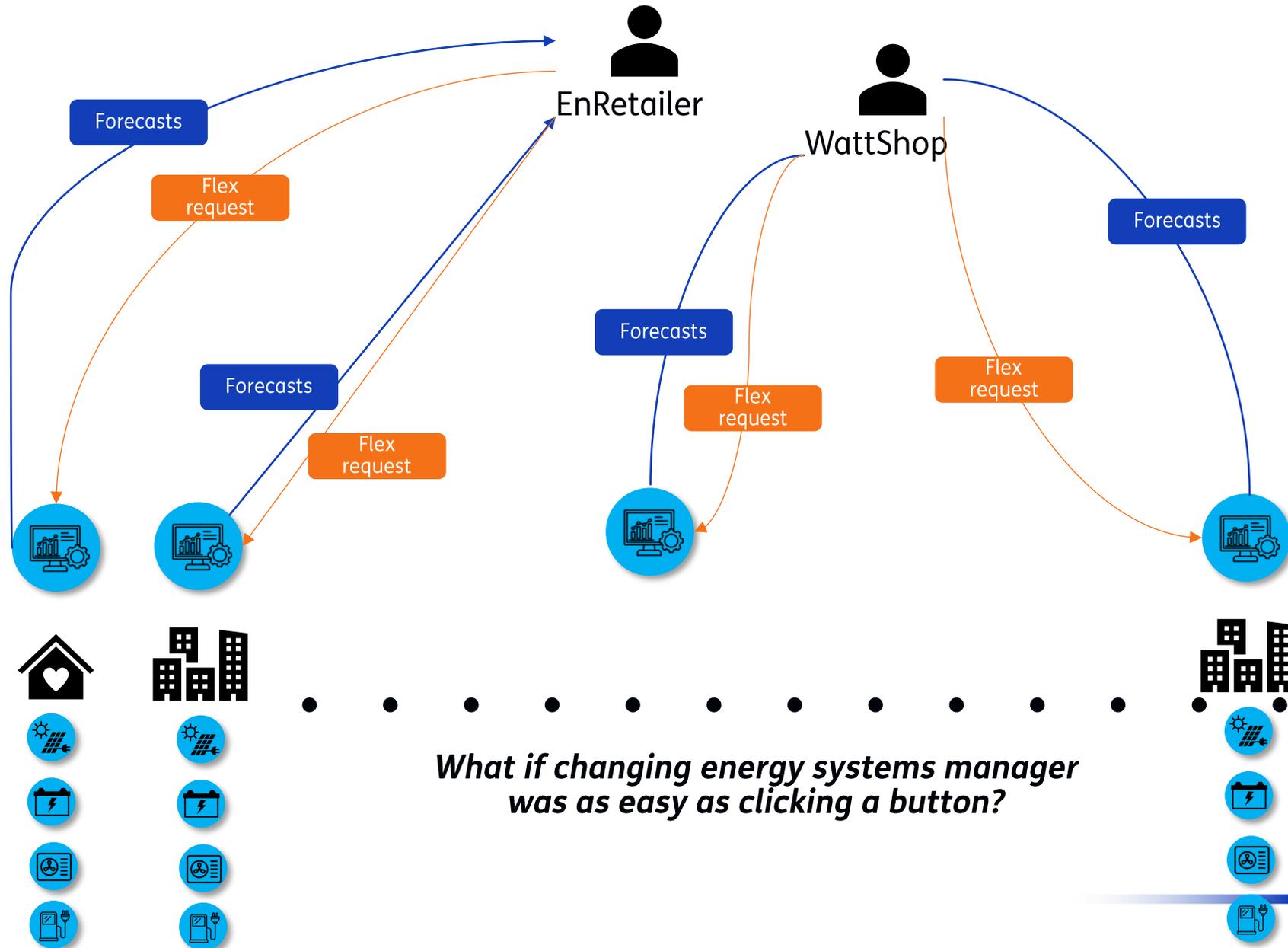
Functionals:

- Tariff optimization
- Etc.

Non-functionals:

- Security req.
- Performance req.
- Etc.

Steps to take Visual examples of switching between energy retailers and BRPs



What if changing energy systems manager was as easy as clicking a button?

Forecasts

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Functionals:

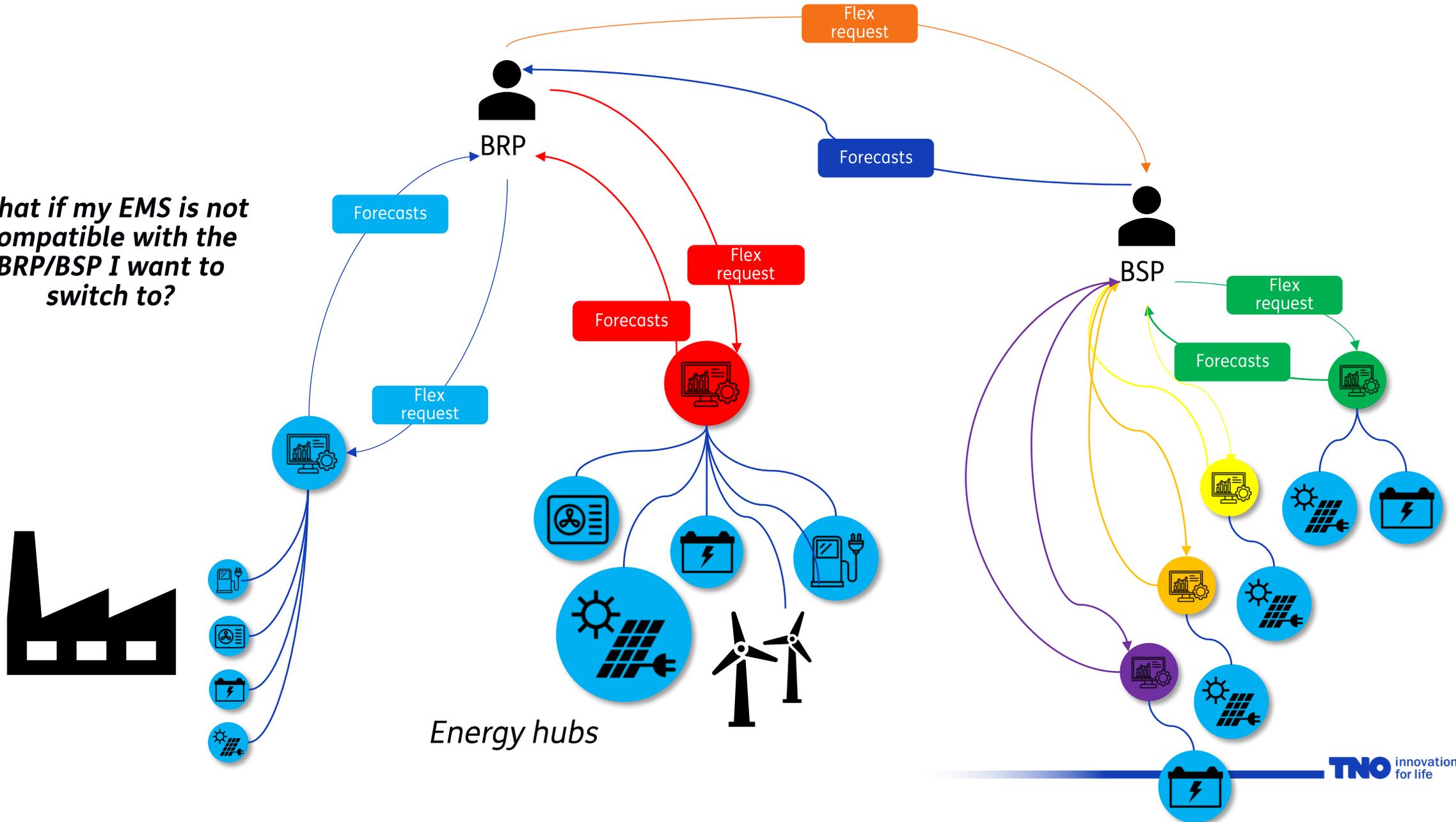
- Tariff optimization
- Etc.

Non-functionals:

- Security req.
- Performance req.
- Etc.

Steps to take Visual examples of switching

What if my EMS is not compatible with the BRP/BSP I want to switch to?



Agree on adding intelligence to make it

- **scalable Across All Aggregation Levels** - From homes and buildings to hubs, districts, and entire regions — including flexibility at scale.
- **vendor-Neutral and Modular by Design** - Enabling plug-and-play features and preventing vendor lock-in.
- **ready for Multiple Market Models** - Supporting current and emerging energy, flexibility, and community market structures.
- **resilient by Design** - Embedding forecasting robustness, adaptive behaviour, modularity/decomposition into every layer.
- **able to Deal With Uncertainty/Uncertainty-Aware Planning and Decision-Making** - Better data, better forecasting, and scenario-driven planning. Operational Digital Twins for better-informed planning. Robust EMSes at scale.

Collaborate on adding intelligence

- **Design and engineer setups** where competing equipment and service providers of digital equipment have to increase capacity together ‘in harmony’
 - Make use of existing products/services, to ensure return on earlier investments.
 - Determine at which interfaces harmonization needs to take place
- **Within the requirements** of open level playing field, reliability and resilience
- **From happy flow** demonstration of **increasing capacity** towards witnessing an energy system withstanding a **perfect storm**

Looking forward to collaborate with....

Ministries and
government
organizations

National
research
institute

Innovation hub/University
living lab/regional
development agency

National and international
standardisation
institute/coalition/innovation
consortium

System operators
(representative)

Private
company

Main take aways

- **Congestion drives** organisations to find **more capacity**
- **Capacity management is evolving** through energy management systems
 - Firm: shifting needs in time at one connection
 - Non-firm leap: shift capacity from other connections
- **Growth** of service providers and product manufacturers
- **Harmonization of digital interfaces** at nodes for capacity control needed to
 - scale up faster, increase resilience
 - keep an open level playing field and support evolving market models



Questions?

Theme name Place text here

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