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Flexibility needs at system level and how RD&I projects are leveraging these solutions

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ISGAN Academy webinar #24

Recorded webinars available at: https://www.iea-isgan.org/our-work/annex-8/

FlexPlan **Project**

(all other portions of the presentation are omitted)

Why «grid flexibility» is needed

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ENERGY TRANSITION
(ambitious targets on: decarbonization, energy efficiency)

- Massive RES deployment
- Decommissioning of conventional power plants
- Development of DER in distribution (becoming an active grid)
- Smart Grids, empowerment of customer, local communities

CONSEQUENCES

- More need of ancillary services (also innovative: artificial inertia, fast freq. services)
- Need of TSO-DSO coordination
- Reform of energy markets
  - coupling of RT markets, extension to distribution,
  - adaptation of algorithms to a RES quota near to 100%
  - Development of capacity markets
  - Development of retail markets
- Reforming grid planning in order to cope with variable flows due to RES

Regulatory process coordinated by EC and NRA is needed to foster a best fitting pattern and avoid un-harmonized developments in the Member States

SmartNet and FlexPlan: two synergic H2020 projects

SmartNet

- **Start date: 01.01.2016**
- **End date: 30.06.2019**

… compares five different TSO-DSO operative interaction schemes and different real-time market architectures with the aim of finding out which one could deliver the best compromise between costs and benefits for the system.

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- **Start date: 01.10.2019**
- **End date: 30.09.2022**

… aims at establishing a new grid planning methodology considering the opportunity to introduce new storage and flexibility resources in electricity transmission and distribution grids as an alternative to building new grid elements.

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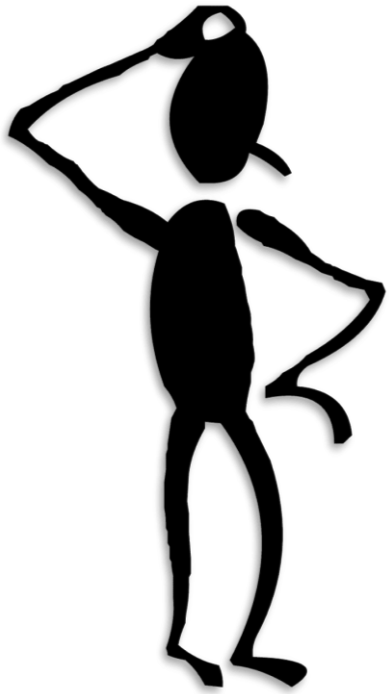
Why FlexPlan?



- High-speed deployment of RES (challenging European target: 32% at 2030) is making T&D planning more and more complex and affected by a high level of uncertainty
- Grid investments are capital intensive and the lifetime of transmission infrastructure spans several decades: when a new line is commissioned it might be already partially regarded as a stranded cost
- Building new lines meets more and more hostility from the public opinion, which makes planning activities even longer and affected by uncertainties
- Variable flows from RES are generating a new type of intermittent congestion which can sometimes be well compensated with system flexibility: investments in a new line would not be justified.
- There is an on-going debate on the employment of storage technologies and system flexibility to make the RES grid injection more predictable ("virtual power plant")
- **Hence the idea of establishing a new grid planning methodology considering the opportunity to introduce new storage and flexibility resources in electricity transmission and distribution grids as an alternative to building new grid elements**

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Partnership

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Research Partners:

- **RSE**, Italy (Project Coordinator, WP7 and WP8 leader)
- **EKC**, Serbia
- **KU-Leuven**, Belgium (WP1 leader)
- **N-SIDE**, Belgium (WP3 leader)
- **R&D NESTER** Portugal (WP5 leader)
- **SINTEF**, Norway (WP6 leader)
- **TECNALIA**, Spain (WP2 leader)
- **TU-Dortmund**, Germany (WP4 leader)
- **VITO**, Belgium

Transmission System Operators:

- **TERNA**, Italy
  - **Terna Rete Italia** as Linked third Party
- **REN**, Portugal
- **ELES**, Slovenia

Distribution System Operators

- **ENEL** Global Infrastructure and Networks
  - **e-distribuzione** as Linked third Party

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The new planning tool

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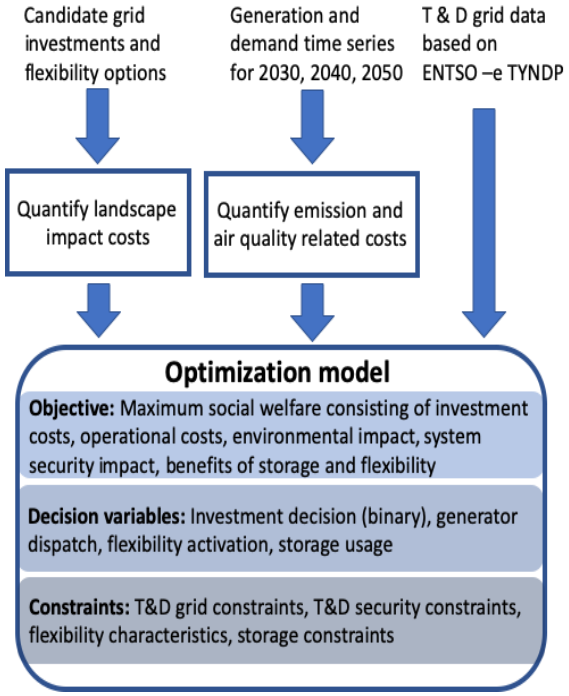

- Best planning strategy with a limited number of expansion options (mixed-integer, sequential OPF)
- T&D integrated planning
- Embedded environmental analysis (air quality, carbon footprint, landscape constraints)
- Simultaneous mid- and long-term planning calculation over three grid years: 2030-2040-2050
- Yearly climate variants (variability of RES time series and load time series) taken into account in by a Monte Carlo process; the number of combinations reduced by using clustering-based scenario reduction techniques.
- Full incorporation of CBA criteria into the target function
- Probabilistic elements (instead of N-1 security criterion)
- Numerical *ad hoc* decomposition techniques to reduce calculation efforts

y = 2030, 2040, 2050

$$min \sum_{y} \sum_{t} \left[\sum_{j} (C_{y,t,j}) + \sum_{j} \alpha_{y,j} (C_{y,t,j}) + \Delta t \sum_{c,j} \widetilde{U}_{y,t,c} C^{voll}_{y,t,j} \Delta P_{y,t,j,c} \right] + \sum_{j} \alpha_{y,j} I_{y,j}$$

Operational costs, of existing generation and load including air quality impact and CO_2 emissions impact of conventional power plants

Operational costs of new investments

Contingencies costs, as the product of curtailed load and value of lost load weighted over a set of contingencies *c*, using contingency probabilities

Investment costs, including carbon footprint (apart conventional generation) and landscape impact costs

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Modelling environmental factors

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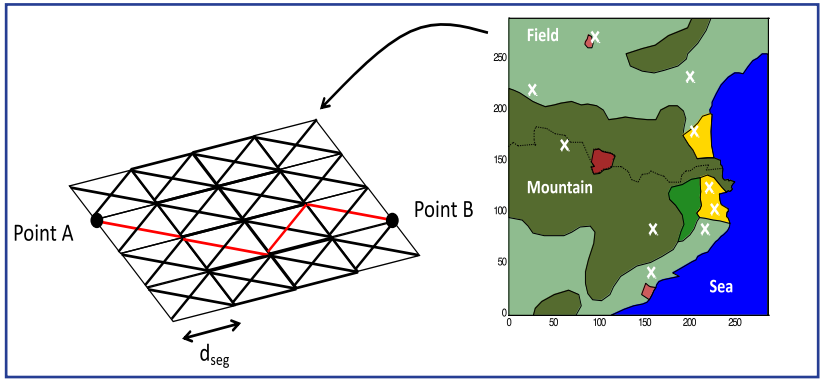
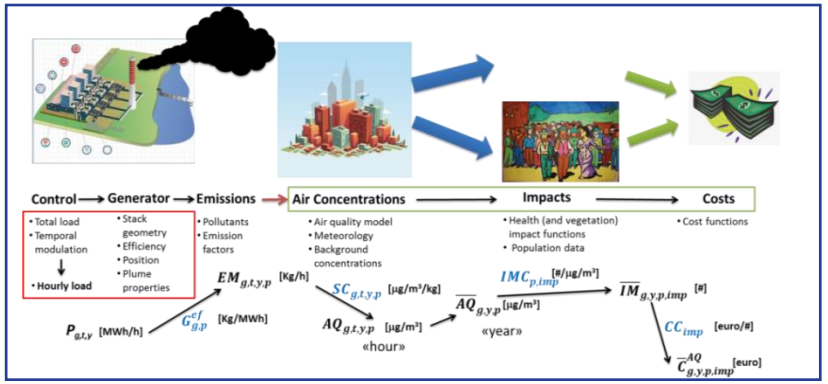
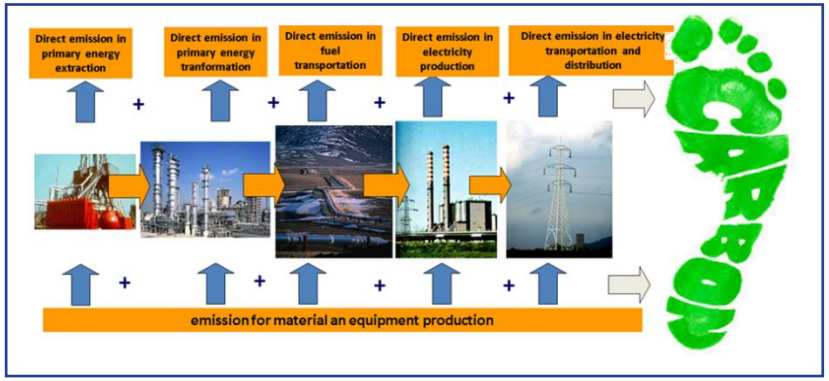


Landscape impact modelling



Air quality modelling



Carbon footprint modelling

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Fix-and-relax: a promising temporal decomposition algorithm

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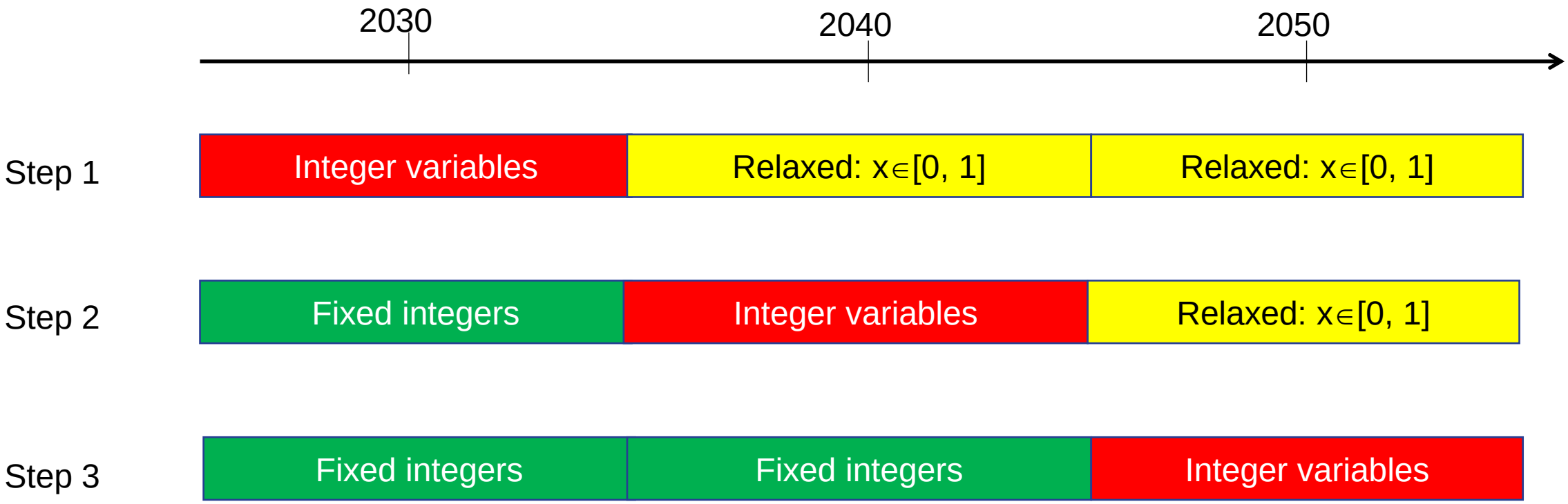

Adapted from: H. U. Yilmaz, K. Mainzer, D. Keles - Improving the performance of solving large scale mixed-integer energy system models by applying the fix-and-relax method – EEM 2020 conference

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The Pre-processor

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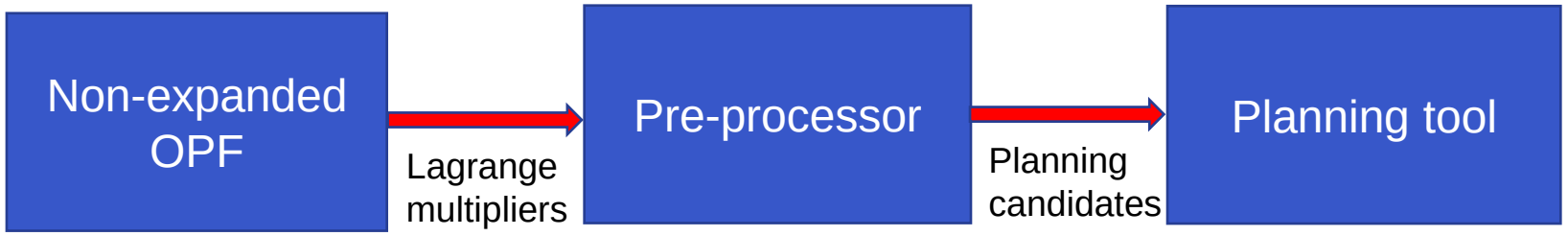

- The planning tool needs to receive as an input the planning candidates for the three years (2030, 2040, 2050) and for each node.
- This input is provided by a software tool (pre-processor) that ranks for each node the suitability of different kinds of investments (new lines/cables, storage elements, flexible management of big loads
- To do so, the pre-processor exploit the information provided by Lagrangian multipliers of line transit constraints and nodal power balance of a non-expanded minimum cost OPF (they provide information on how much the target function would improve as a consequence of a unit relaxation of the constraint).

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The Pre-processor

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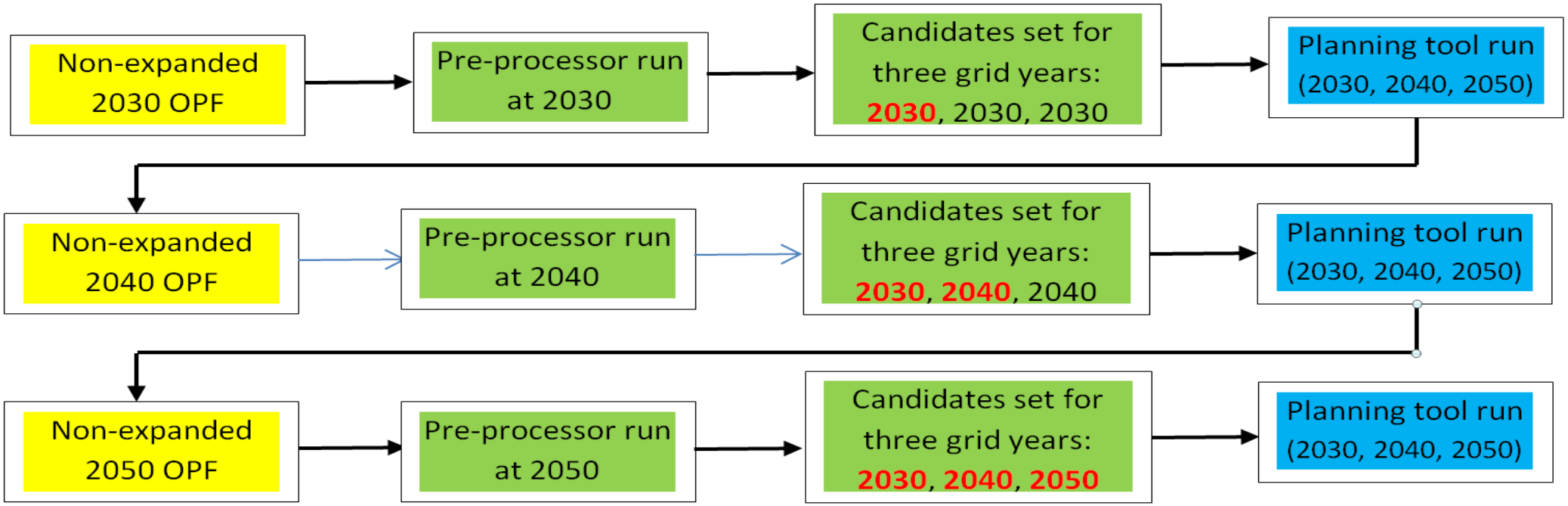
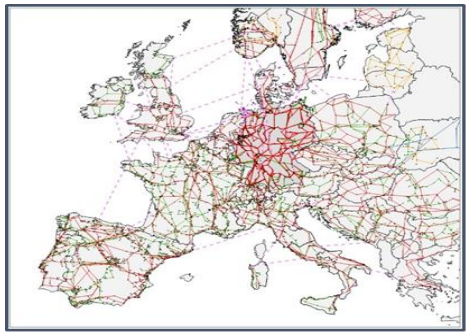
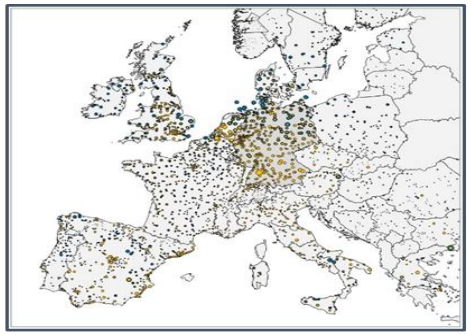
Interaction between pre-processor and planning tool



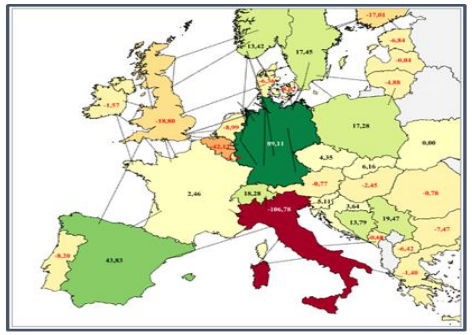
Pan-European and regional scenarios generation



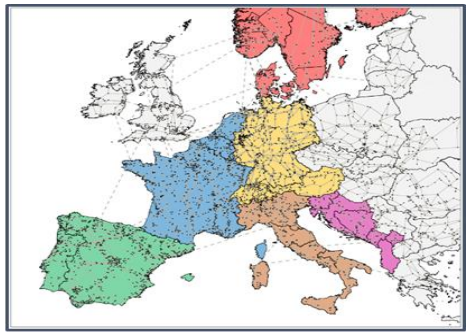
Prepare pan-EU grid model



Regionalization of RES capacities and loads



Market Simulation for cross-border exchanges



Grid simulations for detailed Regional Cases

The main source for the scenarios considered in FlexPlan project is the Ten Year Network Development Plan (TYNDP) 2020, developed by ENTSO-E, which describes possible trends up to 2050. ENTSO-E's TYNDP describes three scenarios:

- National trends
- Distributed Energy
- Global Ambition

that added up over three grid years (2030, 2040, 2050) makes up 9 scenarios to be considered by FlexPlan. For 2050, the document "A Clean Planet for all" by the EC was also considered.

ENTSO-E's TYNDP 2018 pan-European **transmission grid model** (extra-high voltage) is also utilized as a basis for the FlexPlan simulations. For sub-transmission, public data from Open Street Map sources is used alongside with information available to the consortium partners.

Synthetic distribution networks are created in order to have a reduced scale model of the real networks. They are created on the basis of network statistics and with the help of the JRC tool DiNeMo (https://ses.jrc.ec.europa.eu/dinemo).

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Conclusions

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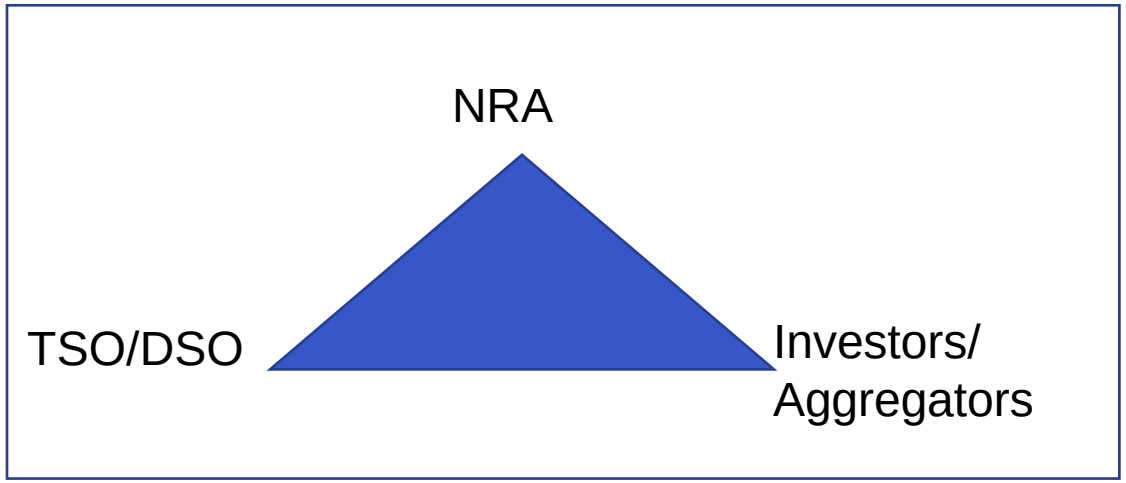

Investments in storage and flexibility will remain mostly in the hands of private investors.
National Regulatory Authorities should translate the suitability of deploying new storage or flexibility in strategic network locations into opportune incentivization to potential investors.
This complicates the traditional scheme, where System Operators after carrying out planning analyses were the only subject entitled to invest.

FlexPlan is going to provide:

- **SOs with a tool to allow optimal contribution of storage and flexibility to grid planning**
- **NRAs with regulatory guidelines for optimal exploitation of storage and flexibility in planning**

The FlexPlan web

- The official web site of the FlexPlan project is: https://flexplan-project.eu/
  All project news and other information are posted there
- Project brochure can be downloaded from: https://flexplan-project.eu/wp-content/uploads/2020/02/FlexPlan_brochure.pdf
- All project publications (deliverables, papers, important presentations) are publicly downloadable from: https://flexplan-project.eu/publications/

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Thank you…

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