

# CINeLDI

Centre for intelligent electricity distribution  
- to empower the future Smart Grid

## Planning methodology for active distribution grids

Webinar, 2022-10-17

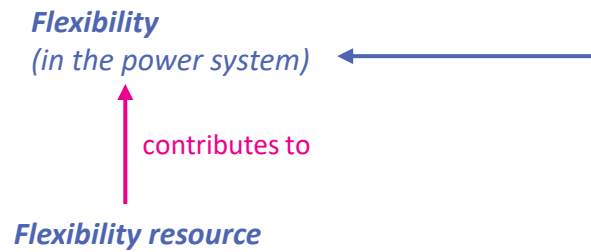
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# Outline

- Flexibility and active measures in the planning of distribution grids
- Gap analysis for active distribution grid planning
- Background for framework and methodology
- Methodology for grid planning with active measures utilizing fast-charging stations and local energy communities – application to the CINELDI MV reference system

# Active distribution grids and flexibility



*CINELDI definition: "Flexibility is defined as the ability and willingness to modify generation injection and/or consumption patterns, on an individual or aggregated level, often in reaction to an external signal, to provide a service within the energy system or maintain stable grid operation"*

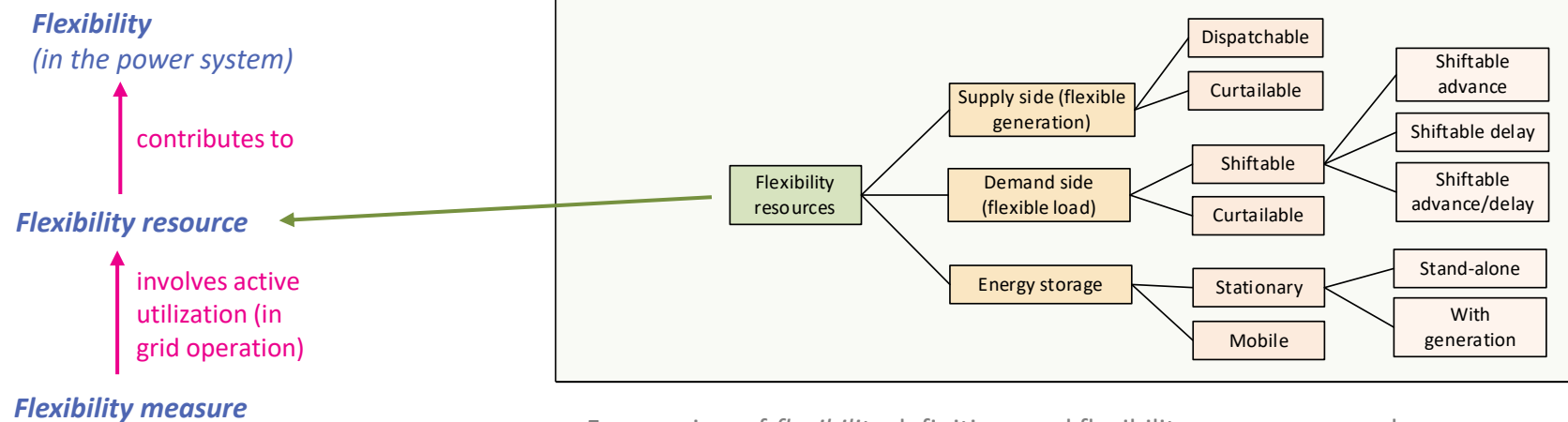
G. Kjølle, K. Sand, and E. Gramme, 'Scenarios for the future electricity distribution grid', in *CIREN 2021 Conference*, Geneva / virtual, 2021, Paper 0858.

For a review of *flexibility* definitions and flexibility resources, see also:

M. Z. Degefa, I. B. Sperstad, and H. Sæle, "Comprehensive classifications and characterizations of power system flexibility resources", *Electric Power Systems Research*, vol. 194, p. 107022, 2021. Available: <https://doi.org/10.1016/j.epsr.2021.107022>.

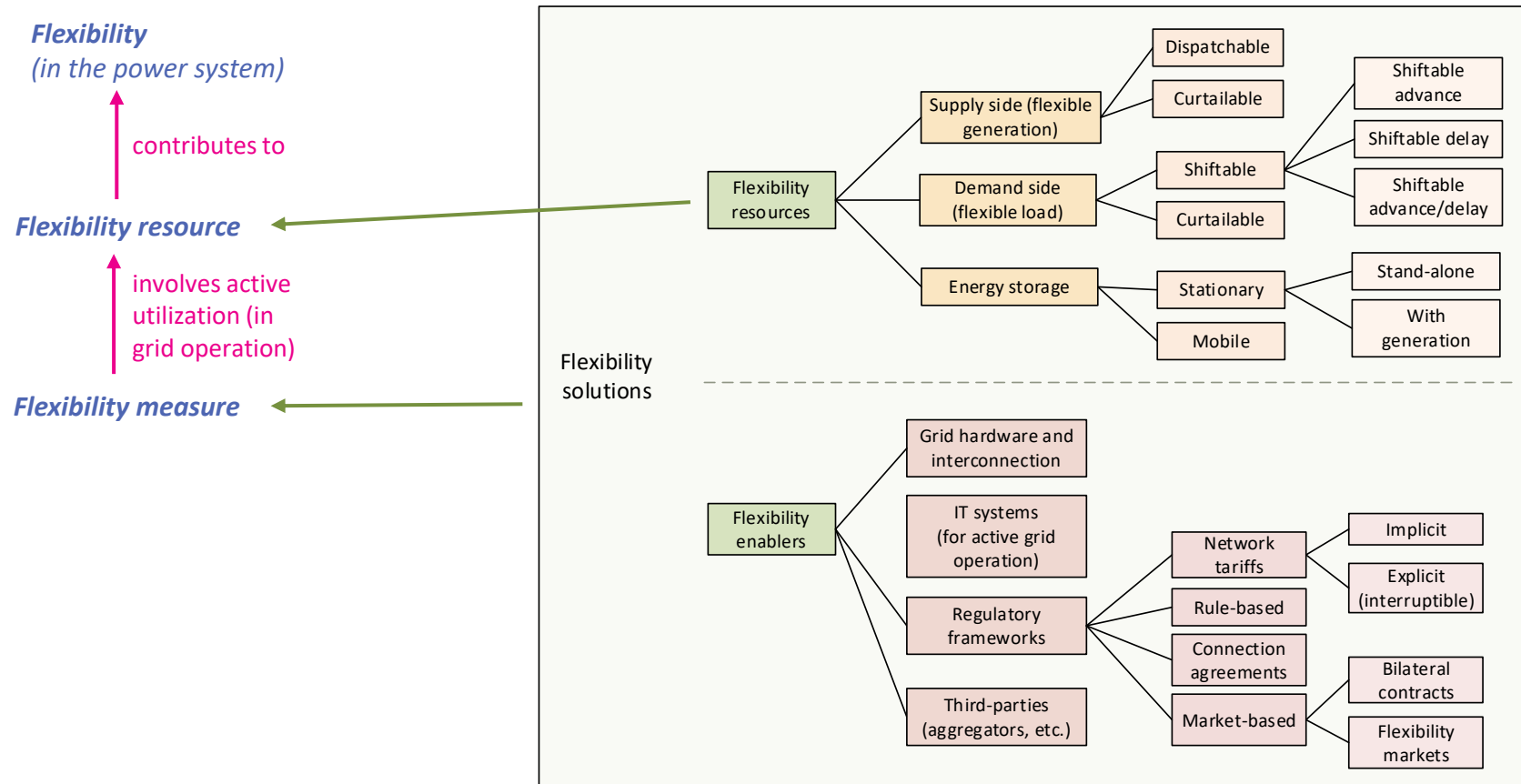


# Active distribution grids and flexibility



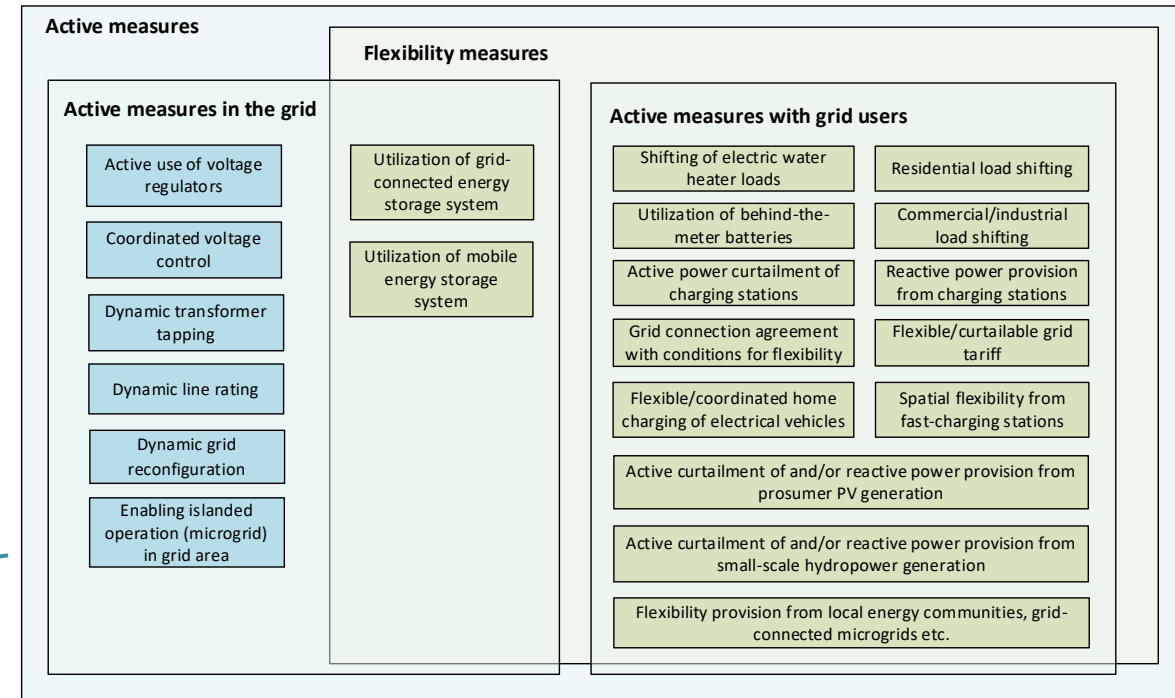
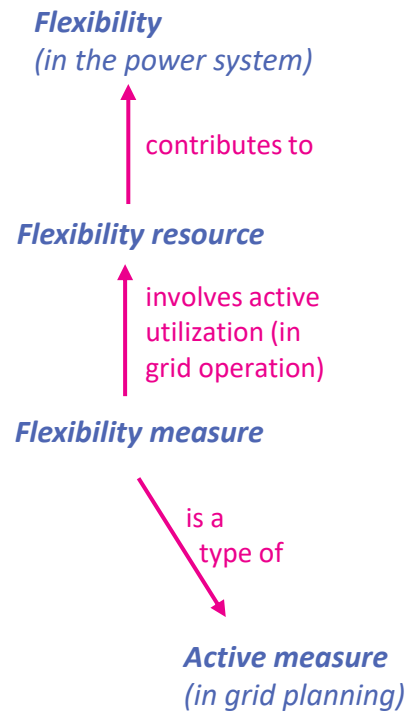
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# Active distribution grids and flexibility

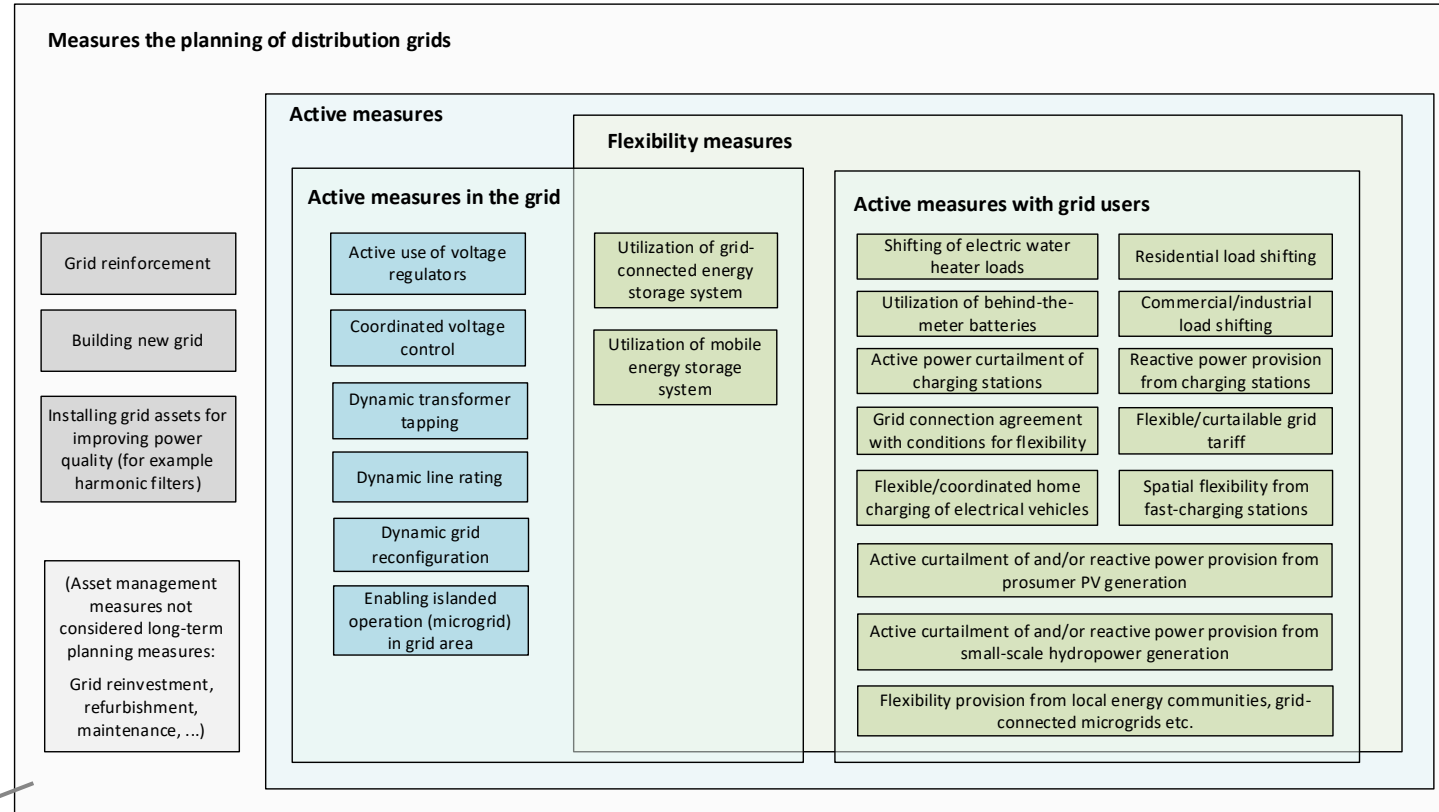
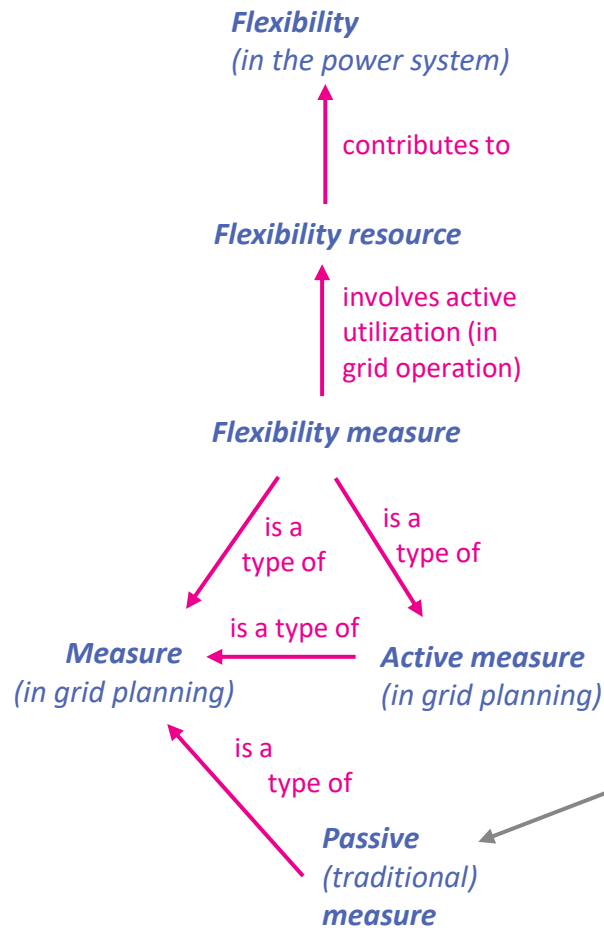


Source: H. Sæle, I. B. Sperstad, K. Wang Høiem, and V. Mathiesen, "Feasibility study for utilising flexibility in operation and planning of the electricity distribution system," *submitted for peer review*, 2022. Pre-print version available online: <https://doi.org/10.36227/techrxiv.20593740.v1>.

# Active distribution grids and flexibility



# Active distribution grids and flexibility





# Gap analysis for active distribution grid planning

Survey (2017) and in-depth interview studies (2021) with Norwegian grid companies

Literature review (2019–) of the international scientific literature

**Current practice  
(industrial state of the art)**

**Research literature  
(scientific state of the art)**

Gap

- Only passive grid measures (little use of flexibility)
- Little use of optimization models
- Neglecting variability and uncertainty
- Risk-averse (or rather risk-ignorant)

- Optimization methods consider sizing and siting for a single type of resource/measure
- Not considering timing of measures
- Not considering the needs driving the grid planning process

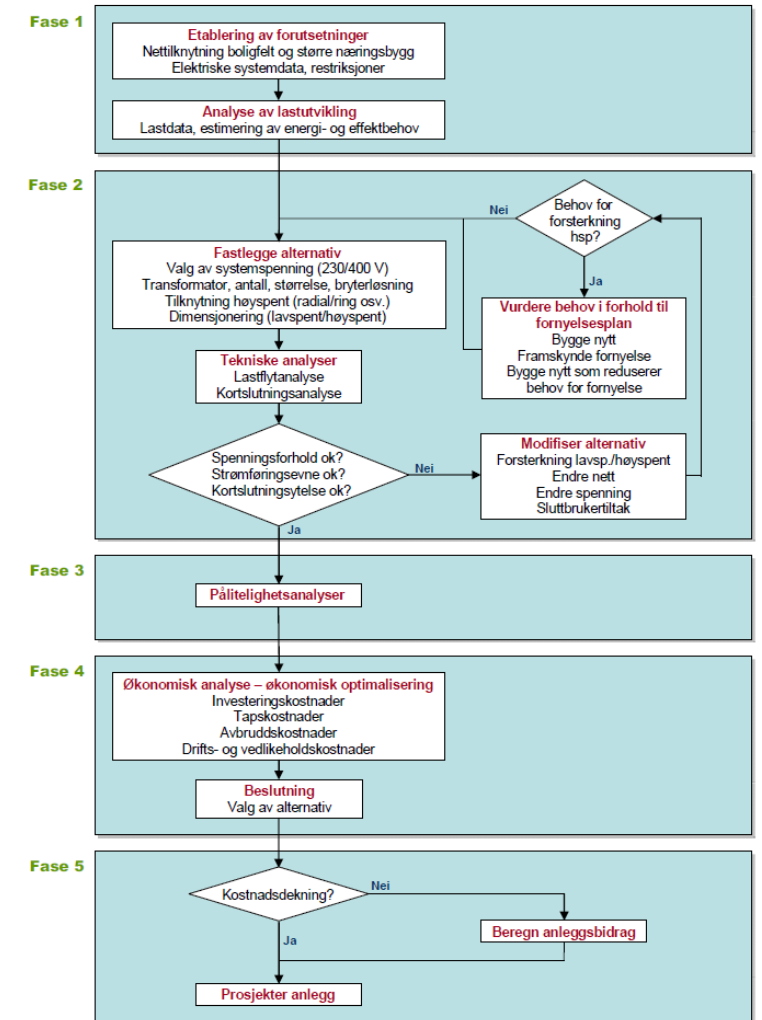
Sources:

- I. B. Sperstad, et al., "Cost-Benefit Analysis of Battery Energy Storage in Electric Power Grids: Research and Practices," *ISGT-Europe 2020*. Available online: <https://hdl.handle.net/11250/2723848>.
- I. B. Sperstad, E. Solvang, and O. Gjerde, "Framework and methodology for active distribution grid planning in Norway", *PMAPS 2020*, 2020. Available online: <https://hdl.handle.net/11250/2689734>.
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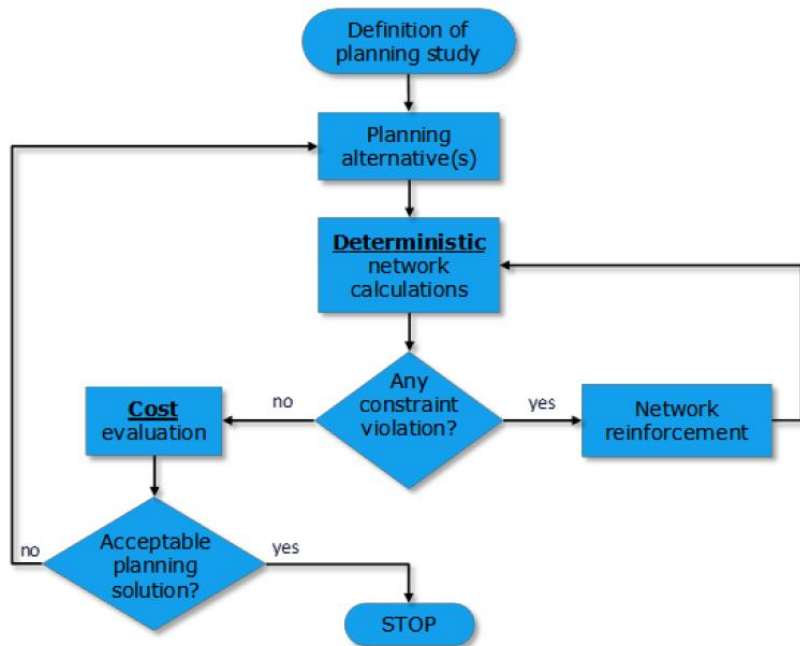
# Background: The traditional framework for grid planning in Norway

- Described in the Norwegian grid planning handbook
  - Reference: SINTEF Energy Research, "Handbook for grid planning" [Norwegian: "Planleggingsbok for kraftnett"]. REN / SINTEF Energy Research, 2021. <https://www.ren.no/tjenester/planbok>
- Framework (or "systematikk" in Norwegian) for distribution grid planning
  - Still mostly describing traditional grid planning processes

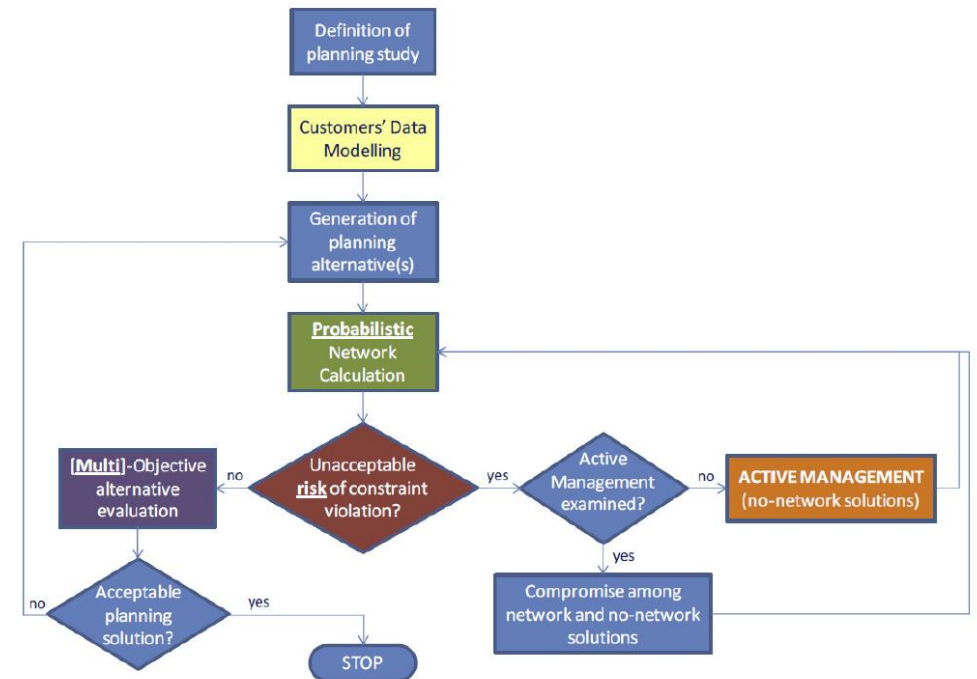


# Background: International research

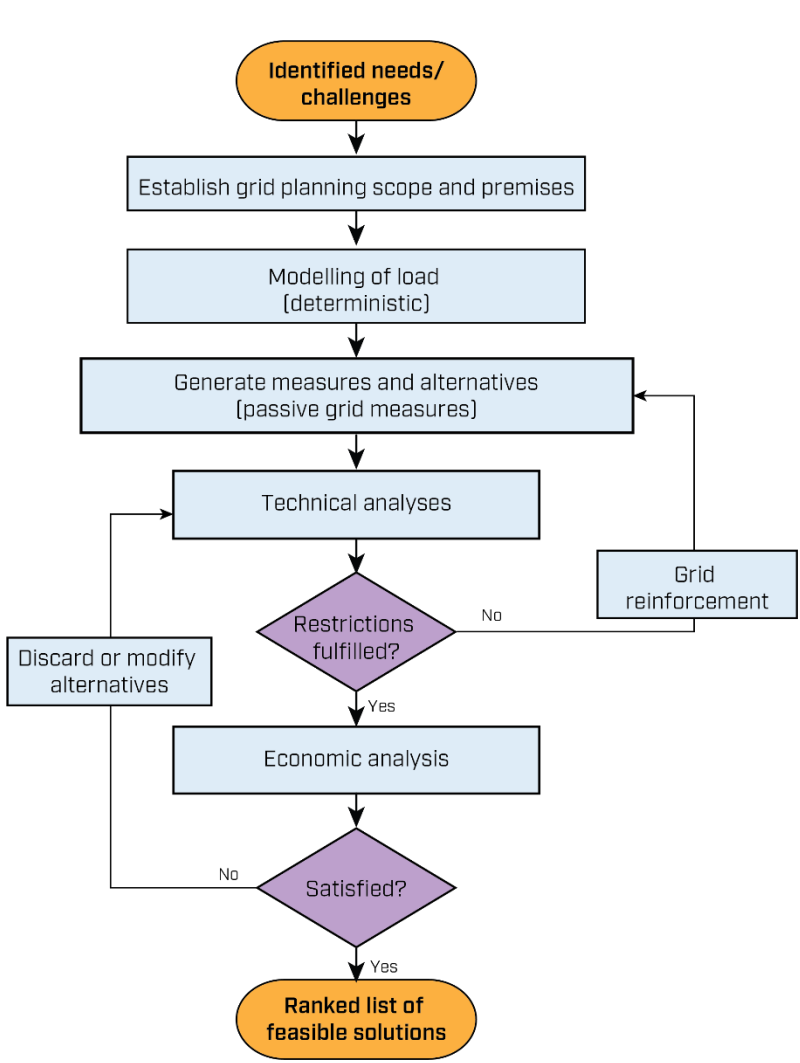
## Passive distribution grids:



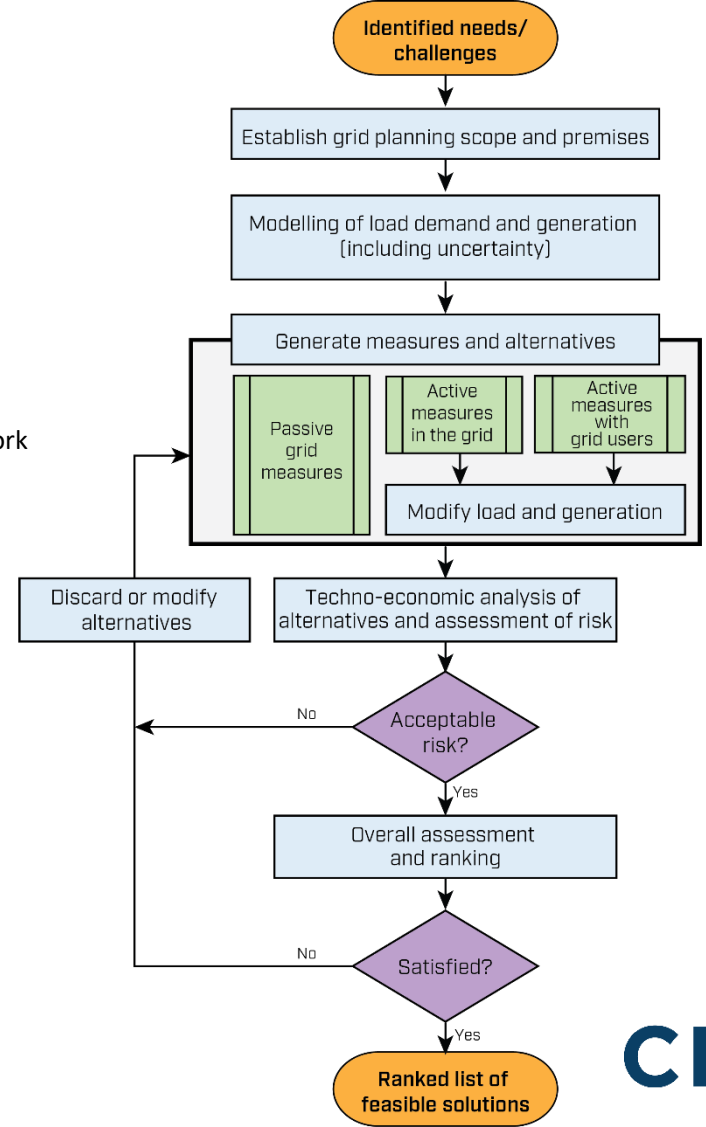
## Active distribution grids:



# Framework for planning of active distribution grids

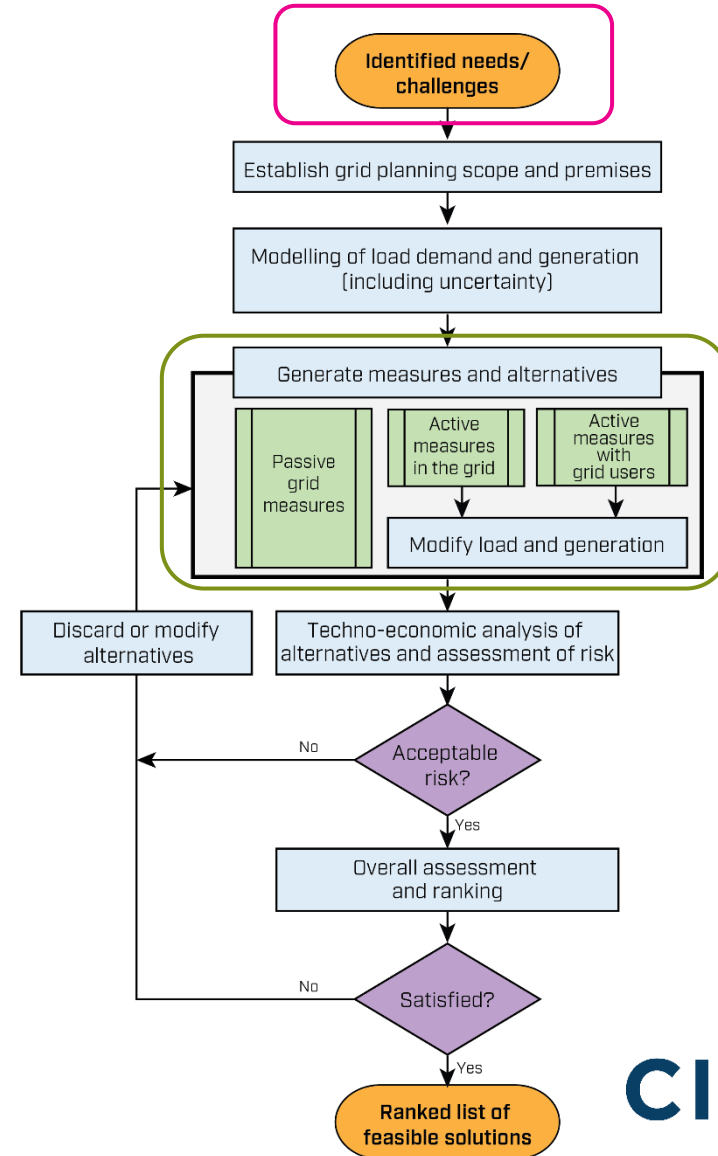
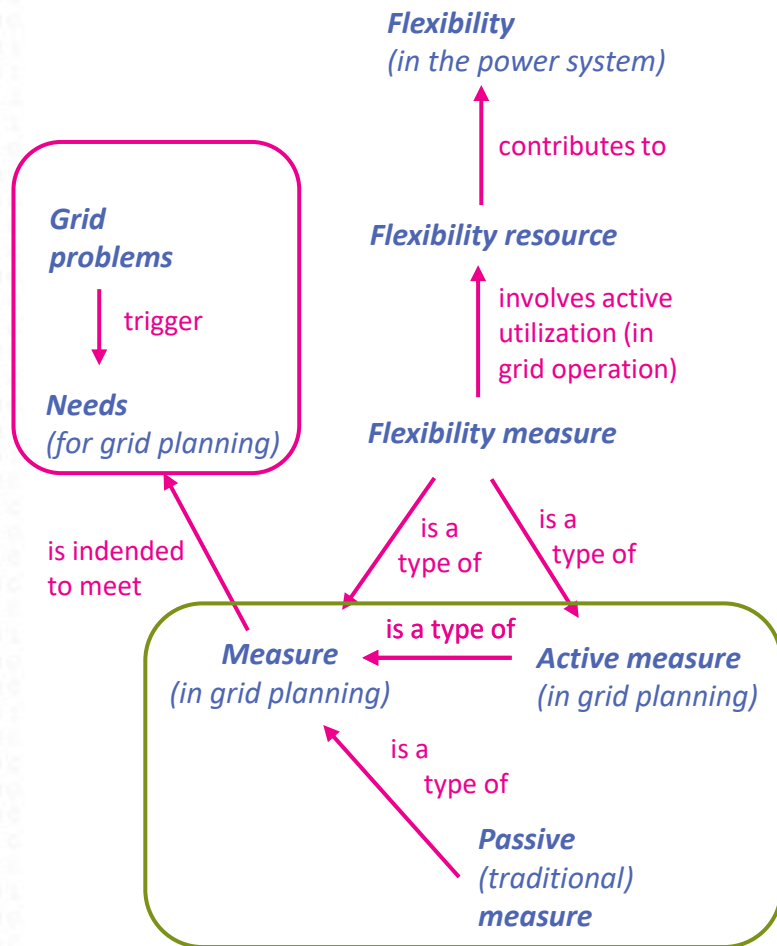


(building upon the work of CIGRÉ WG C6.19)



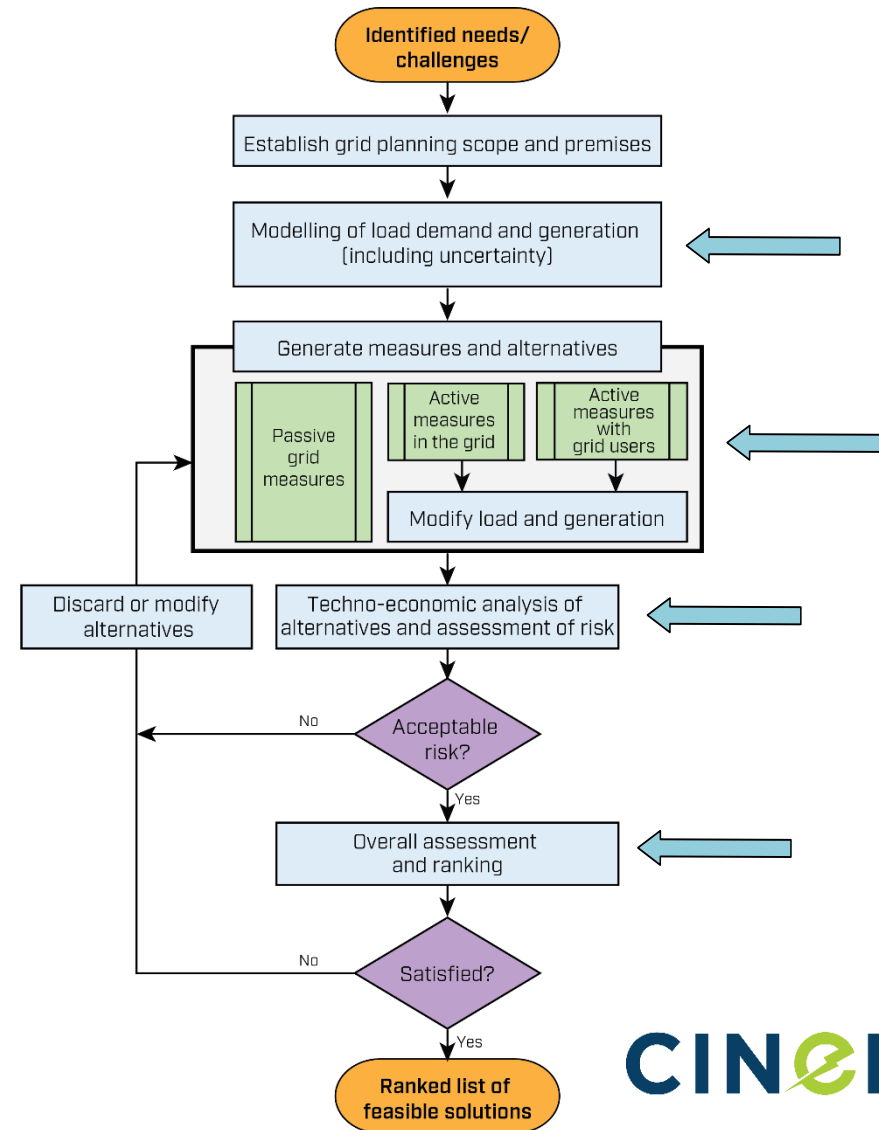


# Framework for planning of active distribution grids

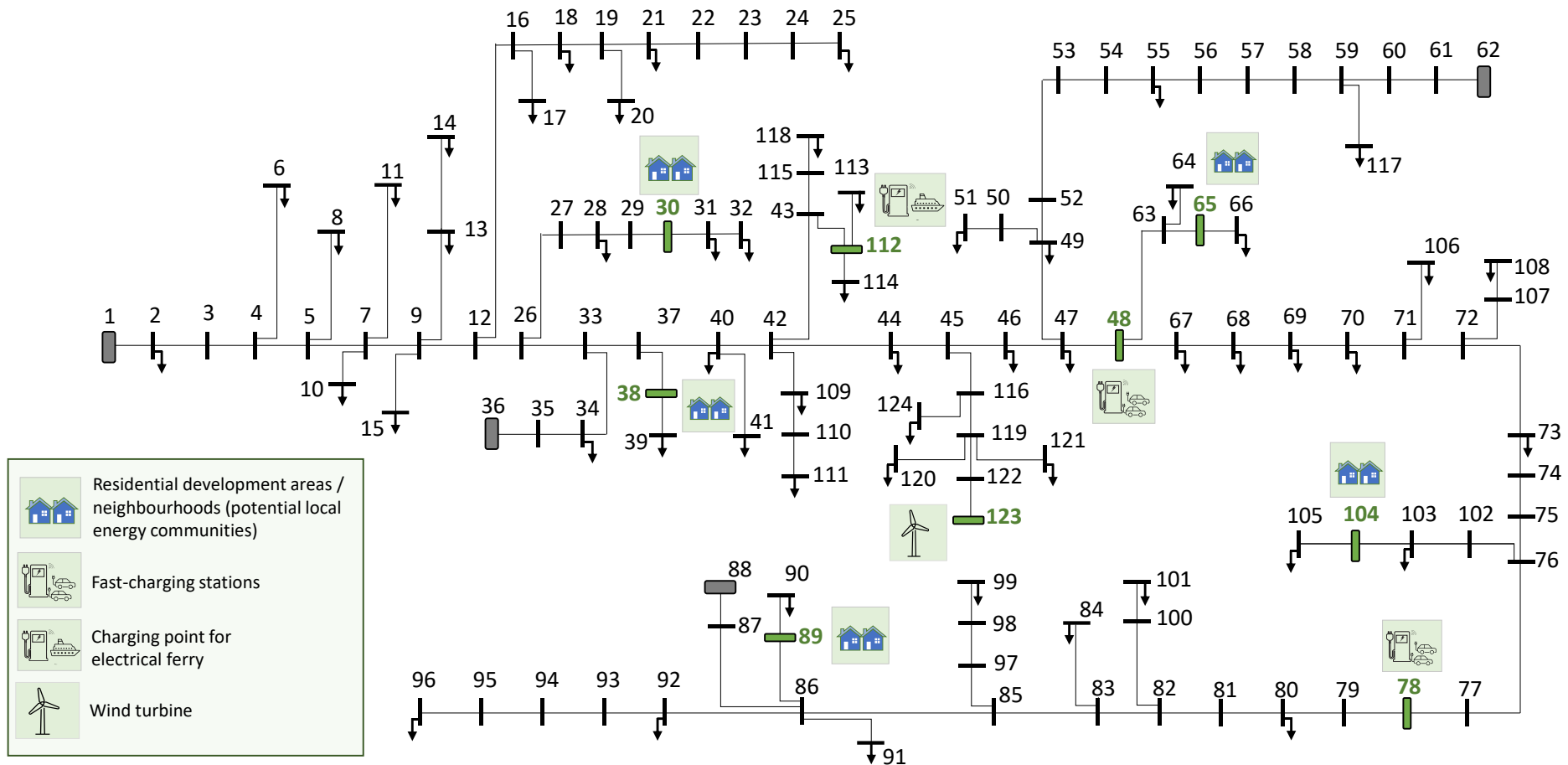


# Framework for planning of active distribution grids

- A framework...
  - gives structure to the planning process
  - gives high-level guidelines (illustrated as flow chart)
  - (In Norwegian: "systematikk")
- A framework is *not* a specific methodology, method, model or tool
  - but different methods, models and tools can be integrated into each step of the framework



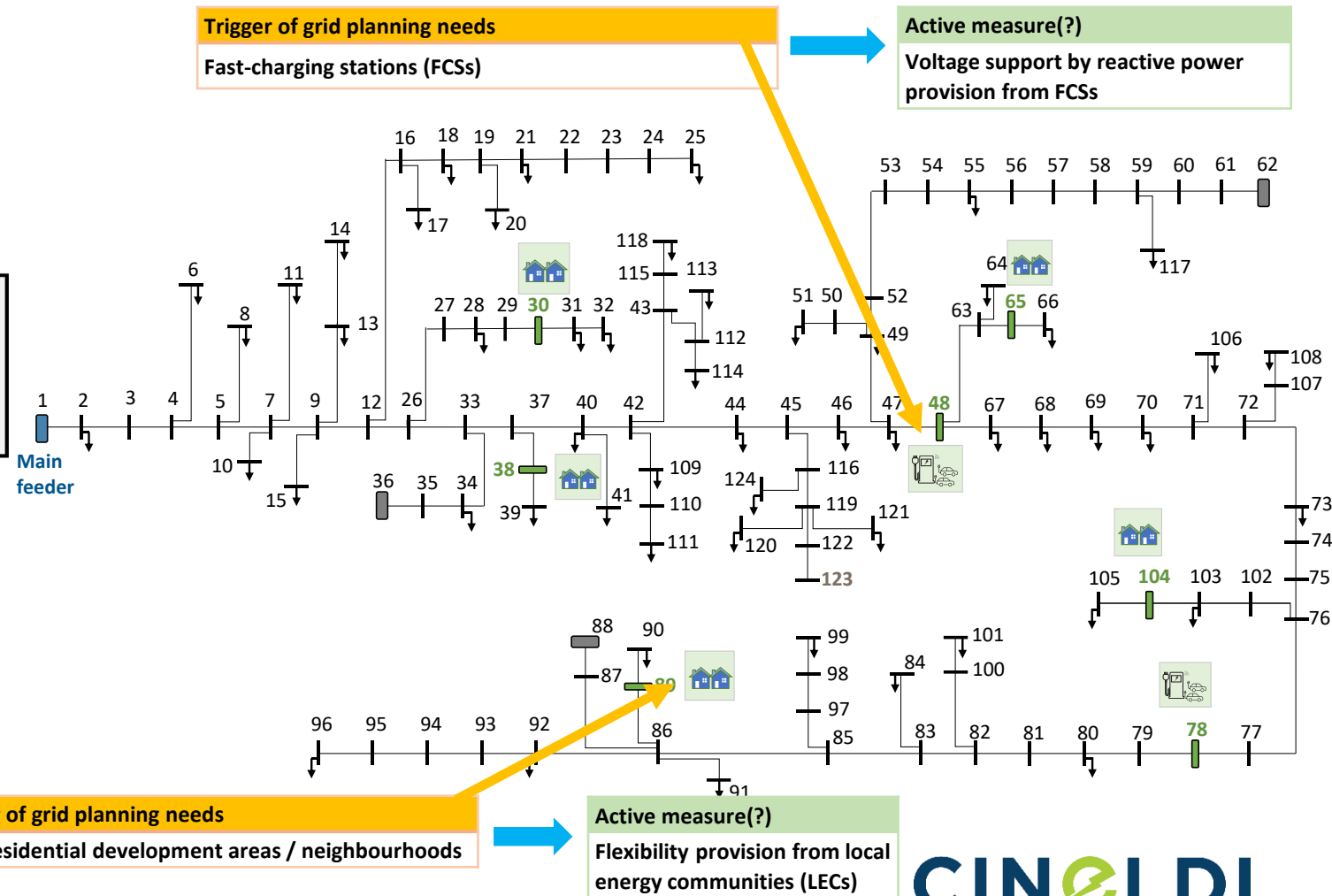
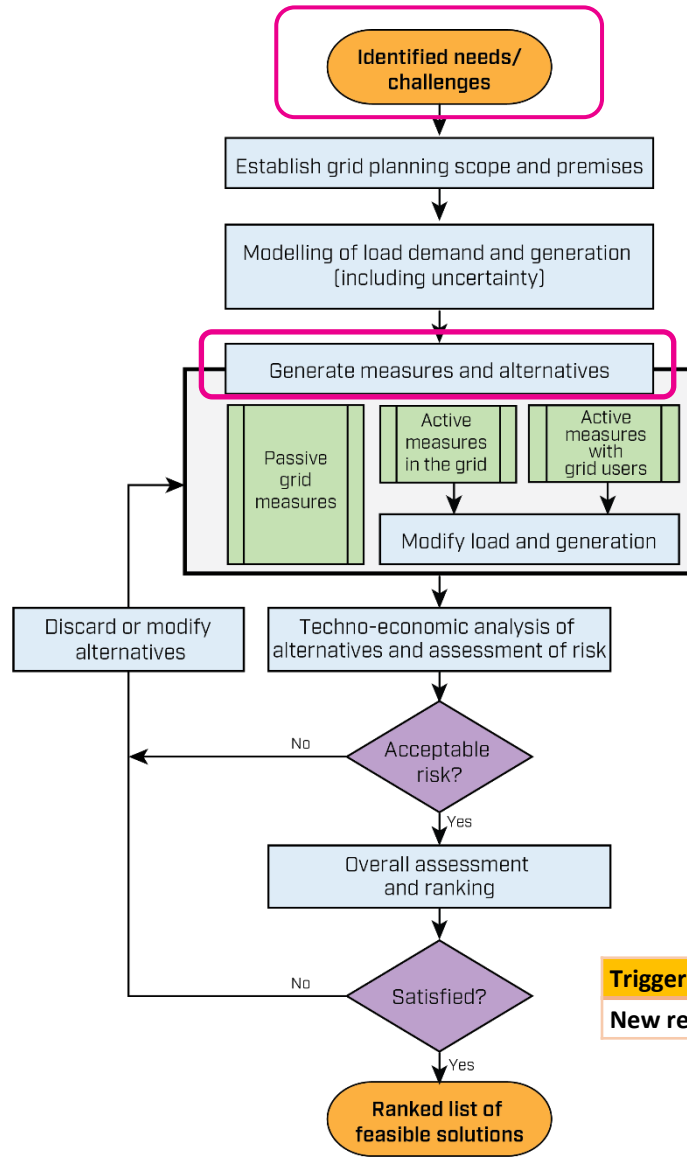
# Case for the CINELDI MV reference system



Source: I. B. Sperstad, O. B. Fosso, S. H. Jakobsen, A. O. Eggen, J. H. Evenstuen, and G. Kjølle, "Reference data set for a Norwegian medium voltage power distribution system", *Submitted to Data in Brief for peer review*, 2022. Data set and preprint version available online: <https://doi.org/10.5281/zenodo.7133506>.

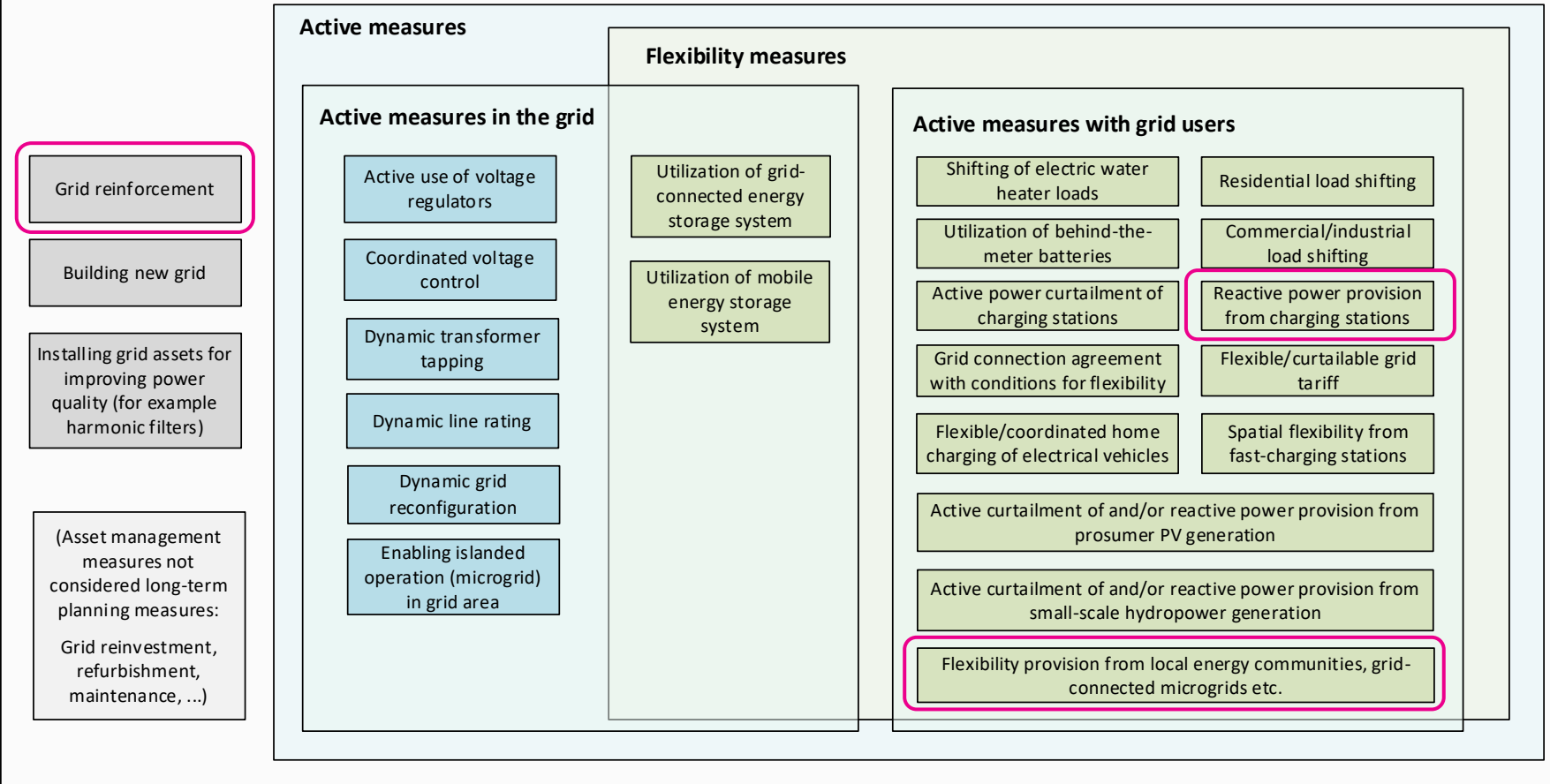


# Selecting active measures

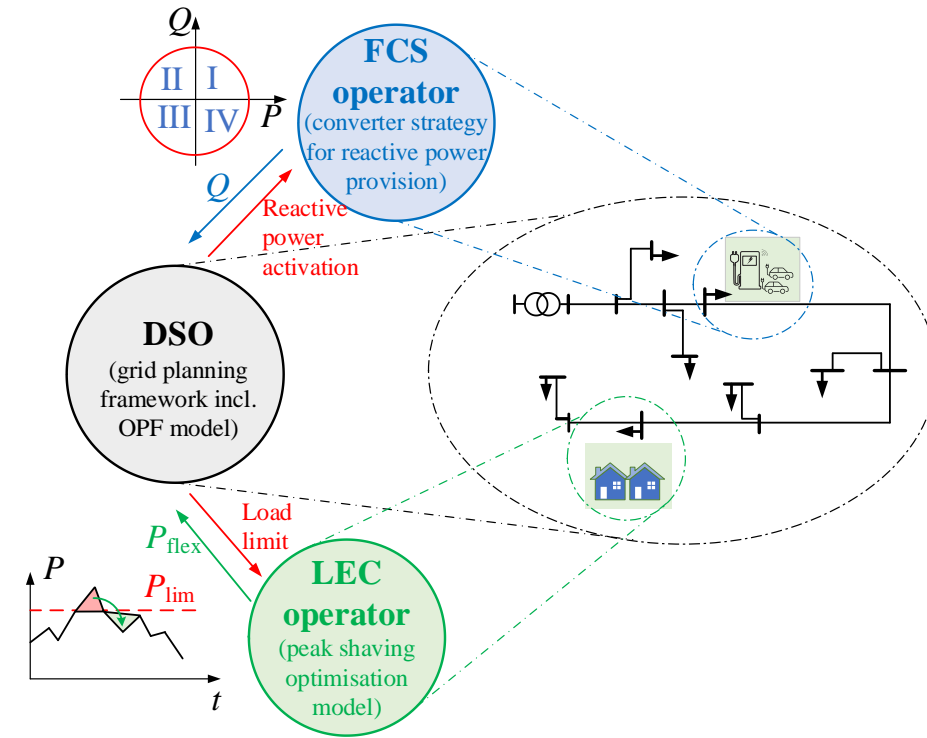
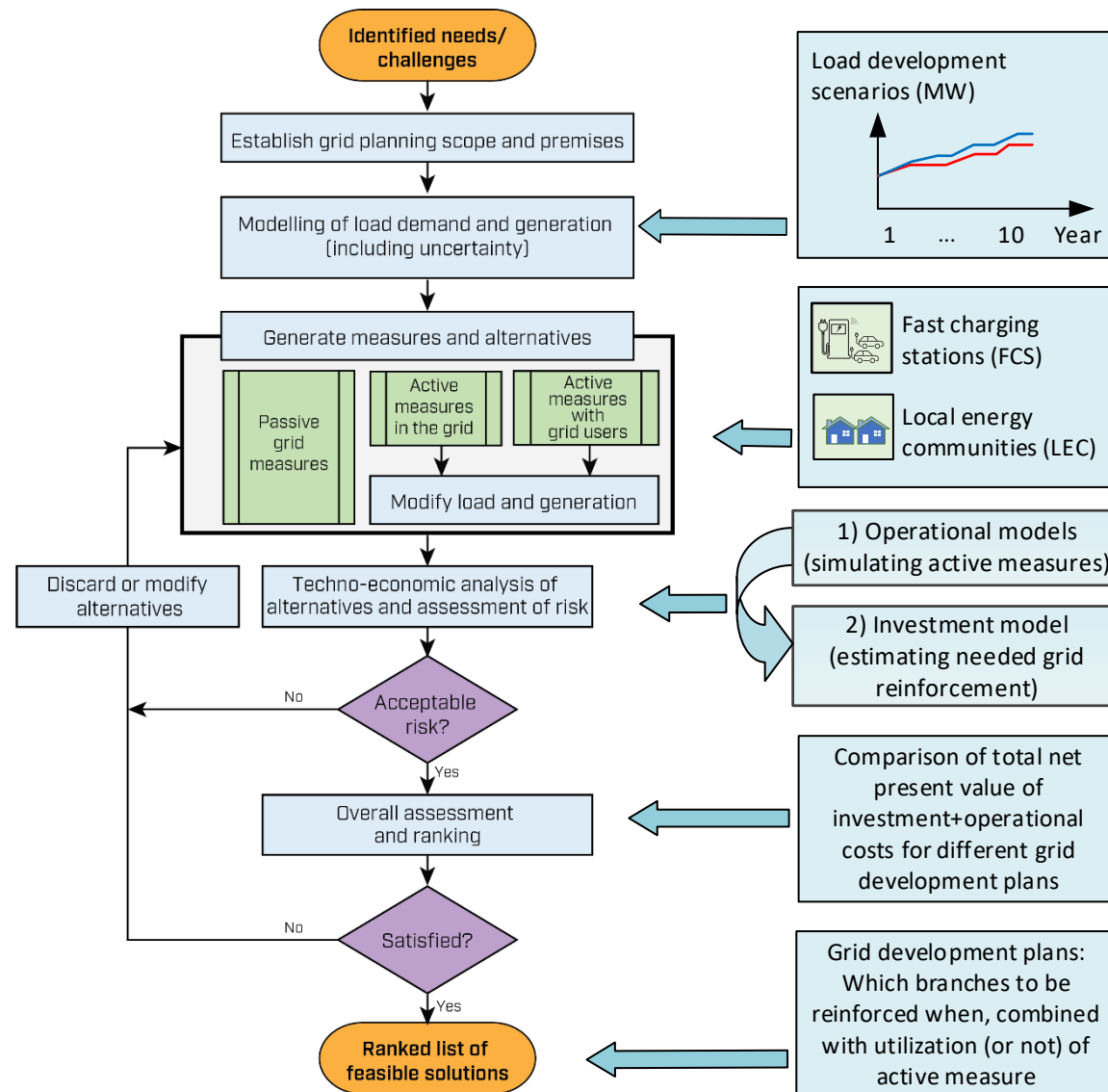


# Active measures

## Measures the planning of distribution grids



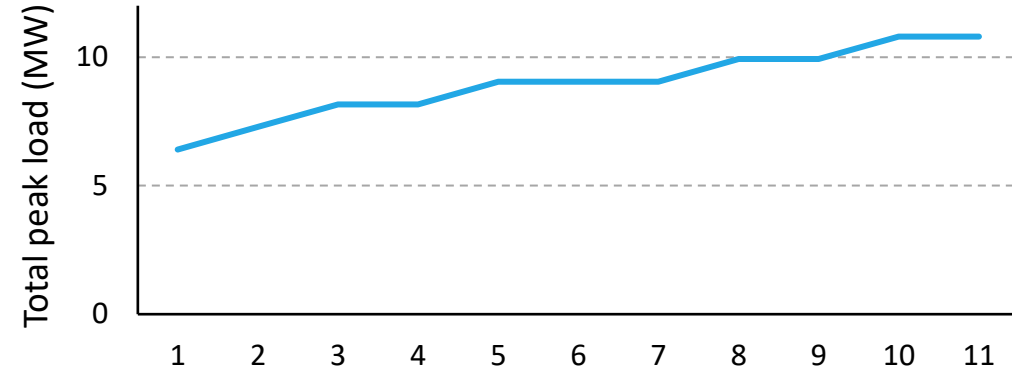
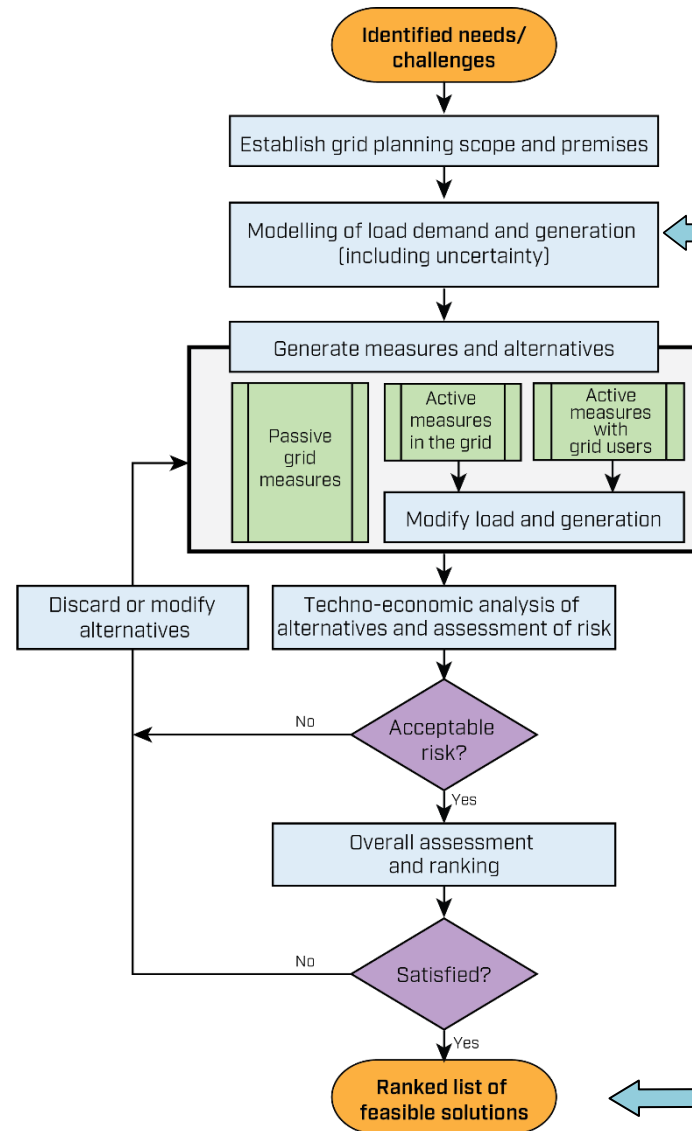
# Framework implementation for case



Source: R. Rana, I. B. Sperstad, B. N. Torsæter, and H. Taxt, "Economic Assessment of Integrating Fast Charging Stations and Energy Communities in Grid Planning", *manuscript to be submitted for peer review*, 2022.



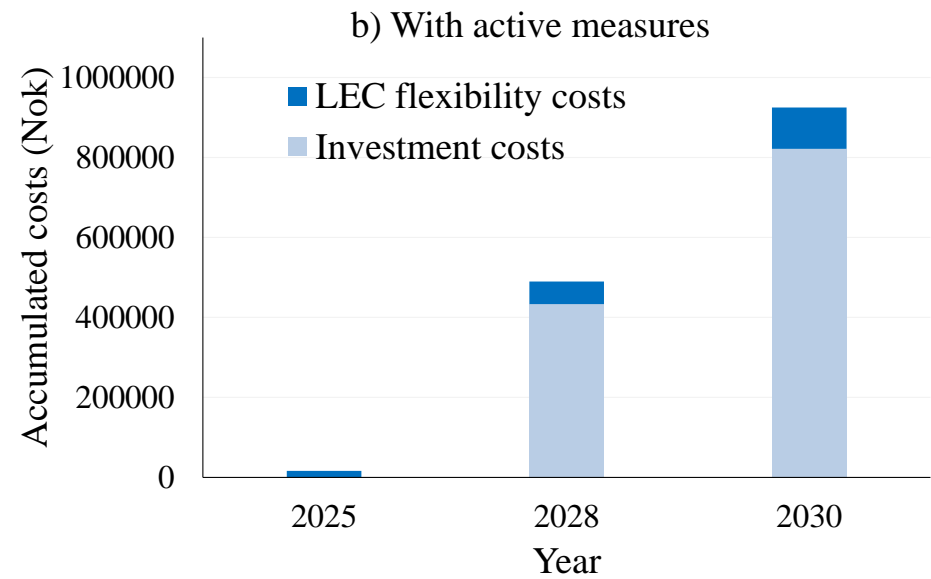
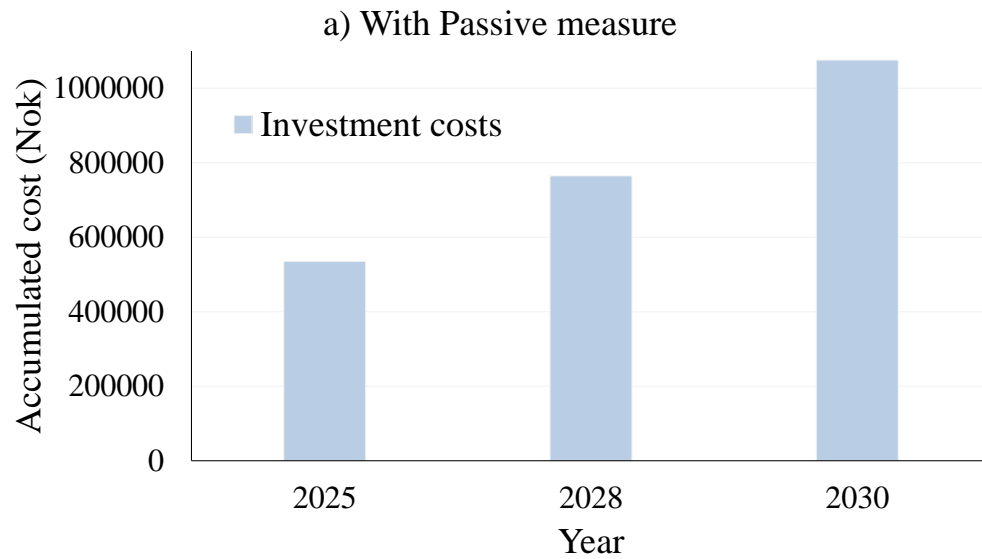
# Framework implementation for case



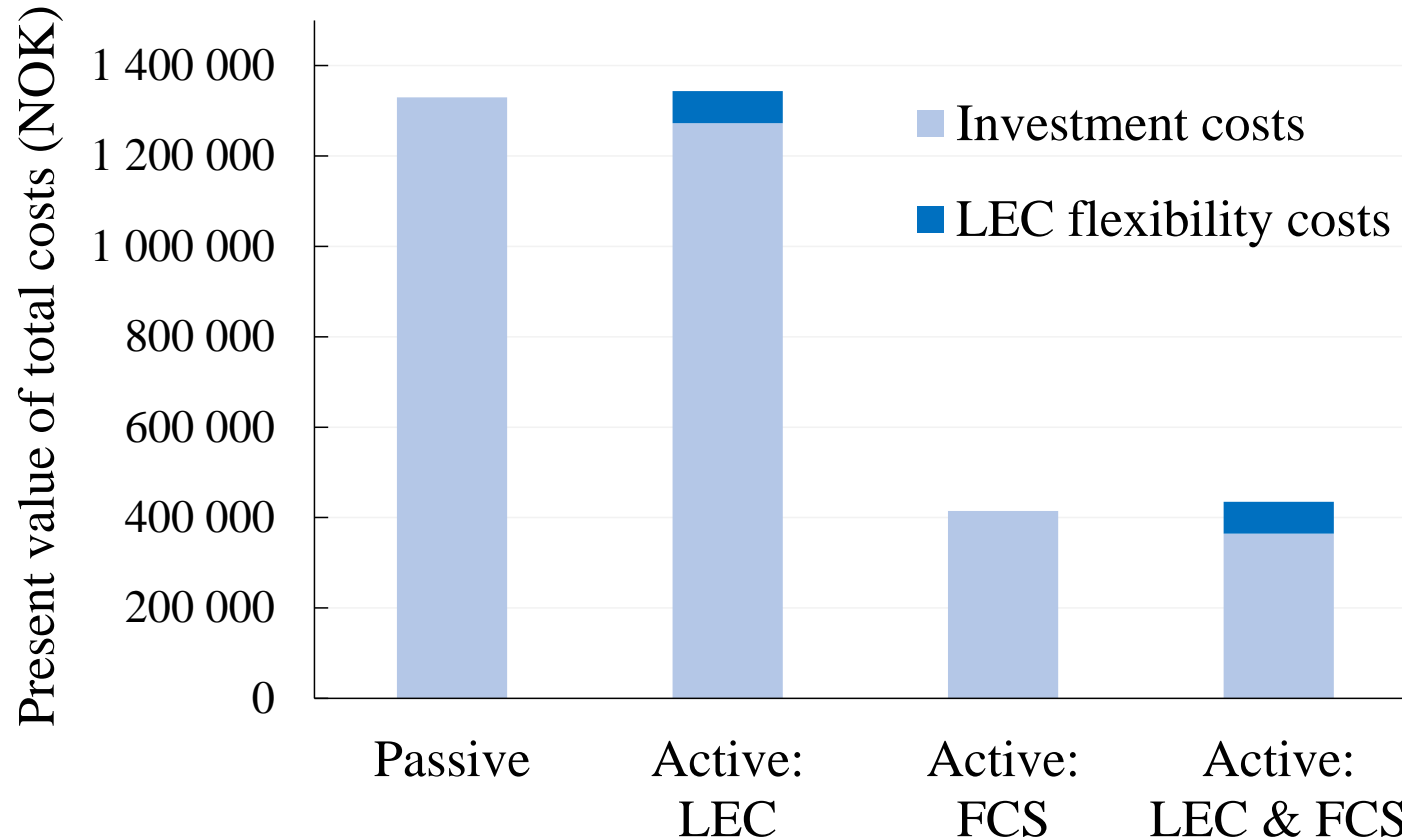
Alternative	Year									
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
...with reinforced branch 5-7, 12-26 and 47-48										
...with reinforced branch 12-26										
Existing grid with active measure (LEC)										
Existing grid										

Grid development plans:  
Which branches to be reinforced when, combined with utilization (or not) of active measure

# Reducing grid investments by active measures utilizing local energy communities



# Combinations of active measures: Local energy communities (LEC) and fast-charging stations (FCS)





# Summary

- Framework for planning of active distribution grids giving a structure to the grid planning process
- Methodology suitable for the use case can be integrated into the framework
- Challenge: Bridging gap between current practice and research

# Selected references

- I. B. Sperstad, M. Istad, H. Sæle, M. Korpås, I. Oleinikova, et al., “Cost-Benefit Analysis of Battery Energy Storage in Electric Power Grids: Research and Practices,” *ISGT-Europe 2020*, 2020. Available online: <https://hdl.handle.net/11250/2723848>; additional details: <http://dx.doi.org/10.6084/m9.figshare.9917945>).
- I. B. Sperstad, E. Solvang, and O. Gjerde, “Framework and methodology for active distribution grid planning in Norway,” *PMAPS 2020*, 2020. Available online: <https://hdl.handle.net/11250/2689734>.
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- Contributors (SINTEF/NTNU)

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- EU H2020 project FlexPlan

- Funding:

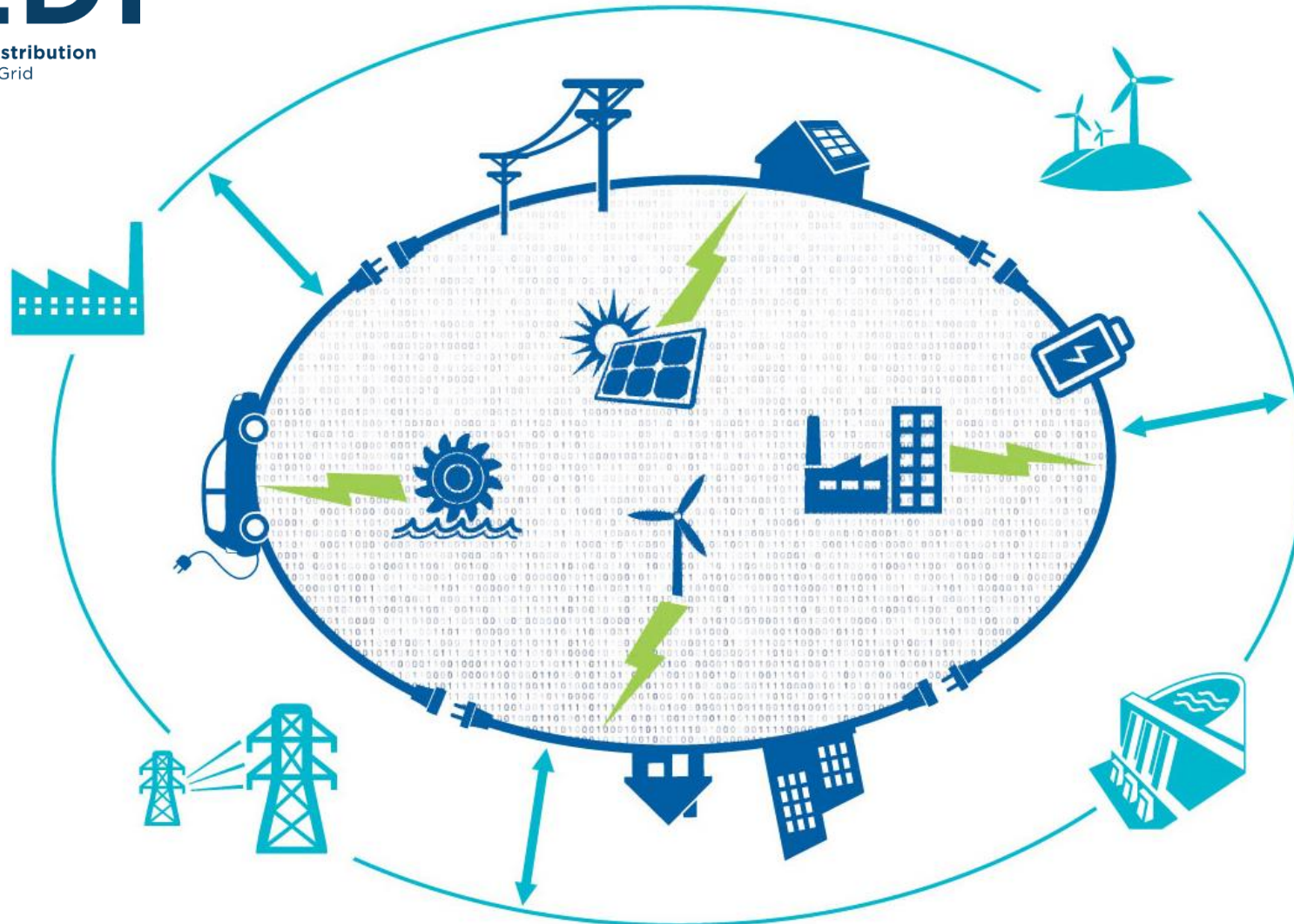
- This work is funded by CINELDI - Centre for intelligent electricity distribution, an 8 year Research Centre under the FME-scheme (Centre for Environment-friendly Energy Research, 257626/E20). The authors gratefully acknowledge the financial support from the Research Council of Norway and the CINELDI partners.
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