Future Network Challenges – An ENTSO-E Perspective

Sonya Twohig

ENTSO-E 4.0
Beyond just the EU

42 TSOs in 35 countries

312,693 km of transmission lines
7 times the Earth’s circumference

3,278 TWh electricity consumption

15% of the global electricity consumption

over 500 million customers served
What does ENTSO-E do?

Contributes to the design and implementation of the Internal Energy Market

Develops the necessary IT tools for enabling the implementation

Provides regular reporting and recommendations for the development of the network
The Energy Transition

27% renewables by 2030 = +/- 45% for the power system

CHALLENGES

• System stability
• Resource variability
• New connections
• Changing power flows
• Emergence of new congestions
• Integrating demand-side resources
• Empowering prosumers & managing data
• Unlocking flexibility
The Energy System Flexibility Challenge

EXAMPLE OF ONE WEEK IN SEPTEMBER IN DENMARK

56% wind power
End-consumers play an increasingly important role

Source: Energinet
Significant Change in the Generation Mix

Demand for power: from 530 to 574 GW

Source: TYNDP 2016 vision 4
Impact on Grids: STRONGER and SMARTER GRIDS

THOUSANDS OF SMALL UNITS

LARGE FLOWS ALL OVER EUROPE
Ten Year Network Development Targets

Barriers identified in TYNDP 2016:
- Main boundaries
- Other important boundaries
- Exchange of flexibility
- Geo-political
- Physical congestions
- Loop-flows
- Market integration

Grid investments by 2040:
- 150 b€
- Connect new entrants
- Allow energy transition
New Renewable integration strategies

**Improved renewable controllability**
- Grid Curtailment
- Integrated Renewable-Storage dispatch
- Volt/VAr dispatch through Smart Inverters
- Advanced Inertial response

**New Generation dispatch strategy**
- Compound real-time renewable forecasting
- Stochastic Economic Dispatch
- Storage & Demand Response controls
- Artificial Intelligence Based Load Forecasting

**New Distributed Energy Resources aggregation**
- DER Virtual Power Plant participation into Markets & Grid ancillary services
- Optimal Gridedge connectivity through Microgrids
New Digital investment wave

Reaching Inflection Point: technology sourced from the consumer internet enabling faster and more secure developments of Industrial IoT apps and fostering new Data Business Models

- Agent Deployment on Grid edge
- Industrial-grade technology
- Optimized for networked asset data models
- Digital Substations
- Industrial Big Data, Artificial Intelligence and Machine Learning
- Generation forecasting & dispatch optimisation
- Modern Development tools and new app store for faster Innovation
- New Partnerships
New Market Integration Strategy

1. Phase out of the priority dispatch for renewables
2. Expose ‘mature’ renewable energy sources to market
3. Renewable energy sources need to have balancing responsibilities
4. Renewables support needs to be market-based
5. Support needs to be coordinated at regional and EU level
Bridging new Prosumers to the market

- Sensitivity to **price signals**
- Participation to the market in all time frames, including **balancing & ancillary services**
- New role for **aggregators**
Next Digital Grid 4.0

**RESILIENCY**
- Real-time Asset conditions & limits assessment
- Grid Stability with less rotating inertia, Wide Area Defense Plan & Natural Disaster Recovery
- New Regional Security coordination

**EFFICIENCY**
- TSO Flow Based markets & DSO Market facilitation
- Digital Substation
- Integrated Grid Edge/OT & IT/cloud architectures
- New Energy Data Play

**DER INTEGRATION**
- Enable DER (renewable, storage, demand, EV) Virtual Power Plant Aggregation
- Real-time DER integration into Grid Economic Dispatch & reserves
- New Smart Connection planning with renewable & community Microgrids
Low Inertia Grid Controls

Belectric deployment

Source: Belectric @ National Grid / GE Grid Solutions

Manage Low Inertia Grids
New Digital Substations

**REDUCE FOOTPRINT**
up to -15% costs

**EASY BAY MIGRATION**
Reduction of up to 50% of outage duration

**ASSET UTILIZATION TO THE LIMIT**
up to +15%

*BEFORE*
Up to 200 km fewer wires & up to 50% less panels
Less material, Labour, & Engineering

*AFTER*
HV/MV signals stay in yard

- Augmented reality
- Wide area control
- Asset health index
- Renewable integration

Source: Rte / GE Grid Solutions

**27 SUBSTATIONS + 56 TRIAL SITES IN 20 COUNTRIES**

2009 – 2015 Cumulative Data
New TSO/DSO interfaces

Enable DSO Market Facilitation
Digital Energy Value Chain Transformation

**Traditional electricity value chain**

1. Power generation and trading
2. Power transmission
3. Power distribution
4. Energy services (retail)
5. Electric devices and appliances
6. End-use customers

**Emerging electricity value chain**

- Distributed resources (generation, storage, electric vehicles)

- Power generation and trading
- Power transmission
- Power distribution
- Energy services (retail)
- Electric devices and appliances
- End-use customers

Source: IBM Institute for Business Value.

*Figure 1:* Traditional and emerging electricity value chain.
First Migration Step 2020

Network Code implementation is a key priority!

CACM Guideline
Balancing Guideline
System Operations Guideline

Ensure market integration and integrity:

Optimal capacity calculation
Foster interconnection
Efficient provision of ancillary services
Wholesale/retail integration
Network code strategic objectives

**MARKET CODES**

Wider market integration
Allow more competition, new entrants, and enhance resources optimisation

**CONNECTION CODES**

Greener power, smarter consumption
Connect new actors to the grid and enable them to play an efficient role

**OPERATIONAL CODES**

Reinforced security of supply
Plan, operate & monitor a grid with new challenges and new technologies
NETWORK CODES/GUIDELINES: THE FOUNDATIONS OF THE INTERNAL ENERGY MARKET

3 CONNECTION CODES

Requirements for:
• Generators
• Demand side
• HVDC connections

...paving the way for offshore wind...

3 MARKET CODES

Rules for:
• Capacity calculation
• Day ahead / Intraday
• Forwards
• Balancing

...market coupling...

2 OPERATIONAL CODES

Rules for:
• System Operation
• Emergency situations

...regional cooperation to increase security...
Value creation of Network Codes

**Sustainability**
- 260 GW of RES connected
- 25 GW in 2016
- >10 GW of EU demand side response

**Network codes**

**Security of supply**
- NO multi-state interruptions recent years
- Up to 300 coordinated regional tasks/day
- Hundreds trained employees in the Regional Security Coordinators

**Competitiveness & Social Welfare**
- 23 states and 85% of European consumption market coupled
- 10 million data files made available yearly for 2500 daily users of ENTSO-E transparency platform
SYSTEM OPERATION GUIDELINE
OPERATIONAL PLANNING

REGIONAL COORDINATION

Common Grid Model
- Common scenarios
- Establish IGMs/CGMs

Security analysis
- Contingency analysis
- Preparation of remedial actions

Outage planning
- Detection of outage planning incompatibilities

Adequacy assessment
- Control area adequacy
- Regional adequacy
- Pan-European adequacy

Scheduling
Ancillary services

ENTSO-E Operational Planning Data Environment
REGIONAL SECURITY COORDINATORS: THE NEW FACE OF COOPERATION
REGIONAL COORDINATION WILL EVOLVE

To evolve overtime

Instruments for the implementation of EU network codes/ guidelines

TSOs MAINTAINING OPERATIONAL DECISION MAKING:

- Minimises risk of wide area events
- Minimises risk of cyber and terrorist attacks
- Cost control

MORE COORDINATION BRINGS:

- More security
- Optimised operation
- Economies of scale
- Market integration
- Maximised transmission capacity to markets
- Links between operational security analysis and market support functions
New Strategic investments towards Digital

- Energy Data Hubs & App Stores
- Reference Grid Architecture Model to support next Network Code deployments

- New Generation Flow Based real-time markets
Next Migration Step: the Clean Energy Package 2030

- Active customer
- Scarcity pricing
- Removal of price caps
- Easier supplier switching
- Risk preparedness framework
- European resource adequacy
- Ambitious Regional Cooperation

FUTURE
- Digital, data-centric system
- Electrification of transport
- Engaged prosumers

Digital, data-centric system
Engaged prosumers
In Summary...

- The Power System is facing significant transformational challenges related to the growth of Distributed Generation and tomorrow’s Electrical Transportation developments (EV).

- In parallel, Digital technologies offer new key development opportunities to Grid Operators to enable new solutions and value proposition.

- A Transformation of the Power System is underway.

- ENTSOE is a strategic enabler of this Transformation through investments in key digital platforms such as the Common Grid Model and Energy Data Hubs and Apps.
The traditional electricity sector is being transformed by digitalization, decentralization, and electrification.

3 trends disrupting the traditional power sector:

**Digitalization**
- **What:** explosion in the number of connected devices and smart sensors
- **Impact:** allowing decision making based on dynamic prices

**Decentralization**
- **What:** growing penetration of distributed resources (generation, storage, efficient devices)
- **Impact:** end user become an active actor of the power system

**Electrification**
- **What:** electrification of energy uses, transport (EVs) and heating
- **Impact:** growth of electricity demand, and an acceleration of decentralization of the power sector
THANK YOU FOR YOUR ATTENTION

For more information:
www.entsoe.eu
www.entsog.eu
Strong European Research and Innovation Program
ETIP Smart Networks for Energy Transition

- Grid observability & controllability
- Tools to manage variability and congestions
- Co-optimization of Centrally Dispatched units & Distributed Energy Resource
New Digital System of System Architecture

Utility Control Room on Prem (OT)
- CIM/JMS
- Grid Domain Services
- New App Store
- WAM App
- DERMS App
- Data Fabric
- Time Series Asset
- App Catalog
- Grid Situational Awareness

Private Cloud
- APM App
- Platform as a Service
- Option

Utility Back Office IT
- ERP
- CIS
- MDM
- Utility ESB

Utility Cloud
- DRMS
- Internet
- 4G/LTE
- Wifi

New Layered Optimisation framework

Utility Integration bus
- CIM/JMS
- Other System

Integrated Industrial Comms
- Internet
- Verizon

Distributed Field Bus (DFB)
- MQTT
- DDS
- CIM
- SEP2
- IEC61850
- Modbus/DNP3
- IEC61860/DNP3
- Distribution Automation Controller
- Distributed Application Function Blocks
- Field Agent
- Controller
- 900MHz
- Inverter
- Controller
- SEP2/IEC61850
- SEP2/IEC61850
- SEP2/IEC61850

Grow Agility in complex IT environments
New sector coupling

- Power with Gas / Combined Heat & Power
- Mobility with Power & Gas & Emission Trading
- TSO-DSO coupling
- Microgrid coupling at Gridedge through #Blockchain