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FlexPlan project: EU regulation and TSO-DSO practice

Speakers: Gianluigi Migliavacca (RSE), Andrei Z. Morch (SINTEF Energy Research)

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ISGAN Academy webinar #23

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

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CLEAN ENERGY MINISTERIAL

ISGAN in a Nutshell

Created under the auspices of:

the Implementing Agreement for a Co-operative Programme on Smart Grids

an initiative of the Clean Energy Ministerial (CEM)

Strategic platform to support high-level government knowledge transfer and action for the accelerated development and deployment of smarter, cleaner electricity grids around the world

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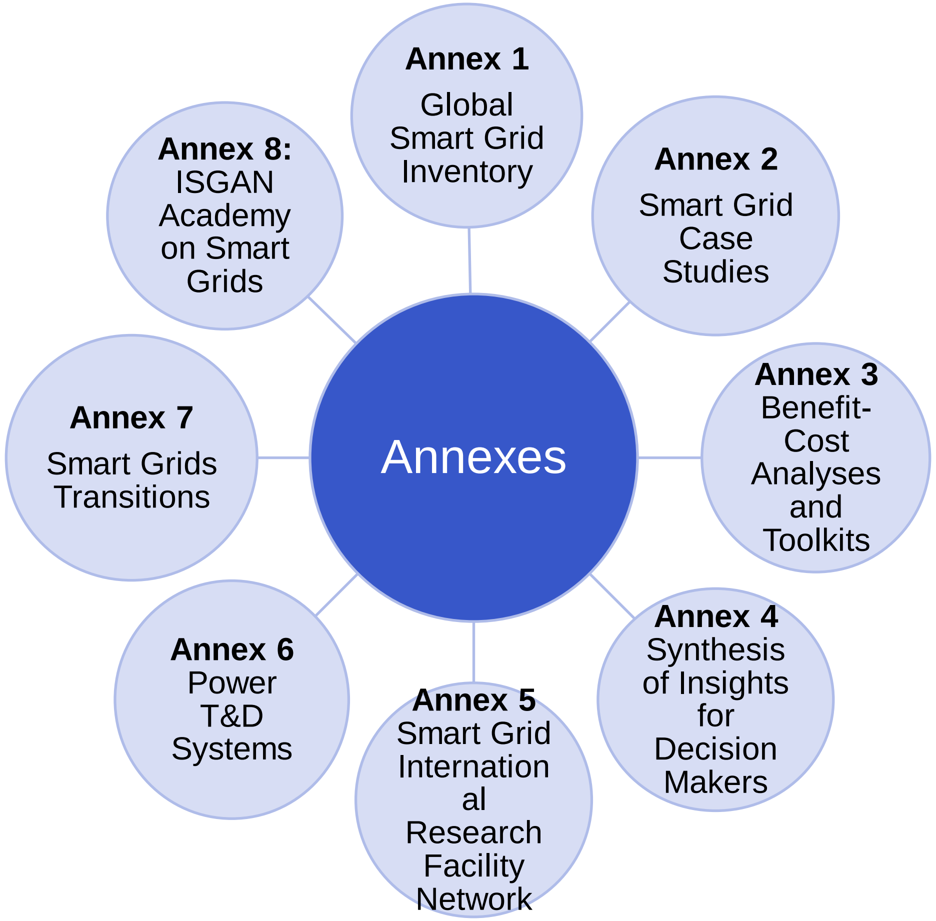
International Smart Grid Action Network is the only global government-to-government forum on smart grids.

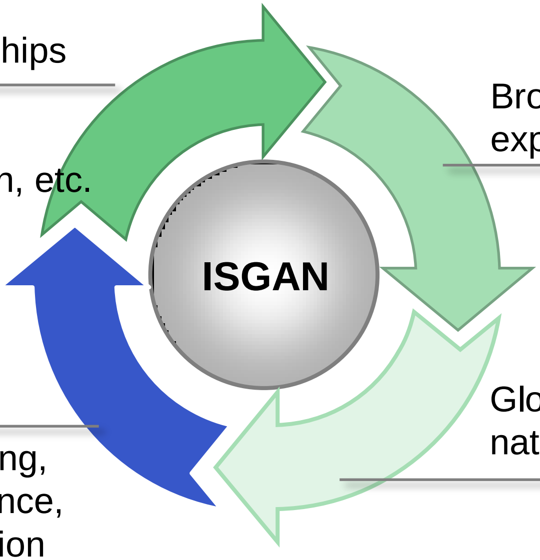


ISGAN's worldwide presence

Value proposition

Strategic partnerships

IEA, CEM, GSGF, Mission Innovation, etc.



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The FlexPlan grid planning approach

Gianluigi Migliavacca (RSE) – Project Coordinator

Agenda

- Motivations of the FlexPlan project
- Project layout and consortium
- Small example showing different grid planning strategies
- The new FlexPlan planning tool: modeling of the different components
- The FlexPlan pre-processor
- Scenario generation
- Final conclusions with some regulatory considerations
- The FlexPlan web

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

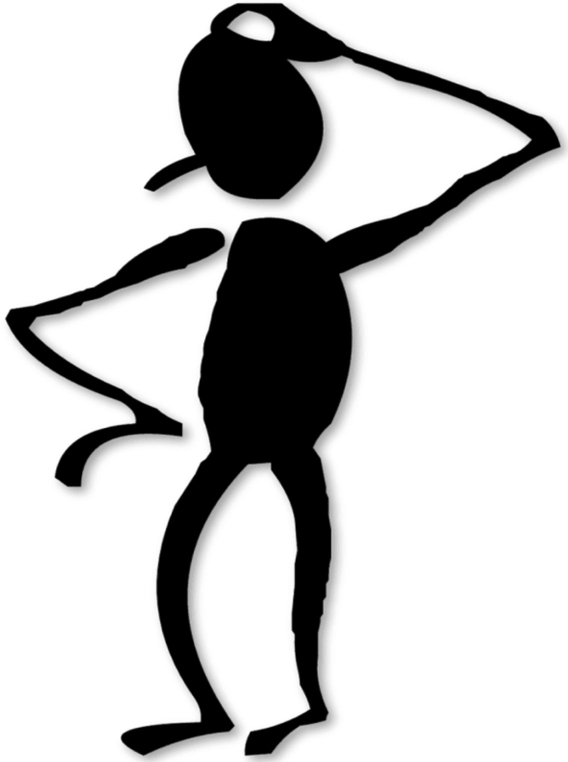
- Grid investments are capital intensive and the lifetime of transmission infrastructure spans several decades: when a new line is commissioned it might be already partially regarded as a stranded cost

- 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.

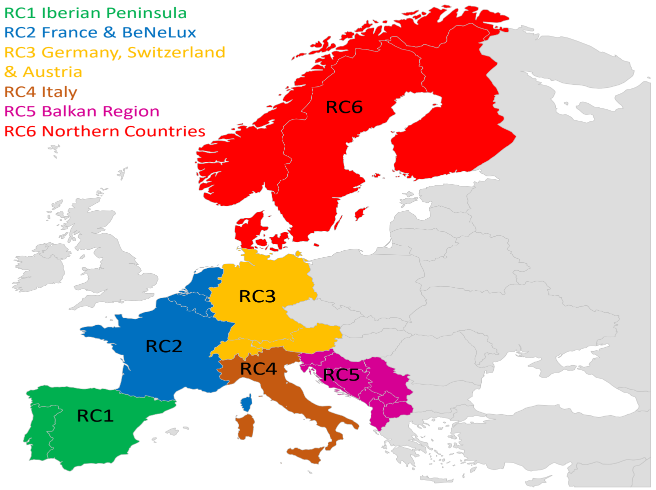
- There is an on-going debate on the employment of storage technologies and system flexibility to make the RES grid injection more predictable ("virtual power plant")

- **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**



What will FlexPlan achieve?

1 – New planning methodology - Creation of a **new tool for optimizing T&D grid planning**, considering the **placement of flexibility elements** located both in transmission and distribution networks **as an alternative to traditional grid planning**: in particular, storage, PEV, demand response)

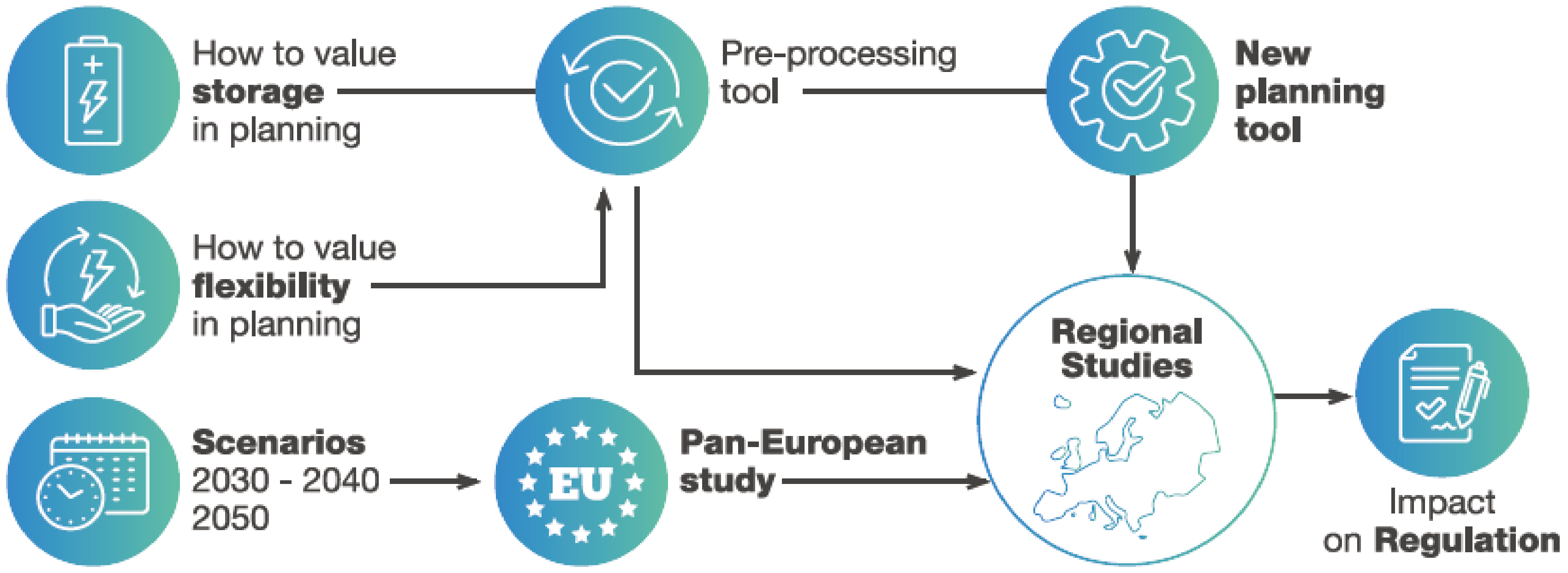


2 – Scenario analysis 2030-40-50 - New methodology applied to analyse **six regional grid planning scenarios at 2030-2040-2050.** A **pan-European scenario** will deliver border conditions to initialize in a coherent way the 6 regional cases.

3 – Regulatory guidelines – FlexPlan goal is to provide:

- an optimized planning methodology for the future usage of TSOs and DSOs
- indications on the potential role of flexibility and storage as a support of T&D planning
- guidelines for NRA for the adoption of opportune regulation.

FlexPlan: overall project layout



FlexPlan: partnership

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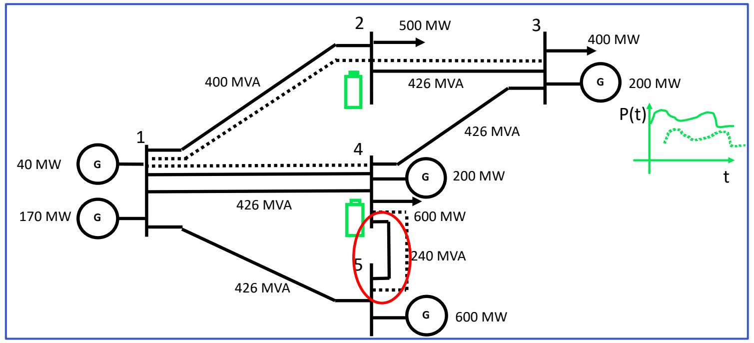
- ## Research Partners:
  - **RSE**, Italy (Project Coordinator, WP7 and WP8 leader)
  - **EKC**, Serbia
  - **KU-Leuven**, Belgium (WP1 leader)
  - **N-SIDE**, Belgium (WP3 leader)
  - **R&D NESTER** Portugal (WP5 leader)
  - **SINTEF**, Norway (WP6 leader)
  - **TECNALIA**, Spain (WP2 leader)
  - **TU-Dortmund**,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

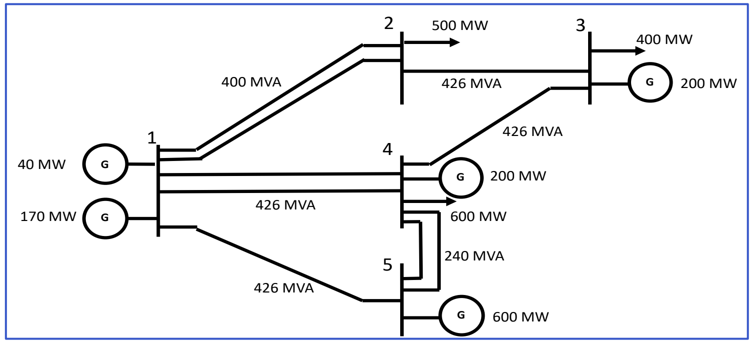
- ## Transmission System Operators:
  - **TERNA**, Italy
    - **Terna Rete Italia** as Linked third Party
  - **REN**, Portugal
  - **ELES**, Slovenia

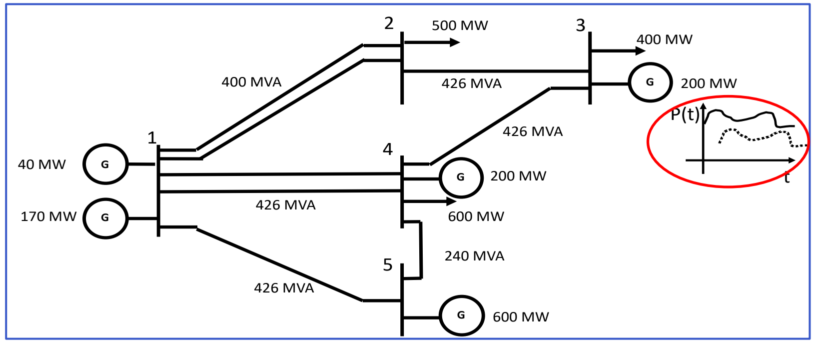
- ## Distribution System Operators
  - **ENEL** Global Infrastructure and Networks
    - **e-distribuzione** as Linked third Party

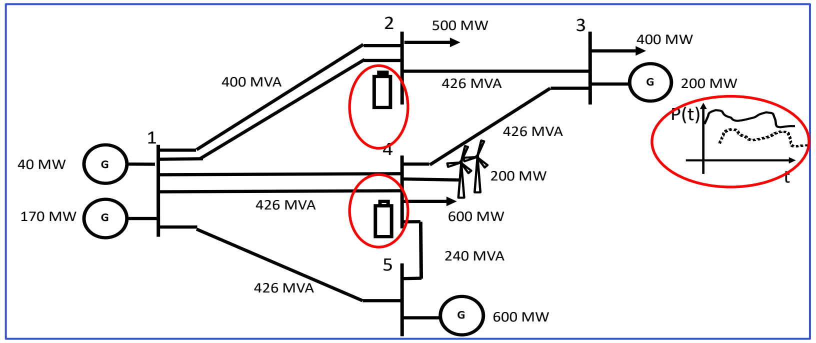
No one-fits-all solution: a simple example



Power transfer capacity of line 4 - 5 limited to 240 MVA, the generation resources connected to bus 5 cannot be utilized to fully supply the demand on bus 3. Investments are needed.
Candidates: four lines (dashed), two storage systems (in green) one flexible demand (in green).





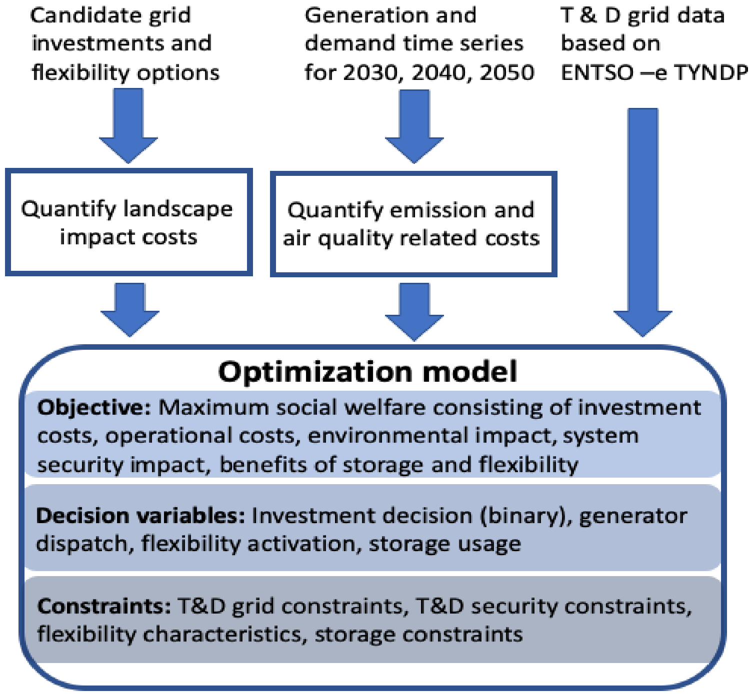


Solution 1 - Classic transmission expansion planning (transmission lines), by designing the system for peak load conditions. If peak load conditions only occur for a limited number of hours this is not economically optimal.

Solution 2 – Omitting investments into line 4-5, as the existing line is sufficient to supply the demand for most of the time, and activate demand flexibility (shifting and/or reduction) whenever needed.

Solution 3 - Conventional generators have been replaced by wind farms, then storage could allow to supply demand in hours of low wind generation and high demand.

The new planning tool



- Best planning strategy with a limited number of expansion options (mixed-integer, sequential OPF)
- Strategy for extending the planning over several decades (DOPF)
- Probabilistic elements (instead of N-1 security criterion)
- OPF target function implementing either CBA or multi-criteria approaches: the CBA is not a separate process but part of the target function
- T&D integrated planning
- Embedded environmental analysis (air quality, carbon footprint, landscape constraints)

y = 2030, 2040, 2050

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

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

Modeling of flexibility

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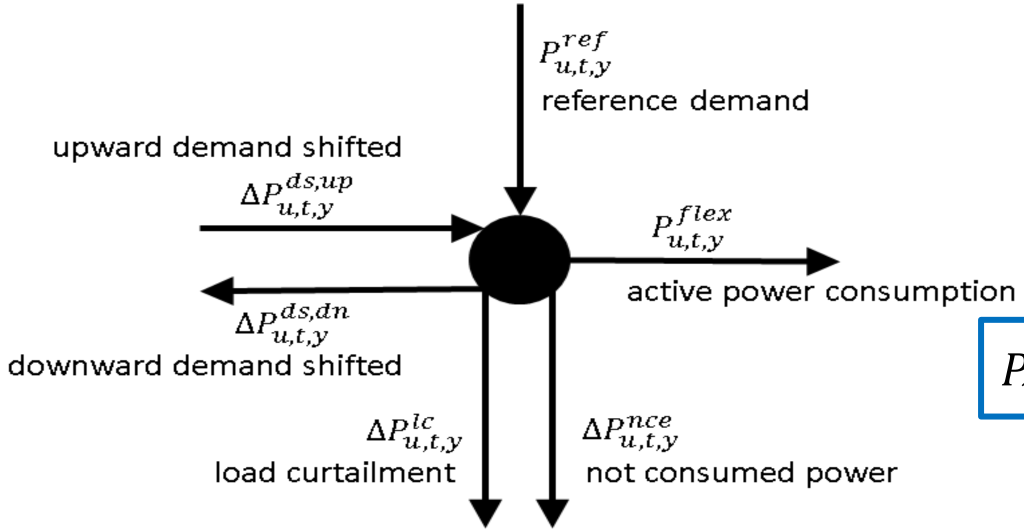


$$P^{flex}_{u,t,y} = P^{ref}_{u,t,y} - \Delta P^{nce}_{u,t,y} + \Delta P^{ds,up}_{u,t,y} - \Delta P^{ds,dn}_{u,t,y} - \Delta P^{lc}_{u,t,y}$$

Voluntary reduction of demand (nce = not consumed energy)

Upwards and downwards demand shifting

Involuntary reduction of demand (lc = load curtailment)

$$0 \le \sum_{t \in S_t} \Delta t \cdot \Delta P^{nce}_{u,t,y} \le \alpha_u E^{nc,max}_{u,y}$$ nce boundaries

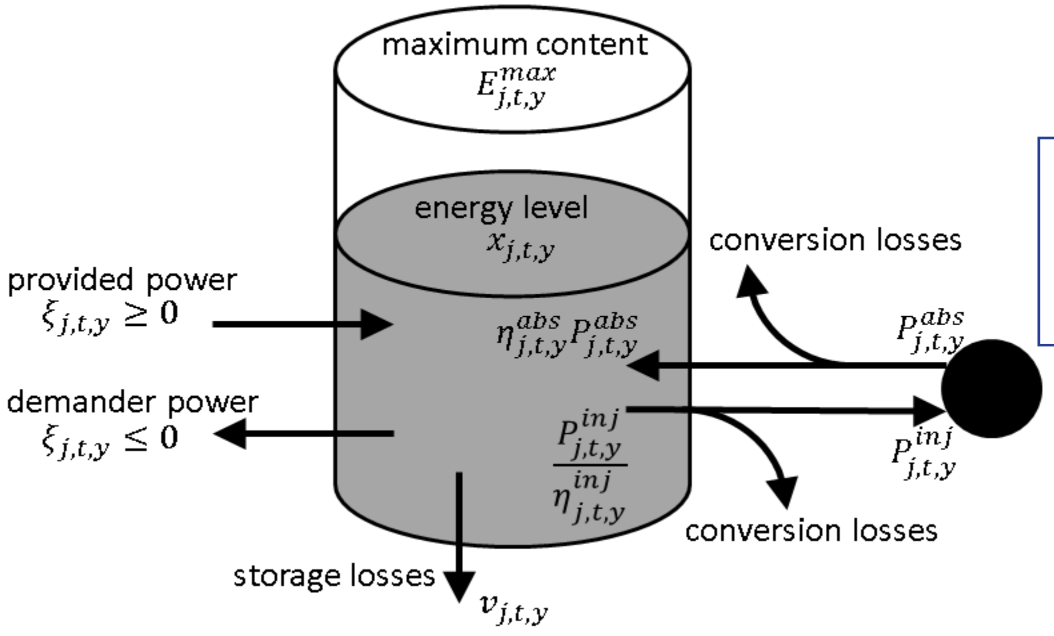
$$\sum_{t \in \tau} \Delta P^{ds,up}_{u,t,y} = \sum_{t \in \tau} \Delta P^{ds,down}_{u,t,y}$$ Same shift in both directions

$$0 \le \Delta P^{ds,up}_{u,t,y} \le \Delta^{ds,up,max}_{u,t,y} - \sum_{\tau \in \left\{t-\tau^{ds,up,grace}_{u,y},\dots,t-1\right\}} \Delta P^{ds,up}_{u,\tau,y}$$

$$0 \le \Delta P^{ds,dn}_{u,t,y} \le \Delta^{ds,dn,max}_{u,t,y} - \sum_{\tau \in \left\{t-\tau^{ds,dn,grace}_{u,y},\dots,t-1\right\}} \Delta P^{ds,dn}_{u,\tau,y}$$

Maximum demand shifting

Modeling of storage



$$E^{max}_{j,y} x_{j,t,y} = E^{max}_{j,y} x_{j,t-\Delta t,y} + \Delta t \cdot \left(\eta^{abs}_{j,y} P^{abs}_{j,t,y} - \frac{P^{inj}_{j,t,y}}{\eta^{inj}_{j,y}} + \xi_{j,t,y} - v_{j,t,y} \right)$$

Energy stored at time t

Energy stored at time t-Δt

Energy absorbed from network at time t

Energy injected into network at time t

Exogenous terms

$$E^{min}_{jc,y} \alpha_j \leq E^{max}_{jc,y} x_{jc,t,y} \leq E^{max}_{jc,y} \alpha_{j,y}$$

Boundaries to per unit load state *x*

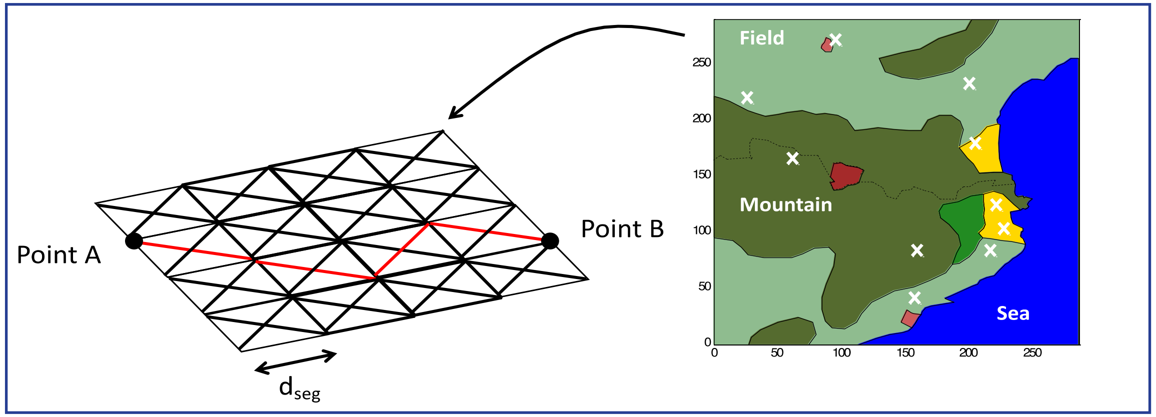
$$0 \leq P^{abs}_{jc,t,y} \leq \alpha_{j,y} P^{abs,max}_{jc,y}$$

Boundaries power absorbed from network

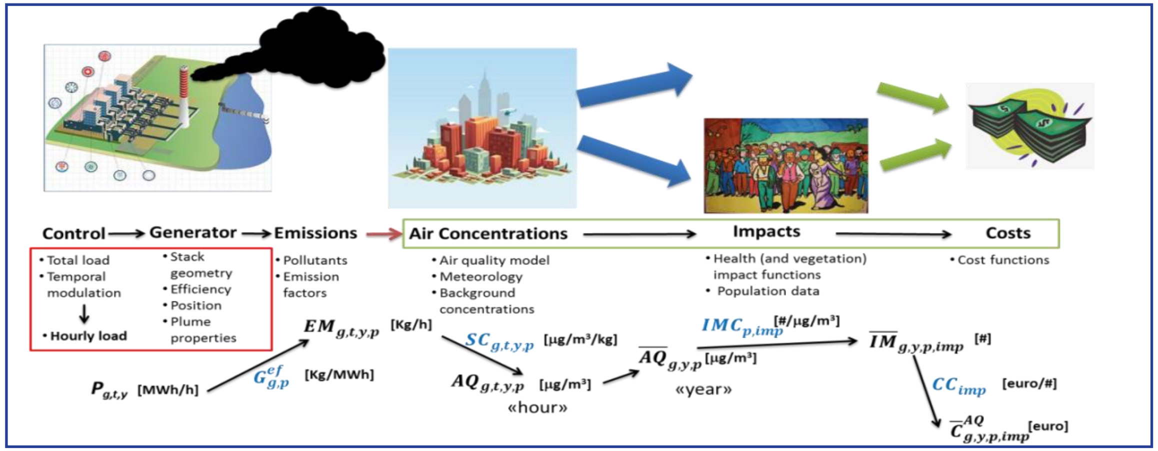
$$0 \leq P^{inj}_{jc,t,y} \leq \alpha_{j,y} P^{inj,max}_{jc,y}$$

Boundaries power injected into network

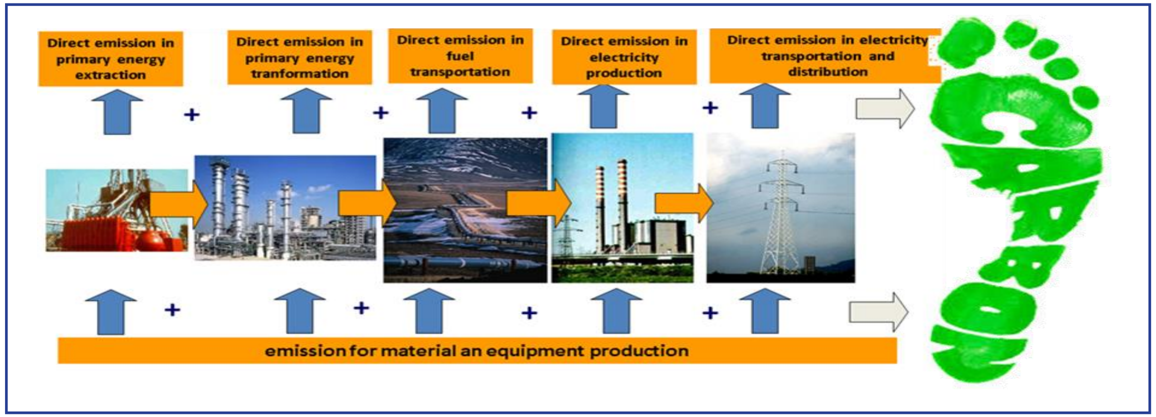
Modeling of environmental factors



Landscape impact modelling

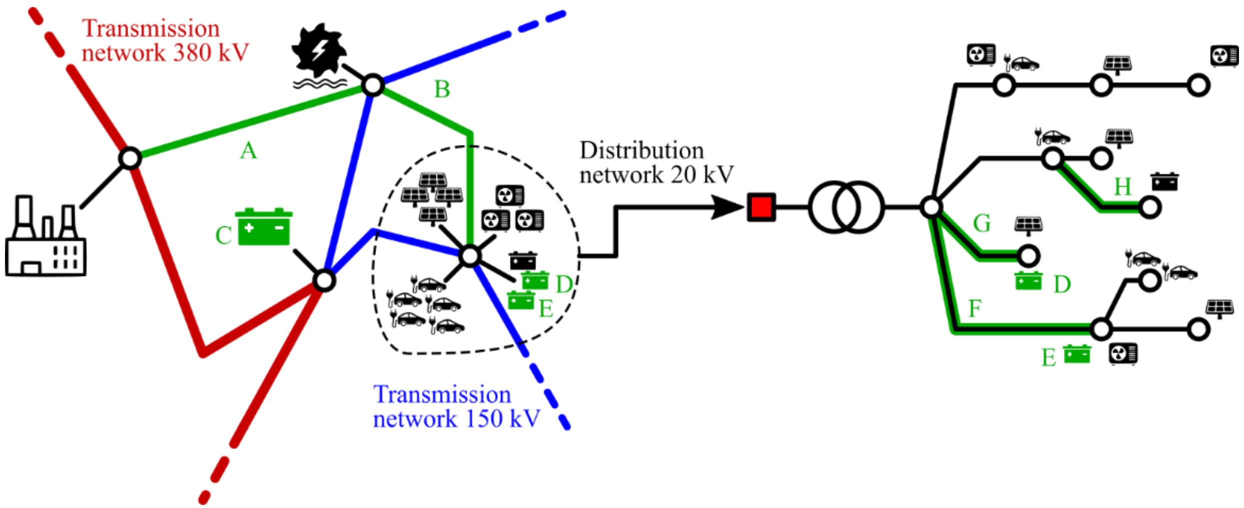


Air quality modelling



Carbon footprint modelling

Modeling distribution grids



Simulating real distribution networks would result in a unmanageable complicacy. Therefore, simplified synthetic distribution grids are generated on the basis of few metrics/statistics which can be easily extracted from the analysis of real networks.

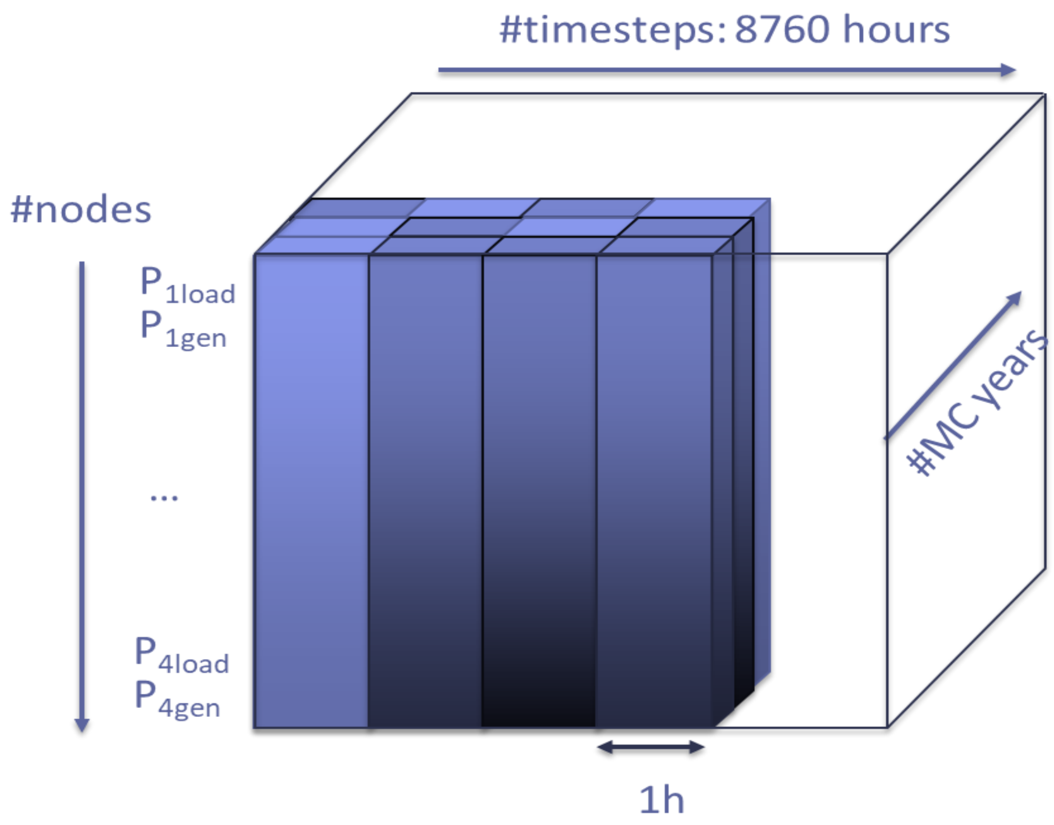
The T&D grid model is decomposed into two components: meshed and radially operated networks. As the modelling of all radially operated systems would result in an unmanageable problem size, a four-step decomposition approach is chosen:

- **STEP 1:** a least-cost expansion plan of the radial network is determined with the objective of solving only local congestion in the most economical way
- **STEP 2:** a highest-cost expansion plan of the radial network is performed with the objective of providing the maximum amount of flexibility in terms of delivering and absorbing active power to/from the meshed network
- **STEP 3:** (optional) intermediate cases are analysed
- **STEP 4:** the radial grid expansion options of steps 1-2-3 are provided as expansion candidates for the meshed system, solved independently. The best trade-off is determined.

The pre-processor

- 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 exploits 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).

Scenarios generation



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:

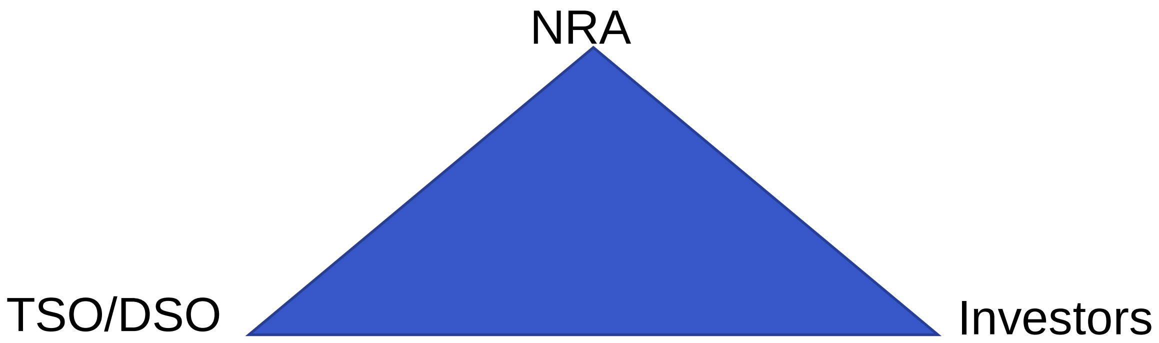
- National trends
- Distributed Energy
- Global Ambition

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 is also utilized as a basis for the FlexPlan simulations.

Yearly climate variants (variability of RES time series and load time series) for each of the grid years are taken into account in the framework of a Monte Carlo process; the number of combinations is reduced by using clustering-based scenario reduction techniques.

Planning guidelines

Investments in storage and flexibility will remain mostly in the hands of private investors. That means that depending on the results of the planning phase carried out by the System Operators, **National Regulatory Authorities should translate the suitability of deploying new storage or flexibility in strategic network locations into opportune incentivization forms towards those who are possibly going to invest in that direction.** This complicates a lot the scheme with respect to traditional planning modalities, where System Operators after carrying out their planning analyses were the only subject entitled to invest.



FlexPlan is going to provide:

- **System Operators with a tool to allow including storage and flexibility into their grid planning analyses,**
- **National Grid Authorities with a set of regulatory guidelines to allow optimal exploitation of the advantages storage and flexibility could provide to the system.**

The FlexPlan web

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- 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/

Thank you…

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Spotlight on the regulatory framework in the EU: barriers and enablers towards a possible role of flexible resources in T&D grid planning

Andrei Z. Morch (SINTEF Energy Research)

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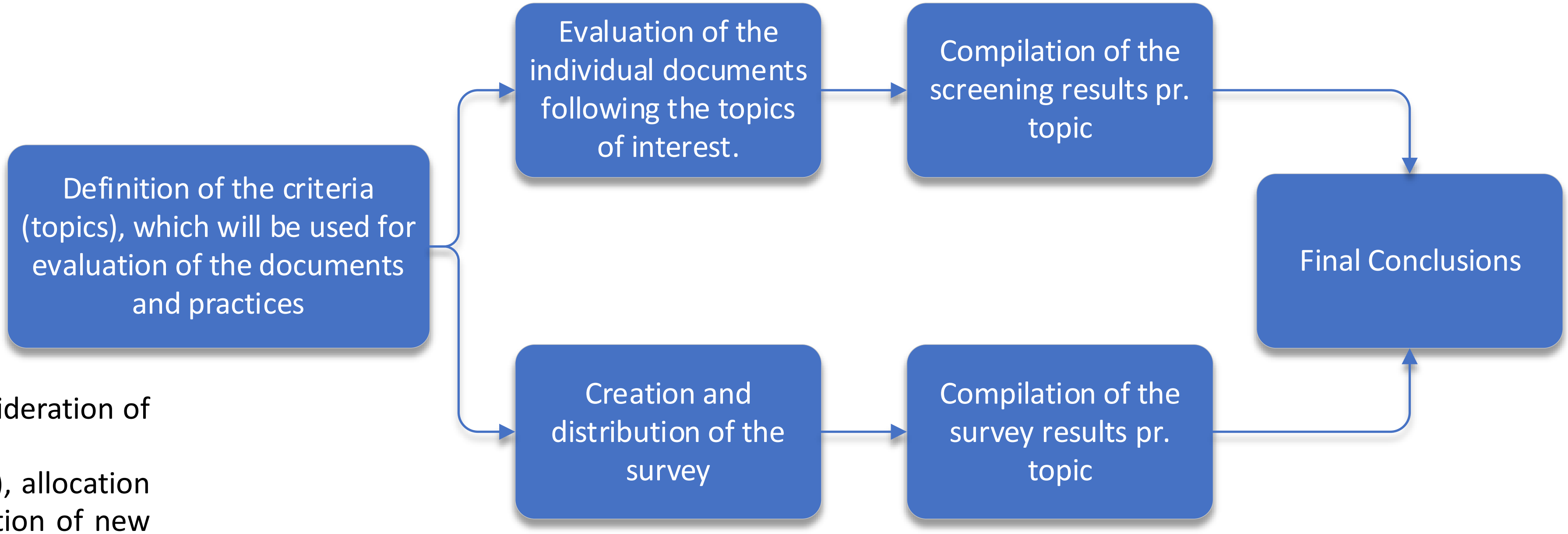
Agenda

- Objectives of the study "Compliance of FlexPlan tool with EU regulation and TSO-DSO practice"
- The applied methodology
- Results
- Conclusions

- Aim of this study is to get a picture of the present overall pan-European regulation and political targets to ensure that the subsequent FlexPlan project activities and development of FlexPlan tool are correctly oriented
- Additional objective is to analyse the existing regulation, identify possible regulatory gaps and raise the need for the consideration of additional topics in future regulation (by the end of the project)

The applied methodology

- The European Commission (EC): Directives and Regulations, including Network Codes (NCs)/Guidelines
- ENTSO-E: NCs/Guidelines, including standard methods for cost-benefit analysis
- Interest organisations and associations as Eurelectric, E.DSO, GEODE and CEDEC



- Flexible resources and consideration of these in planning
- Cost-benefit analysis (CBAs), allocation of costs, criteria for evaluation of new projects
- Interaction between TSOs and DSOs, including planning, sharing of resources, roles and responsibilities
- Other subjects, including incentive mechanisms, criteria for development of scenarios, reliability criteria, etc.

- Three TSOs
- Four DSOs

Requirements related to consideration of flexible resources in planning

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- Internal Electricity Market (IEM) Directive (2019/944):
  - Requires that distribution network development plan shall also **consider demand response, energy efficiency, energy storage facilities or other resources** that the DSO has to use as an alternative to system expansion
  - TSOs shall fully take into account the potential for the use of demand response, energy storage facilities or other resources as alternatives to system expansion when elaborating 10-year Network Development Plan (TYNDP)
- The IEM Regulation (2019/943) requires that for integration of the growing share of renewable energy, the future electricity system should make use of **all available sources of flexibility**, particularly demand side solutions and energy storage
- The ENTSO-E's 3rd Guideline for Cost Benefit Analysis (CBA) of Grid Development Projects: **flexibility of demand** is considered as a consistent part of the estimation of the socio-economic welfare
- **None** of the survey responding System Operators (SOs) consider flexible resources in their current planning practices.

Ownership and operation of energy storage*

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- The most recent recast of the IEM Directive reaffirms the position stated before, not allowing System Operators (SOs) to own, develop, manage or operate energy storage facilities
- However, SOs are allowed to own, operate or manage such devices, among other conditions, if these devices are “*are fully integrated network components and the regulatory authority has granted its approval*”, which can pave the way for many exceptions
- The most recent version of recasts has been partially modified, taking into account input coming from some stakeholders, expending the possible terms of derogation for SOs for operational purposes
- It seems it could be possible to own and operate batteries for some new actors formalised in the IEM Directive, as active customers and possibly Citizens Energy Communities

* *the project does not aim at taking any specific position on this subject*

Rules for allocation of costs and incomes between TSOs and DSOs in new common investment projects

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- There is a clear message from the EC that socio-economic welfare should be taken as the main indicator for the prioritization of investments in new grid projects
- ENTSO-E has developed a CBA of Grid Development Projects, ensuring a common framework for multi-criteria CBA for TYNDP projects (ref. EU Regulation 347/2013)
- There are no commonly agreed rules for allocation of costs between TSOs and DSOs in common investment projects. Two different views presented in common "Data Management Report" (Use Case "Balancing")

DSO view: Balancing services based on assets connected on the DSO level should, for economic reasons, not lead to any additional constraints in DSO networks. If this is the case, TSO and the market actor interested in using this asset connected to the DSO network on the balancing market **should cover the full costs of any grid enforcement** according to the national regulations on the allocation of network expansion costs.)

TSO view: In case of additional constraints in DSO's networks, a regulatory framework should be established in which the **compromise** between the additional value of the flexibility not available to the balancing markets due to these constraints and the network expansion that resolves those congestions is evaluated and, in any case, ensures a proper allocation of the corresponding additional costs.

Rules for allocation of costs and incomes between TSOs and DSOs in new common investment projects

- The survey results indicate that the present practice is based on a **split of costs at transmission system level**
- However, this practice may be reconsidered in case flexibility resources from distribution networks will be actively employed and coordinated for the provision of system services to TSOs.
- For the present, there is no regulatory framework, applicable to this case.

Multi-criteria vs. cost-based approach for evaluation of new projects

- The ENTSO-E's 3rd Cost-Benefit Analysis (CBA) guideline describes the common principles and procedures for performing combined multi-criteria and cost-benefit analysis using network, market, and interlinked modelling methodologies for developing Regional Investment Plans and the EU-wide 10-year network development plan (TYNDP)
- EC Guide to CBA: "*In contrast to CBA, which focuses on a unique criterion (the maximisation of socio-economic welfare), multi-criteria analysis is a tool for dealing with a set of different objectives that cannot be aggregated through shadow prices and welfare weights, as in standard CBA…*"
- The survey indicated that the **multi-criteria approach** is applied by all responding TSOs. On DSOs side the practice seems to be more diversified, even though there is a preference for multi-criteria approaches.

What cost function should be applied to reliability in order to include this into CBAs (I)

- The main challenge is to **represent reliability in monetary terms**. The commonly used key indicator for reliability is the lost load, which is monetised via the Value of Lost Load indicator (VOLL).
- The IEM Regulation demands that by 5 July 2020, for the purpose of setting a reliability standard, regulating authorities shall determine **a single estimate of the VOLL** for their territory.
- ENTSO-E's guideline on CBA: the value for VOLL that is used during project assessment should reflect the **real cost of outages for system users**, hence providing an accurate basis for investment decisions.

What cost function should be applied to reliability in order to include this into CBAs (II)

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- The values for the VOLL vary significantly by geographic factors, differences in the nature of load composition, the type of affected consumers, the level of dependency on electricity in the geographical area impacted, differences in reliability standards, the time of year and the duration of the outage.
- The EC insists on using a CBA estimation in all decision-making processes concerning the power industry. This applies to several aspects like risk-preparedness, demand connection, network expansion planning, etc. This seem to be complicated by the above-mentioned local variations in VOLL values.

Sharing of resources between TSO and DSO: what are the priorities?

- The IEM Directive defines that DSOs shall cooperate with TSOs for the effective involvement of market participants connected to their grid in retail, wholesale and balancing markets. Delivery of balancing services stemming from resources located in the distribution system shall be **agreed with the relevant TSO**.
- Further screening and survey of the present practice indicated that at present **there is no common regulatory or practice** background allowing to draw clear conclusions on this topic. The necessity of defining this is clearly highlighted both at the institutional level and by the stakeholders.

Responsibilities for congestion management and balancing

- The guideline for TSO-DSO cooperation outlines the future responsibilities for the operators:
  - TSOs - maintaining overall system security via frequency control, Load Frequency Control (LFC) block balancing and congestion management (across borders and on the TSO level) and voltage support in the transmission network in an electricity system
  - DSOs - managing voltage stability and congestion on their grids
- In the first 10-20 years it is reasonable to suppose that TSOs will remain responsible for **system balancing and congestion management** in their own networks, while DSOs could be allowed to deal with **congestion in the distribution networks**, provided that the DSO will be able to obtain sufficient resources to this.
- The EC has started the formalisation process of several **new business actors**, including Citizens Energy Communities (CECs) by indicating a scope of their roles and responsibilities in the IEM Directive.
- Eurelectric looks at CECs as an important future resource, which can be endorsed with several new duties (especially balancing responsibility) when acting either as a supplier, as an active customer, as a DSO, or as any other system user.

Conclusions

- The EC strongly emphasises the need for efficiency in different activities of the power system, including a technological scope and social-welfare among others e.g. utilisation of already existing resources, such as demand response, which might have the potential to reduce the necessity for new grid investments.
- The EC proposes to consider the existing flexibility resources as a consistent part of network expansion planning and considering demand response and storage with the same priority as generation in dispatching and re-dispatching procedures.
- Difficult to see any common well-established practice in Europe, meaning that the process is still under development.
- Use of market-based mechanisms whenever possible is underlined in several regulatory documents with reference to many network operative aspects, e.g. for the procurement of resources for ancillary services or even for system defense and restoration services.
- EC shows a very pragmatic approach on several critical issues, as for example ownership and operation of energy storage.

Conclusions

- The application of CBAs is put forward as a unified justification criterion to activate new investments. Development of common CBA guideline for TSOs provides a clear set of principles and procedures for performing combined multi-criteria and cost-benefit analysis using network, market and interlinked modelling methodologies for developing union-wide TYNDP. On DSOs side the practice seems to be much less standardized, with preference of multi-criteria approaches.
- In a 10-20 years' timeframe it is reasonable to suppose that TSOs will remain responsible for system balancing and congestion management in their respective networks, while DSOs could be allowed to deal with congestion in their own distribution network.
- There are several unresolved issues related to interaction between TSOs and DSOs, which have to be addressed. Otherwise these disagreements may potentially become show-stoppers in the future common projects.
- The introduction of new actors e.g. CECs could change the landscape and roles/procedures applied both in the planning and in the operation phases.
- There are strong regulatory signals prompting European system operators to consider flexible resources as a new important active subject in the grid expansion planning process formulation. Despite strong efforts from ENTSO-E to develop common methodologic principles, there are still several missing elements in the puzzle.

Thank you…

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