“Purpose, aim and status of European Ten Year Network Development Plan (TYNDP) in providing a foundation stone for market developments which facilitate high penetration of Renewables”

By Helge Urdal of Urdal Power Solutions Ltd for European Network of Transmission System Operators for Electricity (ENTSO-E)

New Delhi 6-8 September 2017

1st Wind & Solar Integration Workshop
Introduction & the integration of RES challenges

The scenarios

Developing the networks – TYNDP2016
- Benefits & target transfer capacities
- Different technical solutions
- The boundaries – Increasing SEW

Concluding remarks

Additional material
- Monitoring progress – 2014 to 2016
- Assessing projects
- TYNDP 2018
The evolution of the European power system confronts TSOs with major challenges but also presents new opportunities

- **50%**: Of the generating capacity from intermittent renewable energy sources (wind, solar and hydro run of river) by 2030 (V4)
- **350**: Additional GW of wind and photovoltaic to be connected by 2030 (V4), mostly to distribution grids (in addition to 260 GW existing capacity)
- **20%**: Higher installed intermittent renewable energy sources capacity compared to peak demand
- **5**: Countries likely to have significant RES curtailment risks already in 2025
- **14**: Countries likely to have wind and solar outputs higher than 80% of demand already in 2025
- **-20%**: Reduction of dispatchable capacity margin over peak load (in proportion)
- **150**: Billion euros of transmission investments (of which 70-80 by 2030) to reduce congestion and integrate renewables

1. Manage variability / uncertainty of intermittent renewable energy sources
2. Enable cross-border flows over long distance to take advantage of the variety of generation mix and patterns

Development of the Transmission Networks is a key enabler to cope with these challenges and seize new opportunities
SCENARIOS
SCENARIO BUILDING - FRAMING THE UNCERTAINTY

- What will 2020 and 2030 look like?
- What parameters to consider (demand, technology, policies)?
- How to deal with inherent uncertainties?

The further you look, the more scenarios we need to ensure a robust study framework.

Today 2020 = one scenario 2030 = four visions

<table>
<thead>
<tr>
<th>Delayed towards the 2050 RES objectives</th>
<th>On track towards the 2050 RES objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weaker pan-European framework</td>
<td>Stronger pan-European framework</td>
</tr>
</tbody>
</table>
Steps to Build TYNDP Scenarios

For each Vision: create a storyline based on different parameters

**Economy and Market**
- Economic and financial conditions
- New market designs
- National schemes regarding R&D expenses
- Merit order: primary fuel pricing - carbon pricing

**Demand**
- Energy efficiency developments
- New usages (Heat pumps, Electric vehicles)
- Demand response potential

**Generation**
- RES (wind, solar, RoR, biomass)
- Flexibility of generators
- Back up capacity (nuclear, CCS)
- Decentralized and centralized storage

**Grid**
- Smart grid and the impact on load & generation patterns

Information is gathered through workshops/consultations

Comments of different parties are taken into account
- Stakeholders
- National correspondents
- Regional groups
- Team involved in previous TYNDPs
- …
STEPS TO BUILD TYNDP SCENARIOS

- **Storyline**
  - Reference
  - Assumptions

- **Data collection**
  - Installed generation
  - Demand profile
  - Constraints

- **Checks**
  - Quality
  - Consistency

- **Simulations**
  - Multiple tools in parallel
  - Assess convergence and adequacy

- **Scenario Output**
  - Energy yield
  - Country balances
  - Indicators
  - ...
Vision 1
Slowest Progress

Vision 2
Constrained Progress

Vision 3
National Green Transition

Vision 4
European Green Revolution

2050 Roadmap

European Coordination
<table>
<thead>
<tr>
<th>Economic and financial conditions</th>
<th>Slowest progress</th>
<th>Constrained progress</th>
<th>National green transition</th>
<th>European green revolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least favourable</td>
<td>V1</td>
<td>V2</td>
<td>V3</td>
<td>V4</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Focus of energy policies</th>
<th>National</th>
<th>European</th>
<th>National</th>
<th>European</th>
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<tbody>
<tr>
<td>National</td>
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<tr>
<td>European</td>
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<thead>
<tr>
<th>Focus of R&amp;D</th>
<th>National</th>
<th>European</th>
<th>National</th>
<th>European</th>
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<tbody>
<tr>
<td>National</td>
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<tr>
<td>European</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>CO₂ and primary fuel prices</th>
<th>Low CO₂ price, high fuel price</th>
<th>low CO₂ price, high fuel price</th>
<th>high CO₂ price, low fuel price</th>
<th>high CO₂ price, low fuel price</th>
</tr>
</thead>
</table>

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<thead>
<tr>
<th>RES</th>
<th>Low national RES (&gt;= 2020 target)</th>
<th>Between V1 and V3</th>
<th>High national RES</th>
<th>On track to 2050</th>
</tr>
</thead>
</table>

<p>| Electricity demand              | Increase (stagnation to small growth) | Decrease compared to 2020 (small growth but higher energy efficiency) | stagnation compared to 2020 | Increase (growth demand) |</p>
<table>
<thead>
<tr>
<th></th>
<th>Slowest progress</th>
<th>Constrained progress</th>
<th>National green transition</th>
<th>European green revolution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demand response (and smart grids)</strong></td>
<td>As today</td>
<td>Partially used</td>
<td>Partially used</td>
<td>Fully used</td>
</tr>
<tr>
<td><strong>Electric vehicles</strong></td>
<td>0%</td>
<td>5%</td>
<td>5%</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Heat pumps</strong></td>
<td>0%</td>
<td>5%</td>
<td>5%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Minimum level</td>
<td>Intermediate level</td>
<td>Intermediate level</td>
<td>Maximum level</td>
</tr>
<tr>
<td><strong>Adequacy</strong></td>
<td>1%</td>
<td>5%</td>
<td>5%</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>National - not autonomous limited back-up capacity</td>
<td>European - less back-up capacity than V1</td>
<td>National - autonomous high back-up capacity</td>
<td>European - less back-up capacity than V3</td>
</tr>
<tr>
<td><strong>Merit order</strong></td>
<td>Coal before gas</td>
<td>Coal before gas</td>
<td>Gas before coal</td>
<td>Gas before coal</td>
</tr>
<tr>
<td><strong>Storage</strong></td>
<td>As planned today</td>
<td>As planned today</td>
<td>Decentralized</td>
<td>Centralized</td>
</tr>
</tbody>
</table>
2030 Vision Characteristics

- **Vision 1**: Slowest Progress
- **Vision 2**: Constrained Progress
- **Vision 3**: National Green Transition
- **Vision 4**: European Green Revolution

*Notes on diagram:* Economic Conditions, Storage push and concentration, Carbon reduction strength, European dimension of adequacy assessment, Take-up of EVs, HPs, DSR, Electrical demand, European focus of energy policy and R&D efforts, RES-e ambitions.
A WIDE RANGE OF PLAUSIBLE FUTURES: % RES & CO₂ REDUCTION

All 2030 Visions matching the EU renewables targets for the electricity system.
(V1 & V2 compared to V3 & V4 show a strong differentiation in spatial distribution of generation)
A wide range of plausible futures: production by source

Annual generation in each scenario – breakdown per technology

EP = Expected Progress scenario
A WIDE RANGE OF PLAUSIBLE FUTURES: EXPORT / IMPORT

Vision 1
Vision 2
Vision 3
Vision 4

LEGEND

Exporter
Importer
EXAMPLES OF OUTPUTS (I): INSTALLED CAPACITIES

Installed capacities EP 2020

Installed capacities 2030 vision 4
EXAMPLES OF OUTPUTS (II) : ANNUAL GENERATION
EXAMPLES OF OUTPUTS (III) – DEMAND & WIND / PV

Demand across all scenarios

Wind/PV across all scenarios

- Vision 4
- Vision 3
- Vision 2
- Vision 1
- EP2020
- 2014

Installed capacities (GW)
EXAMPLES OF OUTPUTS (IV): PV CAPACITY BY COUNTRY

PV re-allocation from Vision 3 to Vision 4
DEVELOPING THE NETWORKS
BENEFITS & TARGET TRANSFER CAPACITIES
BENEFITS OF TYNDP INVESTMENTS FOR EUROPEAN MARKET INTEGRATION

Average price spread at each border in Vision 3

Without TYNDP 2016 investments

With TYNDP investments
### INVESTMENT NEEDS AND MAIN BOUNDARIES AND BARRIERS

<table>
<thead>
<tr>
<th>Boundaries</th>
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<tbody>
<tr>
<td>Ireland - Great-Britain</td>
</tr>
<tr>
<td>Norway and continent- Great-Britain</td>
</tr>
<tr>
<td>Nordic - mainland, West</td>
</tr>
<tr>
<td>Nordic - mainland, East</td>
</tr>
<tr>
<td>Baltic states integration</td>
</tr>
<tr>
<td>Central East integration</td>
</tr>
<tr>
<td>Iberian peninsula integration</td>
</tr>
<tr>
<td>Italian peninsula integration</td>
</tr>
<tr>
<td>South-East integration</td>
</tr>
<tr>
<td>Eastern Balkan border</td>
</tr>
</tbody>
</table>
2030 Targets for Interconnection Capacities

Legend
- <1000 MW
- 1000 - 2500 MW
- 2500 - 4500 MW
- 4500 - 7000 MW
- 7000 - 10000 MW
- 10000 - 13500 MW
- >13500 MW
DIFFERENT TECHNICAL SOLUTIONS
A RESILIENT PORTFOLIO OF TAILOR-MADE INVESTMENT SOLUTIONS
A RESILIENT PORTFOLIO OF TAILOR-MADE INVESTMENT SOLUTIONS
## TYNDP Portfolio: Overview of Main Elements

<table>
<thead>
<tr>
<th>Type</th>
<th>Total</th>
<th>New compared to TYNDP 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead Line</td>
<td>248</td>
<td>159</td>
</tr>
<tr>
<td>Underground Cable</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Subsea Cable</td>
<td>49</td>
<td>45</td>
</tr>
<tr>
<td>Phase Shift Transformer</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Substation (incl. converters)</td>
<td>57</td>
<td>33</td>
</tr>
</tbody>
</table>
THE BOUNDARIES

Increasing Socio Economic Welfare (SEW)
SYSTEM NEEDS IDENTIFICATION: PAN-EUROPEAN REPORT AND REGIONAL INVESTMENT PLANS
GB – CONTINENTAL EUROPE AND NORDICS

Socio-economic welfare gains through added capacity in each scenario
Socio-economic welfare gains through added capacity in each scenario
Socio-economic welfare gains through added capacity in each scenario (Baltics- continent)
Socio-economic welfare gains through added capacity in each scenario
Socio-economic welfare gains through added capacity in each scenario
Socio-economic welfare gains through added capacity in each scenario
SOUTH EAST INTEGRATION

Socio-economic welfare gains through added capacity in each scenario
Socio-economic welfare gains through added capacity in each scenario
CONCLUDING REMARKS
TYNDP PROJECTS – EUROPE NEEDS THEM BUILT

2x more interconnection capacities by 2030
Integrating up to 60% renewable energy sources
Up to 5 €/MegaWatt hour reduction on bulk power prices

1% increase in the total consumer bill
€150 billion investment
Proper return for investors
Gain support from local communities
Development of transmission capacity is one major corner stone to successful integration of RES.

ENTSO-E manages at European level the process for this, called TYNDP. It is run biannually.

TYNDP (delivering the wires to trade) and Network Codes (delivering the rules for connections, for SO & for Markets) together facilitate means of coping with high RES capacity and variability.

TYNDP process aims to deliver Socio Economic Welfare for the citizens of Europe.
ADDITIONAL MATERIAL
MONITORING PROGRESS - 2014 TO 2016
BUILDING THE GRID FOR THE ENERGY TRANSITION
EVERYONE'S BUSINESS

Involve local citizens more and early on

Need support from policymakers on all levels

Stable rules & improved process for the review of Projects of Common Interest (PCIs)

Monitoring of the TYNDP 2014 projects

- Cancelled
- Delayed
- Progress as planned
- Progress ahead of time
- Commissioned
- Commissioned ahead of time
- Rescheduled
ADDITIONAL GRID TRANSFER CAPACITY IN THE TYNDP: CURRENT STATUS
ADDITIONAL GRID TRANSFER CAPACITY: PROGRESS BETWEEN TYNDPs 2014 AND 2016
INFORMING CITIZENS ABOUT THE IMPACT OF THE TYNDP

Length breakdown of projects in sensitive areas:
- Environmetally protected areas:
  - <than 15km: 20%
  - 15-25km: 11%
  - 25-50km: 13%
  - >50km: 56%

- Dense urban areas:
  - <than 15km: 2%
  - 15-25km: 8%
  - 25-50km: 4%
  - >50km: 86%
ASSESSING PROJECTS
ASSESSMENT OF INDIVIDUAL PROJECTS

Indicators
Multi-criteria approach
Some criteria scenario-specific
Coordinated ENTSO-E study
Specific tailoring for storage projects
Based on scenario/project data available on ENTSO-E website

Approach
Put one IN at a Time
Take One Out at a Time
ASSESSMENT OF INDIVIDUAL PROJECTS

• Reflect maturity of projects
• Assess at two time horizons
→ Classify projects & define reference capacities

Mid-term project
Long-term project
Future project

Planned
Commissioning <= 2022
Planned
Commissioning <= 2030
Others

Boundary capacity

- Expected/planned development of the grid
- Parameter for market modelling tools
- Confirmed by network studies
- Possibly different values in either direction
TYNDP 2018: ALREADY ON THE WAY

TYNDP principle timeline

- Even year
  - Scenarios
  - MAF
  - Pan Eur. needs
  - Regional needs
  - Window for TYNDP project submission

- Odd year
  - MAF
  - Scenarios
  - CBA

- Even year
  - NDP

- Odd
  - NDP

Publication for consultation
Publication
Window for TYNDP project submission
TYNDP 2018: ALREADY ON THE WAY

TYNDP 2018 main deliverables:
- Communication plan
- Scenario report
- Scenario data set
- Pan-European needs report
- Regional Investment Plan
- Monitoring update report
- Project list
- Cost Benefits Analysis report
- Market and network datasets
CBA 2.0 – MAIN CHANGES IN INDICATORS

- Costs
- Env/social impact
- Project assessment
  - Socio-economic welfare
  - 3*20
    - CO2 variation
    - RES integration
    - Losses
  - Security of supply
    - Adequacy
    - System stability