e-Highway 2050

Modular Development Plan of the pan-European Transmission System for 2050

e-Highway2050 results on scenarios setup and quantification:

- Challenging energy scenarios for the pan-European transmission system by 2050
- Decomposition of Europe in 96 clusters
- Related methodologies for long-term energy scenario building and their quantification

Challenging energy scenarios at 2050

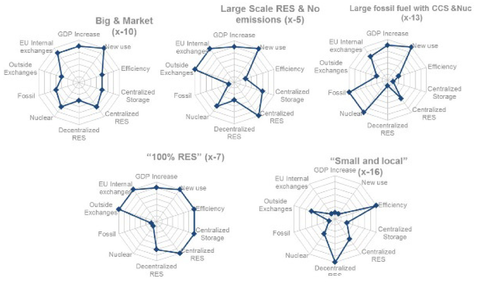
- A Scenario is a combination of a Strategy (endogeneous options: upon which decision makers have control) used within a Future (exogeneous uncertainties: upon which decision makers have no control)
- Scenario setup results from 5 futures and 6 strategies, i.e. 30 possible scenarios

	Strategies	Strategy 1	Strategy 2	Strategy 3	Strategy 4	Strategy 5	Strategy 6
Futures		MARKET LED	LARGE SCALE RES SOLUTIONS	LOCAL SOLUTIONS	100% RES	NUCLEAR & CCS	WITHOUT NUCLEAR
Future 1	Green Globe	X	X-1	X-2	X-3	X	X-4
Future 2	Green EU	X	X5 Large scale RES	X-6	X7 100% RES +E	X	X
Future 3	EU+ Market	X-8	X	X-9	X	X	X
Future 4	Big is beautiful	X10 Big and market	X	X	X-12	X13 Large Small Mix	X-14
Future 5	Small things matter	X	X-15	X	X-16 Small and local	X-17	X

- Each scenario must be challenging for the power system at 2050

Selected scenarios at 2050

- Two-step filtering process: from 30 to 5 challenging scenarios.
- Step 1: spurious scenarios
  - ⇨ NUC and CCS: futures (public perception) and strategies (foreseen deployment) are contradictory for nuclear and CCS.
  - ⇨ No Policy: futures (market driven) and strategies (strong policy framework) are contradictory.
  - ⇨ Non-logical: contradictory futures and strategies (simultaneous development of renewables and storage at small and large scales).
- Step 2: selection of the 5 most challenging scenarios according to 10 parameters measuring their impact on the power system

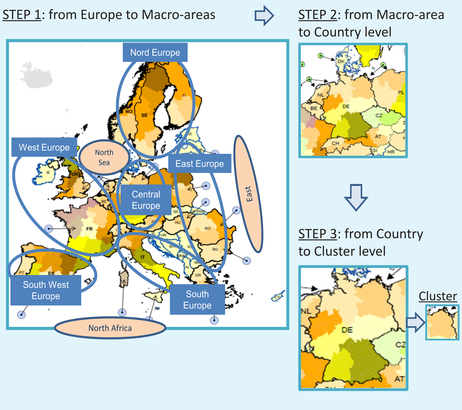


Decomposition of Europe into 96 clusters

- Two-step approach (clusters must not be too small, be based on unified standards and grid characteristics, be scenario independent)
  - ⇨ Step 1: clustering algorithm aggregating smaller areas with a K means function (with weighting functions on specific criteria such as population, potential of RES generation, land use, thermal generation capacity, etc.).
  - ⇨ Step 2: expert view of TSOs (sanity check).

Scenarios quantification methodology

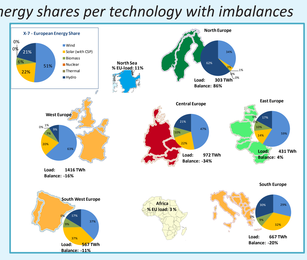
- A **top-down** approach built around 3 steps has been developed to quantify the five scenarios in terms of installed capacities for each cluster with a copper plate assumption
  - ⇨ Initialization: compute energy target per generation technology from demand at European level
  - ⇨ Step 1: installed capacities in each macro-area (9 macro-areas)
  - ⇨ Step 2: installed capacities in each country (33 countries)
  - ⇨ Step 3: installed capacities for each cluster (96 clusters)



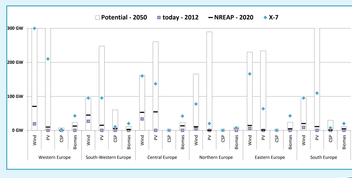
Example: 100% RES electricity scenario

- Step 1 : macro-area level
  - ⇨ Computation of energy shares (per technology) and imbalances for each macro-area (based upon weighting functions). Preliminary allocation of the corresponding generation capacities
  - ⇨ Final allocation of the generation capacities (per technology) based upon ANTARES runs (simulation of system adequacy during one year at a time resolution of one hour using a market simulator)
  - ⇨ Control of energy imbalances (coherency with scenario)
- Step 2: country-level
  - ⇨ Use results from step 1 with same algorithm at country level
  - ⇨ Additional constraints: NREAP for 2020 for each country
- Step 3: cluster level
  - ⇨ Use results from step 2 with same algorithm at cluster level
  - ⇨ Additional constraints: urban areas and natural reserves
- Results for step 3:

Energy shares per technology with imbalances



Final allocation of generation capacities per technology



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