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e-HIGHWAY 2050: METHODOLOGY OF DATA CONTEXTUALIZATION FOR THE PURPOSE OF SCENARIO BUILDING

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Summary: The e-Highway 2050 project is supported by the EU Seventh Framework Programme and is aimed at developing a methodology to support the planning of the Pan-European Transmission Network, focusing on year 2050, to ensure the reliable delivery of renewable electricity and pan-European market integration. One of the tasks of the project is assessing a scenario building approach that has been defined to characterize five scenarios covering the time period 2020–2050. A key question for the downstream simulations to be performed is how to adjust the typical range of technology data according to the five selected scenarios. To that purpose an approach is proposed called data contextualization that aims to allocate, for a given technology, typical values to key variables descriptive of this technology, at the 2050 time horizon for each of the considered scenarios.

Keywords: long-term grid and generation development, future scenarios, data contextualization

1. CONTEXT AND OBJECTIVES OF THE e-HIGHWAY 2050 PROJECT

The rapid expansion of renewable electricity sources and demand-side management technologies is going to change the way transmission systems are designed and operated. Electricity should be transported over longer distances, across national borders, in order to connect renewable resources located far from the main European consumption areas. Active demand response services might also be controlled over large geographical areas, therefore involving many stakeholders under different regulatory regimes. A pan-European infrastructure is thus required to enable more power and data exchanges between the different stakeholders of the power system, in order to comply with these new constraints including the progressive construction of a single European electricity market. This requirement for the development of a pan-European transmission network is addressed by the e-Highway 2050 project supported by the European Commission (DG Research).

The main objective of the project is the development of a methodology to support the planning of the pan-European transmission network up to 2050. This planning approach must be in line with the European energy policy objectives to ensure the reliable delivery of renewable electricity and the pan-European electricity market integration; it consists in a modular development plan involving different pan-European grid architectures, to cope with five of the future power system scenarios which impact the pan-European transmission network most. Its construction involves a consortium of transmission system operators, research institutes, universities, industry associations and a non-governmental organization in order to provide the final results by the end of 2015.

2. GENERAL DESCRIPTION OF THE PLANNING METHODOLOGY

The newly developed top-down methodology is built around four main steps, within which stakeholders from all over Europe are invited to discuss assumptions, intermediate and final results during external workshops and consultations:

- the description of possible assumptions from 2020 to 2050 involving technology, socio-environmental and political boundary conditions,
- the building of energy scenarios involving the foreseen generation and demand profiles, while taking into account storage, demand-side management and transmission technologies available by 2050,
- the grid and market simulations to find optimized grid architectures, which help matching electricity production with demand profiles at European level,
- the proposal of modular development plans of the pan-European transmission system, covering each of the studied scenarios, and optimized by taking into account social welfare, environmental constraints, as well as grid operations and governance issues.

In parallel, the possibility to mathematically formalize such long-term planning methods is investigated using enhanced optimization and advanced simulation tools.

3. TECHNOLOGY PORTFOLIO DATABASE

Technical and economic data on technologies are a critical building block of the e-Highway 2050 modular development plan. WP3, provides a cost and performance database used for the selection of candidate power system technologies at the 2050 time horizon. It also provides the typical technical and economic data used by all numerical simulations performed to detail the selected grid architectures for each of the five e-Highway 2050 scenarios. A portfolio of technologies (generation, storage, transmission, demand) has been selected according to their impact on transmission networks with regard to planning issues by 2050. A dedicated approach has been developed to identify the demand-side technologies of major impact for the electricity demand at 2050 (i.e. electric vehicles, heat pumps and LED/OLED – light-emitting diode/organic light – emitting diode – technologies).

The database is organized per technology (and sub-technology when relevant, i.e. offshore and onshore for wind power for generation).The different technologies are listed hereafter:

- generation and storage technologies,
- demand-side technologies (e.g. electric vehicles),
- passive transmission technologies (e.g. overhead AC lines),
- active transmission technologies (e.g. FACTS).

4. KEY FEATURES OF THE DATABASE CONSTRUCTION PROCESS

The construction process of the data base has involved key stakeholders of the electricity value chain (manufacturers, TSOs, academia) and available scientific and technical literature. Data collection, modelling and calculations have been mainly provided by professional associations per domain of expertise.

Data validation has been ensured by the e-Highway 2050 consortium members (via a Quality Pool and internal workshops) and by external stakeholders via a dedicated workshop.

Apart from the data collection process, two major difficulties have been addressed:

uncertainties and contextualization.

- Uncertainties refer to the intervals of confidence of the values for given variables. The increasing uncertainty over time has been a major difficulty when assessing numerical values for several data types such as costs or technical performances.
- Contextualization refers to the different values that might be taken by a variable depending on the e-Highway 2050 scenario. For example, in a scenario with 100% penetration of large scale renewables in 2050, one can expect that the investment costs for wind power would be lower than the investments costs for wind power in a scenario where renewables reach a lower penetration and the thermal electricity generation is roughly at the same level as today.

Contextualization tries to answer the key question for the downstream simulations to be performed, How to adjust the typical range of technology data according to the five selected scenarios?

5. DATA CONTEXTUALIZATION

Data contextualization aims to allocate, for a given technology, typical values to key variables descriptive of this technology, at the 2050 time horizon, for each of the considered scenarios.

The contextualization process will be described using the example of data regarding CHP technology.

The diagram shown in Figure 1 presents the step by step approach designed and adopted in order to obtain contextualized data.

The input data for the process are data sheets containing range of values of different parameters (variables) describing CHP technology and selected future scenarios described by differing uncertainties and strategy options, which are the result of works of WP1 of e-Highway 2050 project, in which the Institute of Power Engineering also took part.

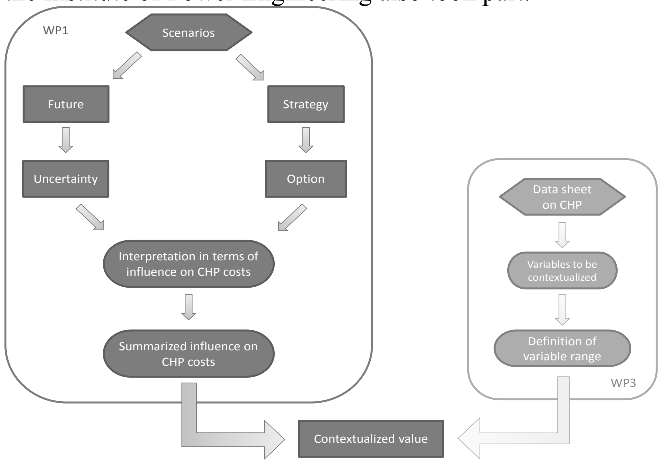

Figure 1 Overview of the contextualization process

The first stage of the contextualization process was to determine the degree of influence of individual factors (uncertainties and options) on selected variables. Only the variables regarding investment and O&M (total) costs were contextualized, as other parameters cannot be reliably contextualized.

The impact of individual factors has been assessed as one of the following values:

- ++ (major impact),
- + (minor impact),
- − (negligible or no impact).

An example of the assessed influence of selected impact factors (future uncertainties) on the projected level of costs for waste-to-energy CHP is presented in Table 1.

Table 1 Impact of factors on costs: waste to energy CHP

Future: Uncertainty	Impact on:	
	Investment costs	O&M costs
International Climate Agreement	+	−
Dependency on fossil fuels from outside Europe	+	−
Fuel costs	++	−
CO2 costs	+	++
Electrification in transport, heating, industry	++	−
Demographic change	+	−

Each of the selected scenario parameter (future uncertainty or strategy option) has then been analyzed in order to determine its impact on potential incentive to develop a given technology and its investment and O&M costs. It has been assumed that a greater incentive to develop a given technology (and hence a potentially larger penetration of this technology) will result in lowering the overall investment costs and vice versa. Based on the impact of each parameter's value, a final assessment of the projected level of both types of costs was assigned to each scenario and each technology category, cf.

Table 2 showing a continued example for waste-to-energy CHP (in some cases future uncertainties are the same for multiple scenarios and therefore have the same impact on the projected level of costs).

Table 2 Contextualization of cost variables – waste to energy CHP

Scenario	**X5** Large scale RES & no emissions	**X7** 100% RES	**X10** Big & Market	**X13** Large fossil fuel with CCS & Nuc	**X16** Small and local
Future					
International Climate Agreement	EU alone: prices relatively stable		Global agreement: no available cheaper installations from outside EU, demand exceeding supply leading to higher prices		EU alone: prices relatively stable
Dependency on fossil fuels from outside Europe	Low: low incentive to build waste CHP		Medium: higher incentive to build waste CHP		Medium: higher incentive to build waste CHP
Fuel costs	High: Very high incentive for new waste CHP		Low: low incentive to build waste CHP		High: Very high incentive for new waste CHP
CO2 costs	High: leads to increasing O&M costs		High: leads to increasing O&M costs		Low: no significant change
CCS maturity	No: higher prices of CCS installations		Yes: lower prices of CCS installations		No: higher prices of CCS installations
Electrification in heating	All: very low incentive to build waste CHP		Large scale (commercial etc.): no significant change		Residential: low incentive to build waste CHP
Demographic change	Growth: more demand for heat		Growth: more demand for heat		Migration only: no significant change
Public perceptions to shale gas	Negative: other fuels (e.g. waste) necessary		Positive: available gas will lower the incentive for other technologies		Negative: other fuels (e.g. waste) necessary
Shift towards greener behaviours	Major: lack of public support for waste CHP		Minor: no significant change		Major: lack of public support for waste CHP
Strategy					
Deployment of de-centralized RES	Low	High	Medium	Low	High
Increase of energy efficiency (include DSM and flexibility)	Low: higher O&M costs due to frequent need of regulation	High: lower O&M costs due to low need of regulation	Medium: no significant impact	Low: higher O&M costs due to frequent need of regulation	High: lower O&M costs due to low need of regulation
Increase of funds and better coordination of RDD activities (at EU level)	High: technology may become cheaper	High: technology may become cheaper	Medium: prices at medium level	Medium: prices at medium level	Low: higher technology prices
Permitting framework (including EU nature legislation)	Convergent and strong framework: lowering investment costs	Convergent and strong framework: lowering investment costs	Convergent and strong framework: lowering investment costs	Heterogeneous framework at EU level: possibly higher investment costs	Heterogeneous framework at EU level: possibly higher investment costs
Resulting scenario for costs					
Investment	**medium**	**low**	**high**	**high**	**medium**
O&M	**high**	**medium**	**high**	**high**	**medium**

Finally, the values of selected variables have been allocated to individual scenarios and technologies. The allocation has been performed based on assessment of final marks to adequate technology groups in a given scenario and the range of values for the selected variable as determined in the data sheets. The values for three defined levels of final marks for selected variables have been defined as follows:

- In case a range of values is available for a given variable in the data sheet, the low end value of the range is assigned to the "low" final mark, the high end value of the range is attached to the "high" final mark, while the "medium" final mark is attached an arithmetical mean of low and high end values of the range.

- In case only a single value of the variable is available, it is assumed to correspond to the "medium" final mark. The values for "low" and "high" final marks are then calculated using the assumption that they differ respectively by −12,5% and +12,5% from the available "medium" value – an arbitrary approach based on values of variables for which a range of values is available.

6. CONCLUSIONS

The presented contextualization process designed and performed by the Institute of Power Engineering assists building models corresponding to future scenarios predefined by other work packages of e-Highway 2050 project by enabling a more accurate reflection of the possible and probable characteristics of individual technologies. This in turn helps support the long-term planning of the pan-European transmission network up to 2050, which is the main objective of the project.

7. LITERATURE

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e-HIGHWAY 2050: METODA KONTEKSTUALIZACJI DANYCH NA POTRZEBY BUDOWY SCENARIUSZY

Projekt e-Highway 2050 jest wykonywany przez międzynarodowe konsorcjum uczelni, jednostek badawczych oraz przedstawicieli przemysłu w ramach 7 Programu Ramowego Unii Europejskiej. Jego celem jest opracowanie metodyki wspierającej planowanie rozwoju paneuropejskiego systemu elektroenergetycznego w długim horyzoncie czasowym (rok 2050) w celu zapewnienia niezawodnej transmisji i dystrybucji energii elektrycznej z odnawialnych źródeł energii oraz wspierania integracji europejskiego rynku energii. Jednym z zadań projektu jest wypracowanie spójnego podejścia do budowy modeli odpowiadających scenariuszom rozwoju sieci w okresie lat 2020–2050. Ważnym pytaniem w kontekście procesu budowy tych modeli jest zdefiniowanie typowego zakresu wartości kluczowych parametrów opisujących charakter poszczególnych rodzajów generacji w zależności od konkretnego scenariusza. W tym celu opracowana została autorska metoda kontekstualizacji danych, która ma na celu przyporządkowanie odpowiednich wartości poszczególnym parametrom dla każdego rozpatrywanego scenariusza w horyzoncie 2020–2050.

Słowa kluczowe: długoterminowy rozwój sieci i generacji, scenariusze rozwoju, kontekstualizacja danych