Overview of interim results and challenges

Workshop “Enhanced pan-European Transmission Planning Methodology”
May 28th & 29th, 2015

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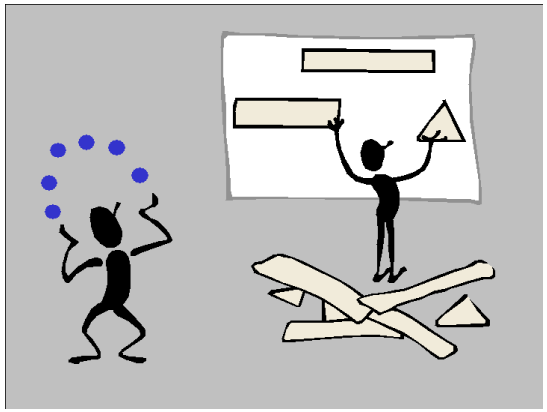
Objective of *Enhanced* pan-European *Transmission Planning Methodology*

- Definition of a new methodology and specification of new tools ≠ Not a grid planning study



✓ Scientific correctness and practical relevance

✓ Practical relevance checked using realistic data but not necessarily actual data

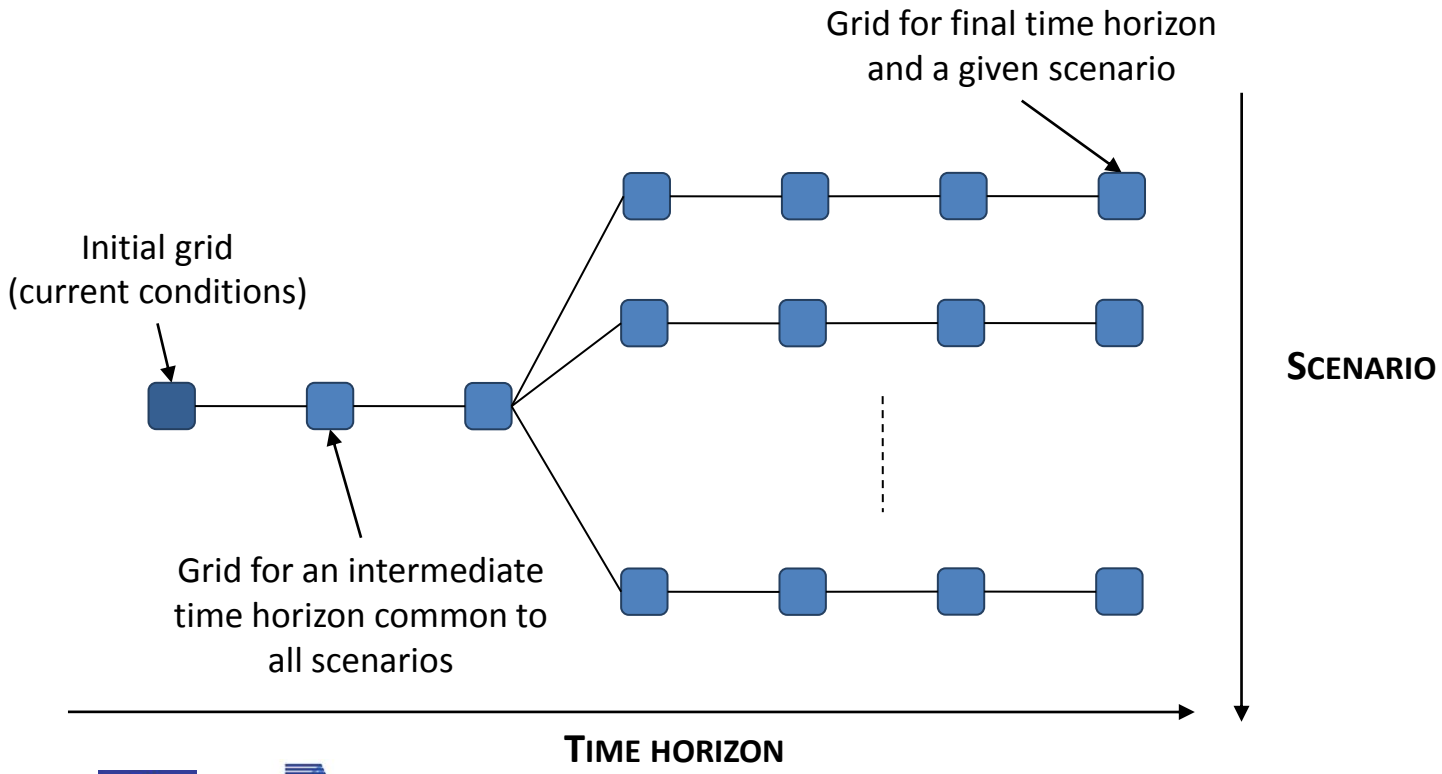
✓Requirements of computational power (HPC)

Outline

- High-level problem statement
- State of the art and challenges
- Proposed methodology
- Conclusion & Discussion

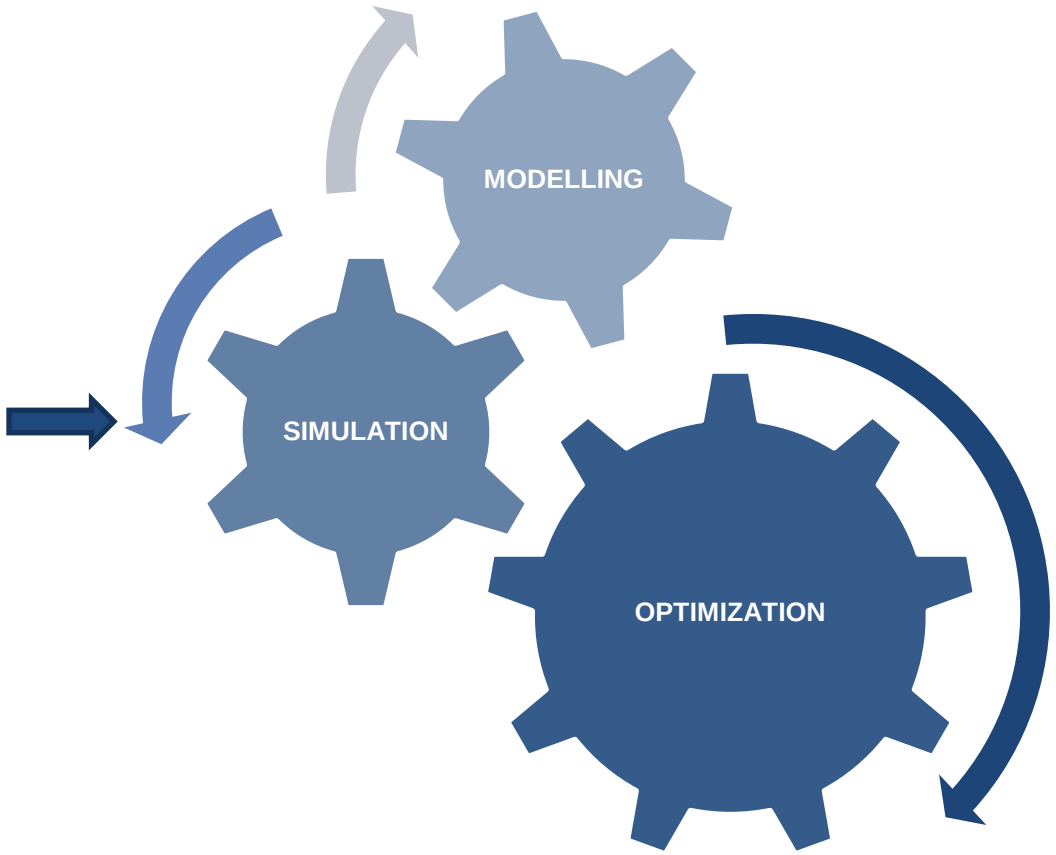
High-level problem statement:

- an optimal design of a very large grid including its modular development plan over a very long time horizon
  - ✓ minimizing grid Capex and Opex
  - ✓ without control on generation planning (defined by scenarios)



Sequence of well defined problems

- Assumptions: scenarios
- Computational engines
- Enhanced modular grid long term planning



Enhanced?
Formulation as an “optimization” problem

- The current practices for grid expansion planning are based on simulation tools and expert knowledge to find the “optimal” solution.

- Generally for a single time horizon and a single scenario.

✓ The modular development plan over a very long time horizon with multiple future scenarios?

- Most of the time at the national/state level with boundary conditions

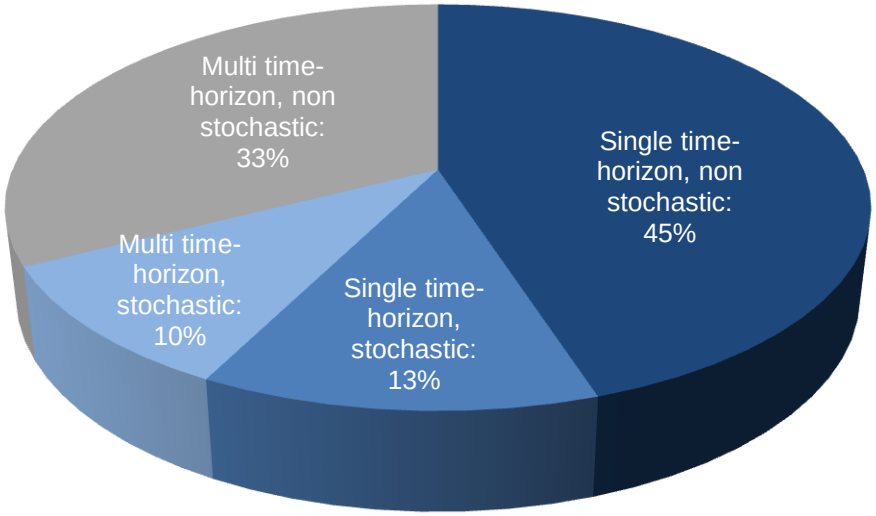
- The modelling of stochastic factors impacting the electrical system is generally very simple: selection of “typical” snapshots by the experts.

✓ Load: peak and off-peak but now with massive integration of wind and solar power?

➔ Complexity is increasing, need for more advanced tools to help the planners

State of the art *(academic)*

Survey of papers from IEEE Transactions on Power Systems and IEEE Transactions on Power Delivery from 2003 to 2013 and title with “transmission planning”, “expansion planning” or “transmission expansion” ➔ 41 papers



100 % deal with **single-scenario methodologies**.

78% do **not** consider **stochastic behaviour of system components**.

58% with **single time-horizon methodologies**.

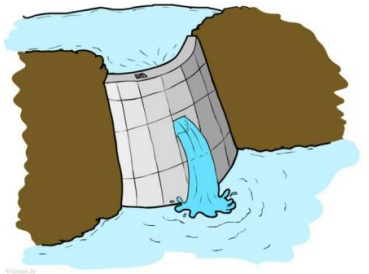
Paper closest to the proposed high level problem statement :

Diego Mejia-Giraldo and James McCalley, *“Maximizing Future Flexibility in Electric Generation portfolios”*, IEEE transactions on Power Systems, September 2013

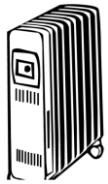
Challenges:

Spatial complexity: *Europe to smart cities*

Temporal complexity: *msec. to decades*



Stochastic complexity: *weather conditions and human behaviors*



Approximations ➔ “well defined” trade-offs between realism and practical possible implementation

- Impossible to tackle together the 3 complexities even using High Performance Computers (10000 cores during 20 hours)

➔ *Approximations are mandatory*

➢ System adequacy without grid: all time horizons, all scenarios, probabilistic approach

✓ *No spatial dimension* ➔ *Reduction of the spatial complexity*

➢ Zonal expansion planning: all time horizons, all scenarios

✓ *Zones and candidate selection* ➔ *Reduction of spatial complexity*

✓ *Selection of snapshots* ➔ *Reduction of stochastic and temporal complexity*

➢ Nodal expansion planning: only for 2 first time horizons

✓ *Selection of snapshots* ➔ *Reduction of stochastic and temporal complexity*

➢ Robustness Assessment: only for 2 first time horizons and dedicated phenomena

Overview of the proposed methodology

ALL TIME HORIZONS AND SCENARIOS

STEP 1 – ADEQUACY WITHOUT GRID

STEP 2 – DETECTION OF OVERLOAD PROBLEMS

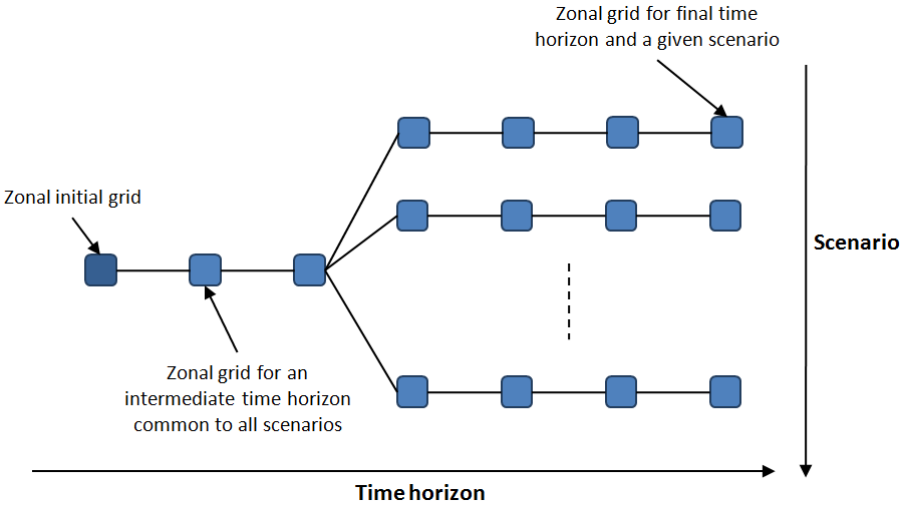
STEP 3 – NETWORK REDUCTION ACCORDING TO CRITICAL BRANCHES (≈100 NODES)

STEP 4 – OPTIMAL GRID EXPANSION AT ZONAL LEVEL FROM TODAY TO 2050

FIRST TWO TIME HORIZONS

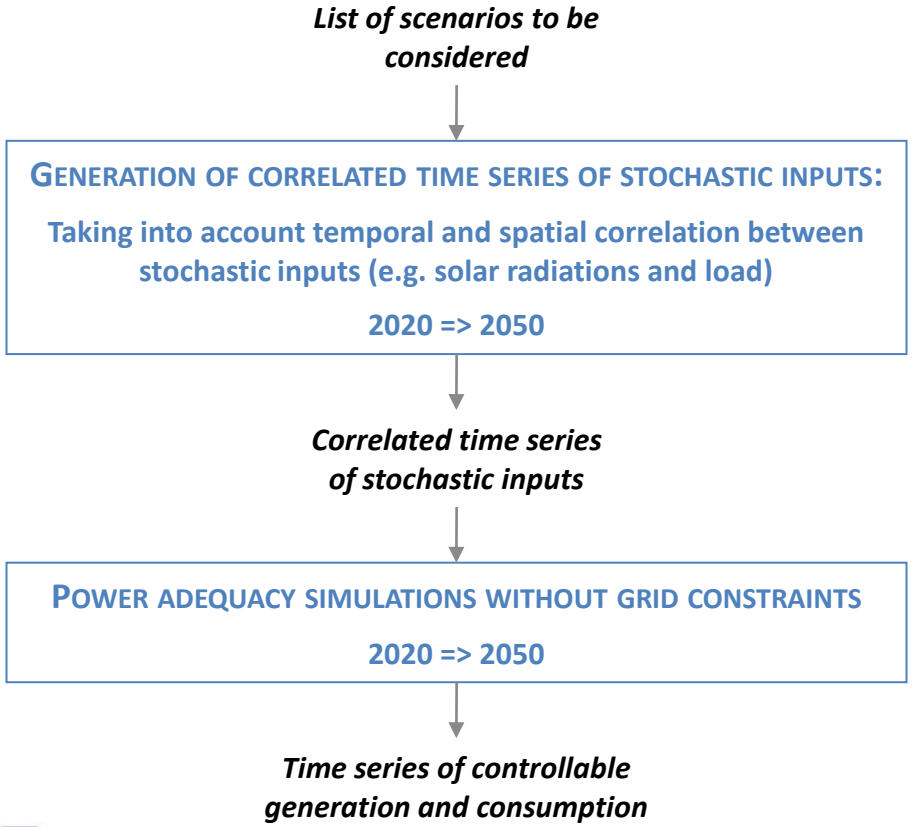
STEP 5 – GRID EXPANSION AT NODAL LEVEL

STEP 6 – ROBUSTNESS OF THE PROPOSED GRID ARCHITECTURES



Adequacy without grid

Objective: to compute the **hourly dispatch of controllable and consumption** and thus to calculate **time series of power injection** in each location of the system



Detection of overload problems and assessment of congestions' severity

2020 grid (10 000 buses)

REDUCTION OF THE INITIAL NETWORK

Simplified nodal grid (1 000 buses)

AUTOMATIC MAPPING OF GENERATION AND CONSUMPTION ON BUSES

Simplified nodal grid with generation and consumption

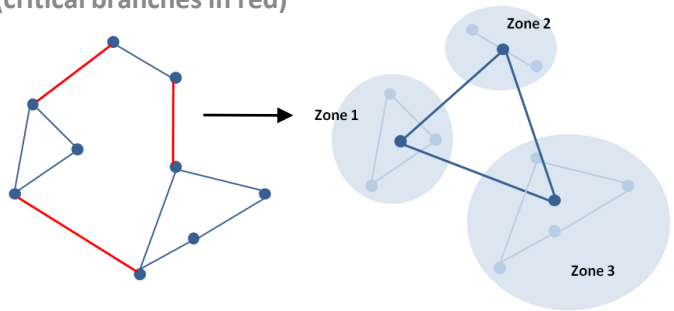
DETECTION OF OVERLOAD PROBLEMS

List of critical branches

REDUCTION OF THE NODAL INITIAL GRID ACCORDING TO CRITICAL BRANCHES

Simplified nodal initial grid (critical branches in red)

Zonal initial grid



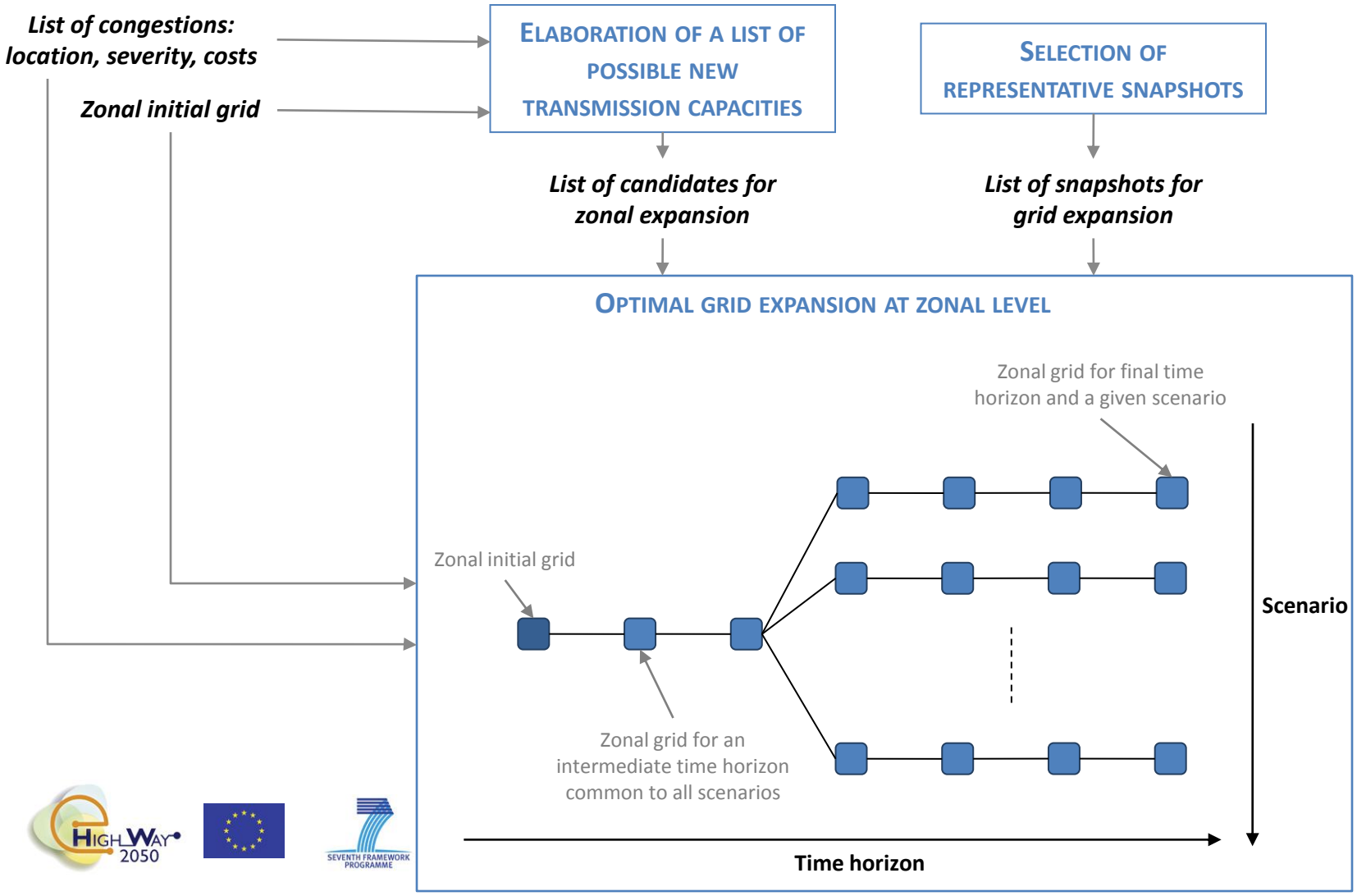
Zonal initial grid

ASSESSMENT OF CONGESTIONS' SEVERITIES AND ASSOCIATED COSTS

List of congestions: location, severity, costs

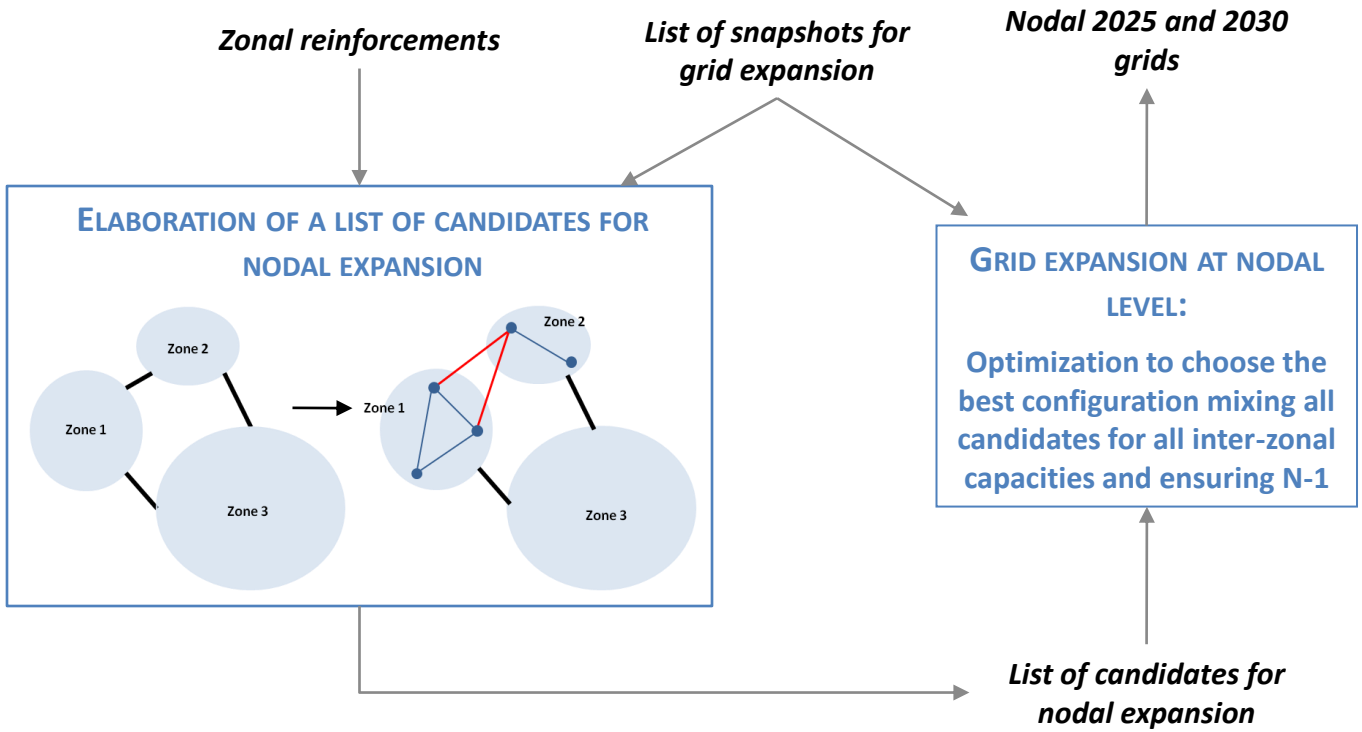
Optimal grid expansion at zonal level

Objective: find **a modular development plan minimizing capex and opex**



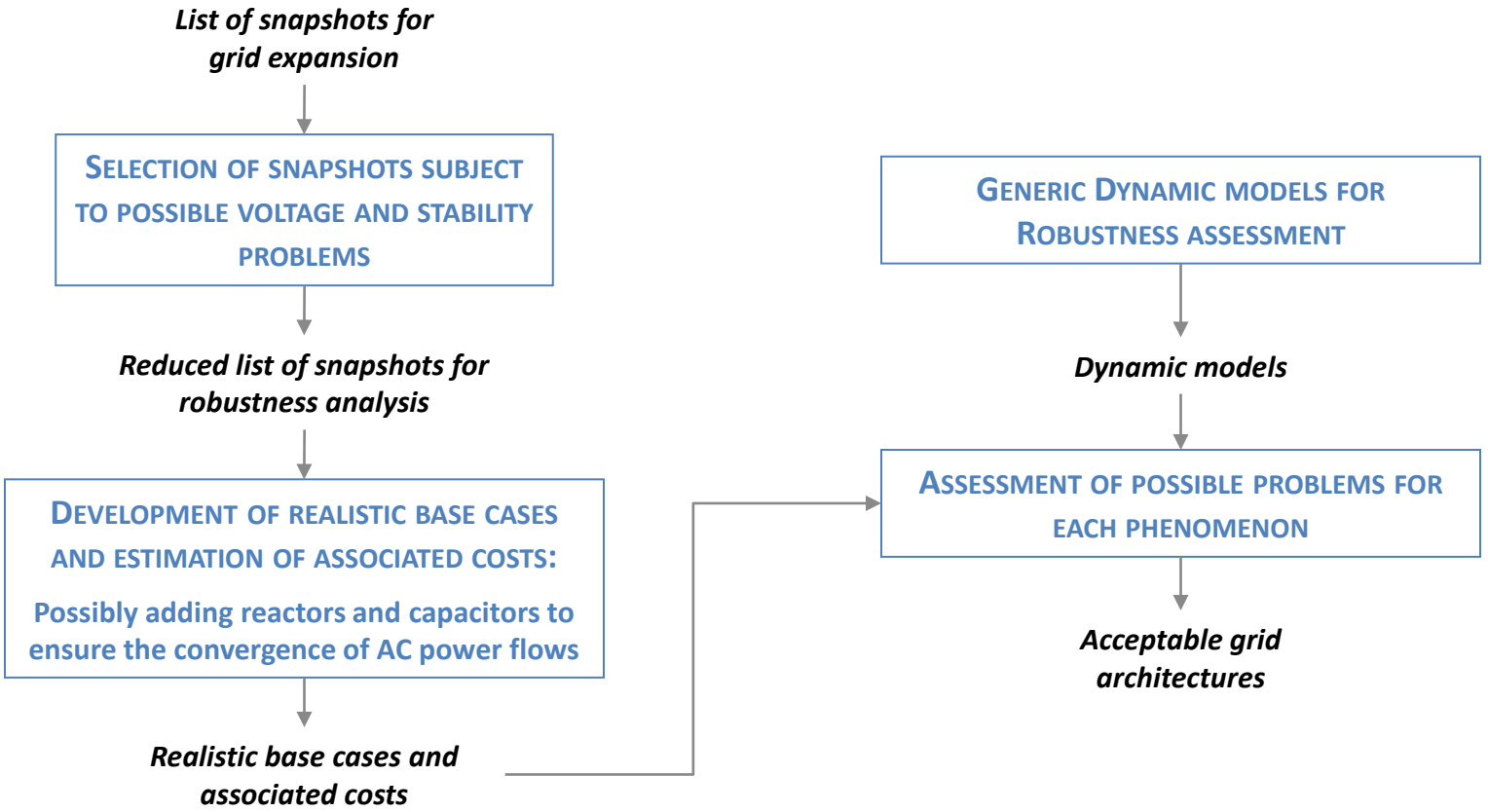
Grid expansion at nodal level

Objective: define **precise nodal grid expansions** for **2025 and 2030** ensuring **system reliability** (N-1)



Robustness of the proposed grid architectures

Objective: check that proposed grid architectures could be operated **without major voltage and stability issues**



Conclusion: in the following presentations

- Formulation of the planning expansion problem as an *optimization problem*, while the state of the art is based on expert knowledge and simulation tools

- Very complex problem which requires a large amount of computational power, taking advantage of high performance computing (many cores,..) is not sufficient. *Formal approximations are required* to find a right balance between computation time and optimality