Challenges of the RES Integration
For the Long Term Development of Electricity Transmission Infrastructure in Europe

1. Context: ENTSO-E, 10/20/40 year views
2. ELECTRICITY HIGHWAYS 2050
3. Conclusion

1 October 2013, Budapest, Hungary

5th Annual Wind Energy in Hungary Workshop
Budapest Congress Center

Dr. Mihai PAUN
Network Development - ENTSO-E
ENTSO-E has significant role in delivering European energy and climate change objectives

Key activities set out in Regulation 714/2009 (on cross-border electricity trade, part of the 3rd IEM Package)

- Deliver **network codes** binding to all network users (through ‘Comitology’)
- Deliver **network plans** European / regional view of system needs (“TYNDP”)
- Deliver crucial aspects of **market integration** (“market coupling”)
- **R&D Plan** (fully included in EEGI – European Electricity Grid Initiative, part of the SET Plan)

Through its members deliver the **infrastructure** to:

- enable markets to function,
- secure energy supply,
- meet climate change objectives through connecting RES

41 TSOs (among whom swissgrid) from 34 countries; 530 million people; 910 GW gen.; 300 000 km transm.
ENTS-O-E Organizational Structure

- **WG 2050 ELECTRICITY HIGHWAYS**

  - System Development Committee:
    - European/Pan-European Transmission Network Development
    - Ten Year Project Development
    - System Adequacy & Market Modelling
    - 2050 Electricity Access
    - National Transmission Grids

  - System Operations Committee:
    - Critical Systems Protection
    - Interoperability & Synchronous Areas
    - Coordination Strategy
    - ENTSO-E Academy
    - Indus Classification System

  - Market Committee:
    - Market Integration
    - Ancillary Services
    - Market Information & Transparency
    - Economic Aspects
    - Renewable Energy Sources

  - Research & Development Committee:
    - Research & Development Plan
    - Monitoring & Knowledge Sharing
    - IEC 61860 Interoperability

- **6 REGIONAL GROUPS FOR 6 REGIONAL NETWORK DEVELOPMENT PLANS**
INSTITUTIONAL RELATIONSHIPS and Stakeholders involved in the Electricity Value Chain

- **DSOs**: Eurelectric, ENTSO4SG
- **CONSUMERS**: Industrial groups, Consumer associations
- **TSOs**: Not members of ENTSO-E
- **GAS NETWORK OPERATORS**: ENTSO-G
- **EQUIPMENT MANUFACTURERS**: Europacable, T&D Europe, Friends of the supergrid, European Smart Metering Industry Group
- **ENERGY GENERATORS & RETAILERS**: Eurelectric
- **REGULATORY BODIES**: ACEER, CEER, National regulators
- **RENEWABLE ENERGY ASSOCIATIONS**: Erec, Etc.
- **POLICY MAKERS**: EC, Member States, Regions, Cross border regional structures
- **RESEARCH & DEVELOPMENT PERFORMERS**: Universities, Technical centers
- **FINANCIAL INSTITUTIONS**: European Investment Bank, European Investment Fund, European Bank for Reconstruction and Development
- **ENVIRONMENTAL AGENCIES**: EEA, National/Regional agencies
- **NGOs**: Climate NGOs, Wildlife NGOs, Landscape NGOs, etc.
CURRENT RELATIONSHIPS of the ENTSO-E WG 2050 ELECTRICITY HIGHWAYS
CURRENT RELATIONSHIPS of the ENTSO-E WG 2050 ELECTRICITY HIGHWAYS

ELECTRICITY HIGHWAY SP

E-Highway2050 Project

EIP → PCIs

Climate Parliament
www.climateparl.net

Sir Graham Watson MEP
ALDE

ITRE Report 2050 Roadmap
Niki Tzavela
FUTURE COOPERATION

ENTSO-E ELECTRICITY HIGHWAY CONFERENCE 2014
Drivers for grid development

EU Strategic Goals

Sustainability
• More renewables far from loads
• New electricity uses (mobility with electricity, heat pumps...)

Competitiveness / Market integration
• Optimal resources sharing
• More long distance trans-European flows

Security of Supply
• Continuity of supply of remote/isolated areas
• Prevent large disturbances
What are the tools needed for infrastructure development?

1. The EC’s Infrastructure Legislation!
   - Transmission line permitting in <3 years with one-stop shops
   - Transmission regulatory improvements for better financing
   - The ENTSO-E TYNDPs with better and better cost-benefit methodologies as the basis for “Projects of Common Interest”

2. A 2030 and 2050 modular transmission plan for a Electricity Highways system
   - A 3-year R&D study with TSOs + broad consortium for the definitive 2050 grid study
   - Major changes in electricity generation and use ➔ major changes in transmission
   - Need to know soon whether to introduce a higher voltage level, of which kind
   - Transmission becomes cheaper and more efficient (less losses, less land needed) at higher voltage

3. And: Public acceptance campaigns by MS governments for Electricity Highways, linking European infrastructure to their daily needs
2020 Europe - About €100 billion in investments

- €100 billion investment on grids...
- ≈ 1.5-2 €/MWh in Europe over the 10-year period,
- ≈ 2% of the bulk power prices,
- ≈ less than 1% of the total end-users’ electricity bill

<table>
<thead>
<tr>
<th>Country</th>
<th>Investment (billion €)</th>
</tr>
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<tbody>
<tr>
<td>Austria</td>
<td>1.1</td>
</tr>
<tr>
<td>Belgium</td>
<td>1.9</td>
</tr>
<tr>
<td>Bosnia-Herzegovina</td>
<td>0.0</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>0.2</td>
</tr>
<tr>
<td>Croatia</td>
<td>0.2</td>
</tr>
<tr>
<td>Czech Republic</td>
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</tr>
<tr>
<td>Cyprus</td>
<td>0.0</td>
</tr>
<tr>
<td>Denmark</td>
<td>1.4</td>
</tr>
<tr>
<td>Estonia</td>
<td>0.3</td>
</tr>
<tr>
<td>Finland</td>
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<tr>
<td>France</td>
<td>8.8</td>
</tr>
<tr>
<td>FYROM</td>
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</tr>
<tr>
<td>Germany</td>
<td>30.1</td>
</tr>
<tr>
<td>Greece</td>
<td>0.3</td>
</tr>
<tr>
<td>Hungary</td>
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</tr>
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<td>Iceland</td>
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<td>Italy</td>
<td>7.1</td>
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<tr>
<td>Ireland</td>
<td>3.9</td>
</tr>
<tr>
<td>Latvia</td>
<td>0.4</td>
</tr>
<tr>
<td>Lithuania</td>
<td>0.7</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>0.3</td>
</tr>
<tr>
<td>Montenegro</td>
<td>0.4</td>
</tr>
<tr>
<td>Netherlands</td>
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<tr>
<td>Norway</td>
<td>6.5</td>
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<td>Poland</td>
<td>2.9</td>
</tr>
<tr>
<td>Portugal</td>
<td>1.5</td>
</tr>
<tr>
<td>Romania</td>
<td>0.7</td>
</tr>
<tr>
<td>Serbia</td>
<td>0.2</td>
</tr>
<tr>
<td>Slovakia</td>
<td>0.3</td>
</tr>
<tr>
<td>Slovenia</td>
<td>0.3</td>
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<tr>
<td>Spain</td>
<td>4.8</td>
</tr>
<tr>
<td>Sweden</td>
<td>2.0</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.7</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>19.0</td>
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Total ENTSOE perimeter: 104 billion €
Building the necessary infrastructure – 3 main problems

1. Permitting and public acceptance
   - Slow and cumbersome permitting procedures the main obstacle for delivering investments
   - Public acceptance cannot be improved by TSOs alone
     
     *One third of the transmission infrastructure is currently delayed.*

2. Legislative implementation
   - Some compatibility among the 27 MS energy policies
   - Some stability in EU legislation - avoid new concepts becoming part of official documents

3. Attractive financing framework
   - “real” return in line with businesses of similar risk profiles
   - incentives for activities “really” managed by TSOs
   - legislation and regulation in line with 20 to 50 years assets
EU electricity high voltage landscape will drastically change in the coming years: (Offshore grid, Electricity Highways…)

Partial undergrounding of EHV power lines can help to build grids faster.
ENTSO-E paves the way to e-Highway250

Possibilities & Uncertainties

- Planned projects & policies
- Regional plans
- Envisaged projects

2020

ENTSO-E's TYNDP

RIP's: NSCOGI, MEDGRID...

SO&AF

ENTSO-E Visions

2030

e-Highway2050

- TSO questionnaires
- Review of European policies
- Review of scenario studies

European scenarios
Possible projects

2050

IEA ETP/WEO
ECF Roadmap 2050
EU Energy Roadmap 2050
EURELECTRIC's Power Choices
FP7 projects...
etc...

Time
The STUDY

e-Highway 2050 Project
The Concept of ‘Electricity Highways’

Why electricity highways?

Wind energy
Solar energy
Wave energy
Bioenergy

Simplified Map

Two main drivers for infrastructure development in Europe:
RES Integration & Market integration
Electricity highways: what are we talking about?

✓ **An electricity highway is:**
  ✓ A transmission line with significantly more capacity to transport power than existing high-voltage lines
  ✓ Technology solutions and integration in existing AC grid are still open today
  ✓ though some DC technologies most likely
  ✓ In the longer term **Electricity Highway System (EHS)** is likely to be created
Why Electricity Highways?

- Political will to decarbonise EU economy
  - 20-20-20 Strategy
  - 2050 Energy Roadmap

- RES - key tool of the decarbonisation are located far from consumption centres
  - Offshore wind
  - Desertec – MENA (Middle Eastern and North African)

- Integration of large RES will dramatically change geography of electricity flows across Europe
  - Variable renewable potential across Europe
  - Intermittency of RES requires more network development for balancing purposes
Why Electricity Highways?

Wave energy
Bioenergy
Solar energy
Wind energy

Electricity Highways 2050
e-Highway2050

Modular Development Plan of the Pan-European Transmission System 2050

Objectives
Supported by the EC-DG Research, e-Highway2050 is a research and development project: it aims at developing a new planning methodology able to deliver, within three years, a first version of coherent Modular Development Plans of the pan-European power transmission system, going from 2020 to 2050.
The resulting pan-European grid is supposed to enable electricity market integration and the 2050 decarbonization goals of the electricity system, therefore integrating large quantities of renewables to be transported over long distances from production sites to load centers.

http://www.e-highway2050.eu/e-highway2050/
The Structure of the Project

Leaders

WP1  Sintef
WP2  Amprion
WP3  Technofi
WP4  REN
WP5  Elia Gr
WP6  RSE
WP7  DENA
WP8  RTE
WP9  ENTSO-E
WP10 RTE

Boundary Conditions

WP2 Scenarios & 2050 Grid architectures
WP3 Technologies
WP6 Socio-Economic profitability
WP4 Implementation & operation
WP5 EHS Governance

Stakeholders involvement

Planning and steps towards a Pan-European EHS

Dissemination

Coordination & Management
The Progress Report of e-Highway2050 Project

- The project started on September 1st 2012
- Grant Agreement was signed in October.
- e-Highway2050 project in figures:
  - 28 direct partners, 16 TSOs
  - 18 nationalities,
  - 911 person.months,
  - 13 M€ total cost, 9 M€ Grant,
  - 40 months.
The choice of the Energy Scenarios for 2050: a key milestone of the whole e-Highway2050 Project.

CONSULTATION with:
- TSOs
- Stakeholders → comments before developing the next steps of the project.
e-Highway2050 scenarios are neither predictions nor forecasts about the future. We do not conclude that one scenario will be more likely to happen than another, nor that one scenario is more preferred or "better" than another.

Rather, each e-Highway2050 scenario is one alternative image of how the future of European Electricity Highways (EHS) could unfold.

Objective: select a panel of scenarios challenging enough in order to cover a wide scope of possible futures, in a limited cases to study for the Pan-European transmission grid".

Scenario = { Σ criteria }

Criteria

Uncontrollable ➔ uncertainty (Future)

Controllable ➔ option (Strategy)
## 5 relevant e-HW2050 Scenarios:

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</tr>
</thead>
<tbody>
<tr>
<td>Future 1</td>
<td>Green Globe</td>
<td>NUC</td>
<td>X-1</td>
<td>X-2</td>
<td>X-3</td>
<td>NUC</td>
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<tr>
<td>Future 2</td>
<td>Green EU</td>
<td>CCS</td>
<td>X-5</td>
<td>X-6</td>
<td>X-7</td>
<td>CCS</td>
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<td>Future 3</td>
<td>EU- Market</td>
<td>X-8</td>
<td>No Policy</td>
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<td>Future 4</td>
<td>Big is beautiful</td>
<td>X-10</td>
<td>CCS</td>
<td>Illogical</td>
<td>X-12</td>
<td>X-13</td>
<td>X-14</td>
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<td>Future 5</td>
<td>Small things matter</td>
<td>NUC/CCS</td>
<td>Illogical</td>
<td>X-16</td>
<td>X-17</td>
<td>NUC</td>
<td>CCS</td>
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</tbody>
</table>
The next steps of the project will be built from these scenarios.
A consultation of the TSOs followed by Consultation with Stakeholders by the partners working on scenarios development.
Four main Processes to elaborate Grid Architecture Options in 2050:

1. 2050 Scenario Development
   - To develop detailed scenarios of the distribution of generation (G) and demand (D) in Europe for 2050, including third country exchanges (E).

2. Pan European Grid Model
   - Introduce an adequate model of the Pan-European transmission system in 2050 based on interacting-clusters.

3. Power Market Simulation
   - Power market simulations that balance G/D/E in each cluster.

4. Grid Analyses
   - Grid analyses based on developed grid model and power market simulation results to develop options for “overlay grid”-architectures.
**PRELIMINARY “PROJECTED” DEMAND PER SCENARIO:**
in figures...

<table>
<thead>
<tr>
<th>Calculation step</th>
<th>Large scale RES &amp; no emissions</th>
<th>“100% RES”</th>
<th>Big &amp; Market</th>
<th>Big Nuc and CCS</th>
<th>“Small and Local”</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) ‘BAU’ electricity demand in 2050</td>
<td>(x-5) 4600</td>
<td>(x-7) 4600</td>
<td>(x-10) 4600</td>
<td>(x-13) 4600</td>
<td>(x-16) 4100</td>
</tr>
<tr>
<td>(2) 2050 ‘BAU’ + electrification</td>
<td>(x-7) 6100</td>
<td>(x-10) 6100</td>
<td>(x-13) 6100</td>
<td>(x-16) 4400</td>
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<tr>
<td>(3) final electricity demand in 2050</td>
<td>(x-13) 5500</td>
<td>(x-16) 4900</td>
<td>(x-16) 5200</td>
<td>(x-16) 5500</td>
<td>(x-16) 3500</td>
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<tr>
<td>(4) Final demand met by transmission</td>
<td>(x-16) 4700</td>
<td>(x-16) 3000</td>
<td>(x-16) 4100</td>
<td>(x-16) 5200</td>
<td>(x-16) 1400</td>
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</table>
TOTAL EUROPEAN ELECTRICITY DEMAND IN 2050: COMPARISON WITH OTHER EU STUDIES (TWh/year)
Conclusions

1. Europe-wide grid planning and RES integration for the urgent 10-year needs, and for 2030 and 2050 is needed.

2. ENTSO-E paves the way to e-Highway2050 and the selection of the Energy Scenarios is a key milestone of the e-Highway2050 project.

Thank you very much for your attention!

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