



# ISGAN – Annex 3

## Smart grid evaluation toolkit

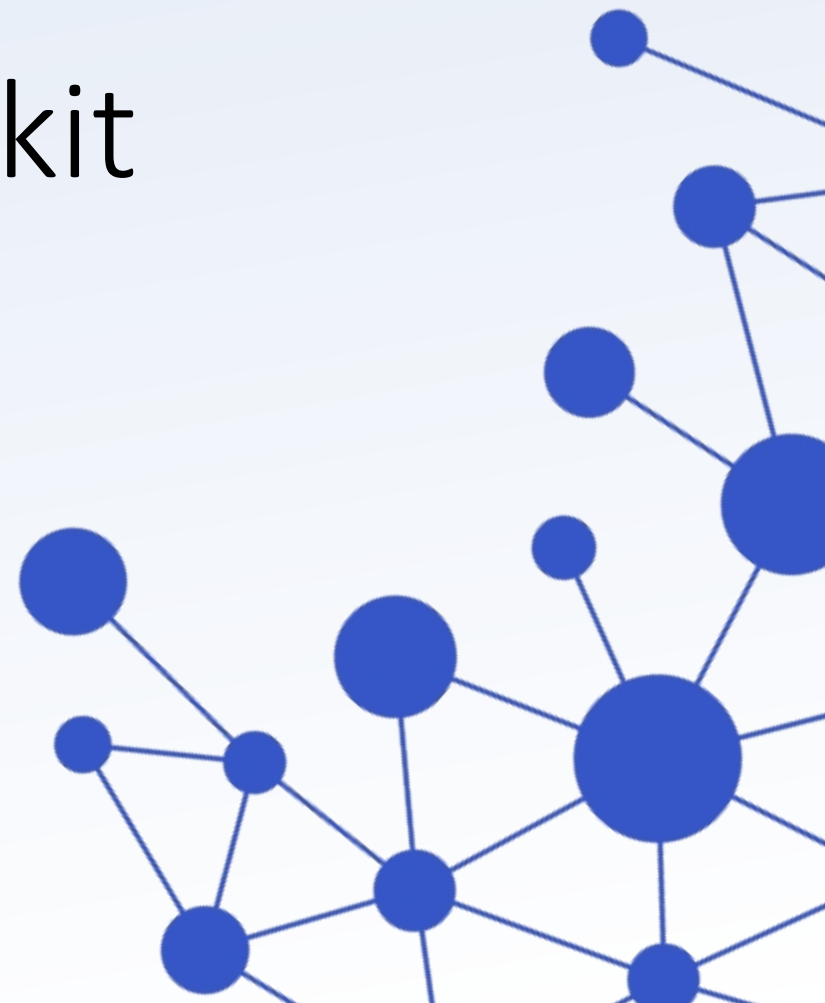
Prof. Fabrizio Pilo, Italy

Matteo Troncia, Italy

Joint ISGAN-MI IC#1 event

International Smart Grid Action Network

Vancouver, Canada, 27-29 May 2019



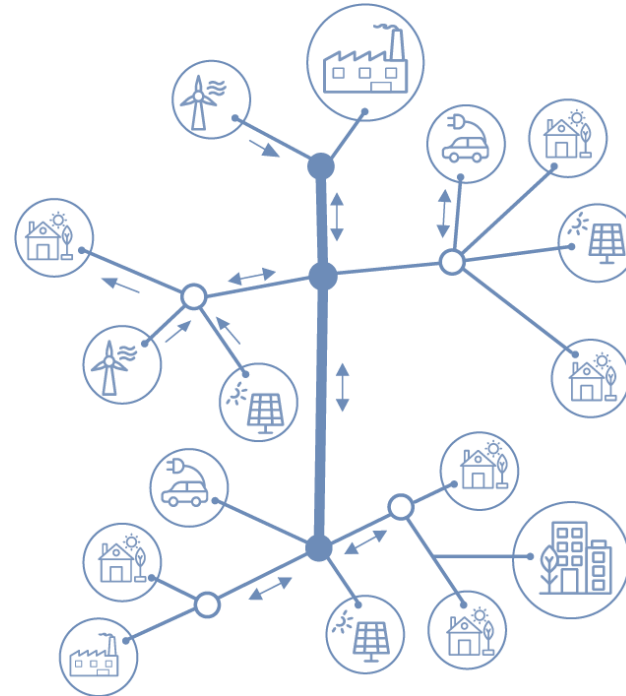
# Context and motivation

Smart grids: impacts span over the power system borders

Novel features and enabled services will produce relevant socio-economic impacts

## Impact characteristics:

- Wide range impacts
- Indirect/side effects
- Intangible impacts
- Lack of data availability
- Data uncertainty



## Implications:

- Not only monetary aspects are of interest
- Identify the impact allocation is difficult
- Quantify all impacts is not possible
- Strategic decision making is under uncertainty

Smart grid planning calls for effective tools for complex decision-making problems

# ISGAN smart grid evaluation toolkit



## Objective:

Provide a **reliable support tool** for orienting the **investments** and the **regulatory policies** on **smart grids**



## ISGAN smart grid evaluation toolkit

- **Decision support tool** for evaluating smart grid projects
- **Combines** Cost Benefit Analysis (**CBA**) and Multi-Criteria Analysis (**MCA**)
- Allows an **output-based** assessment of smart grid initiatives based on an **automated procedure**
- Considers **monetary and non-monetary** impacts
- Includes the **stakeholders' view** in the analysis
- The evaluation can be based on **synthetic weights**



## Smart grid evaluation toolkit



### Login

Username:

Password:

Login



The smart grid evaluation toolkit is part of the ISGAN ANNEX 3 activities. The smart grid evaluation toolkit helps decision makers in identifying the best smart grid planning option. The techno-economic assessment of the alternatives integrates the Cost-Benefit Analysis (CBA) within a Multi-Criteria Analysis (MCA) framework.

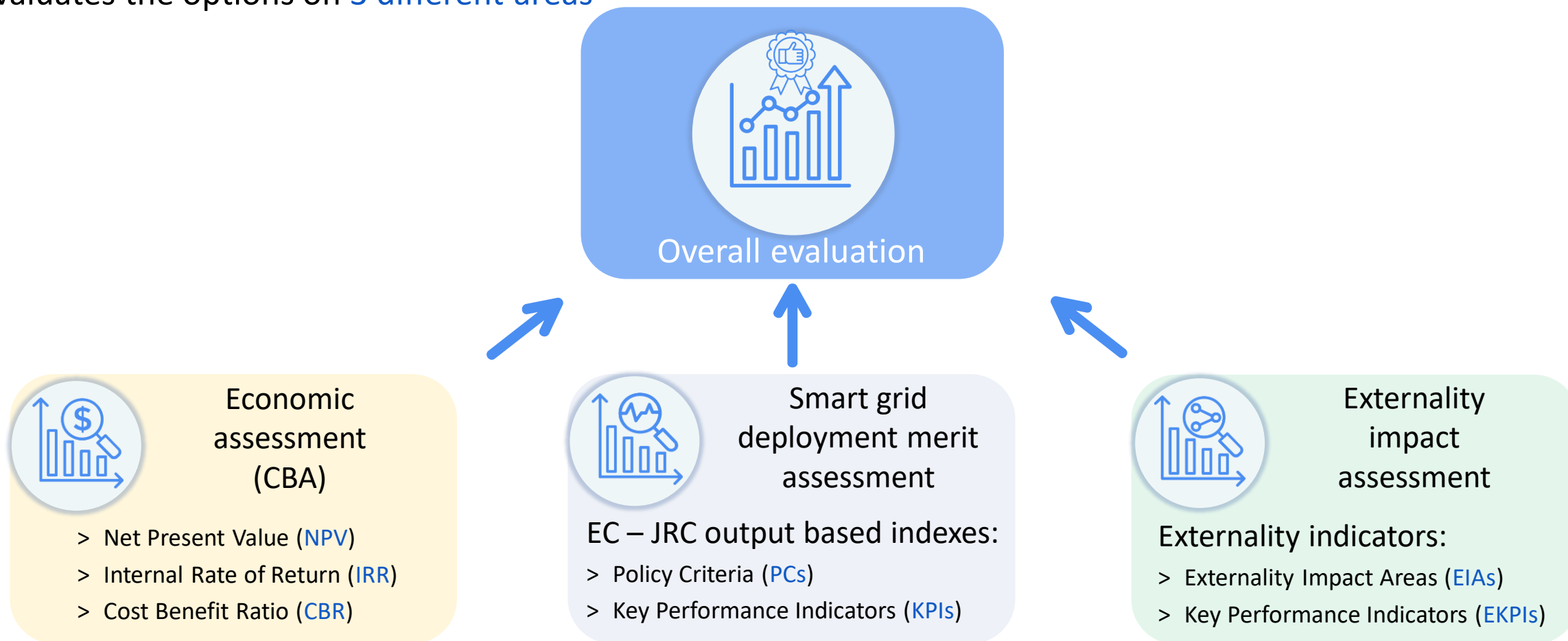
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# Overview of the assessment

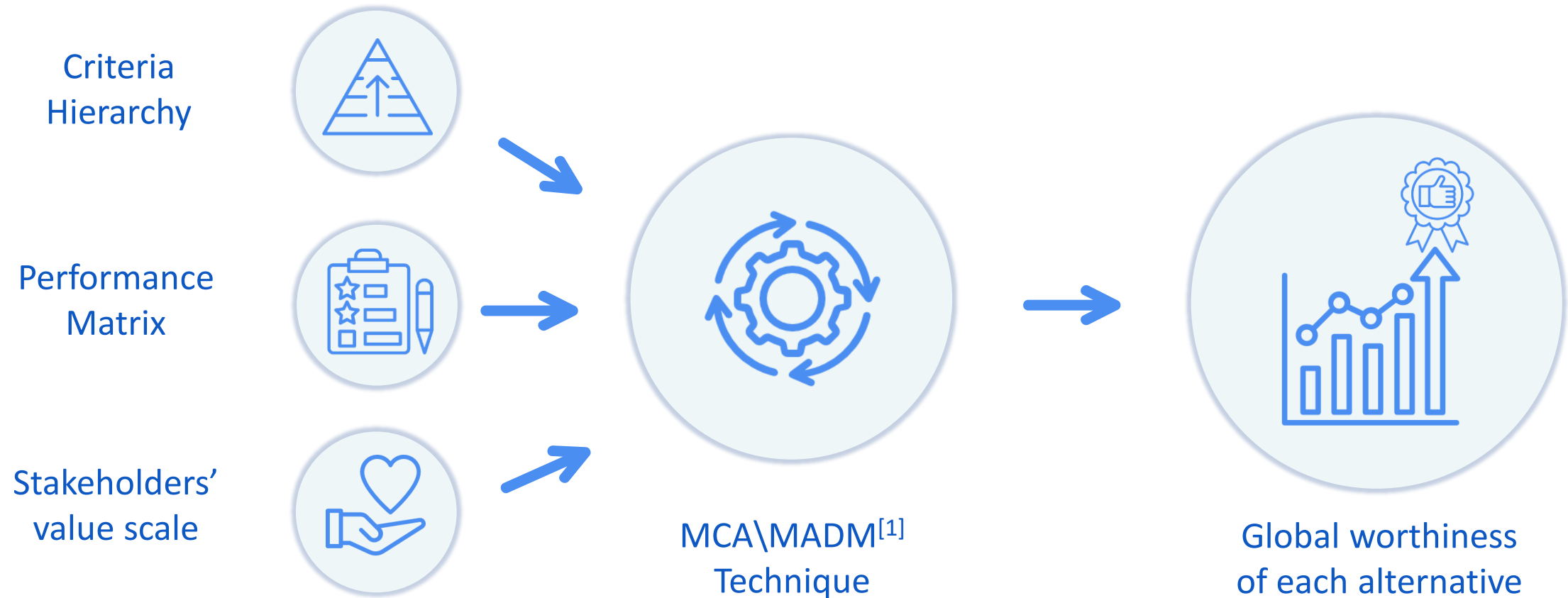
The main goal is to identify the best smart grid option

Complies with international guidelines on project assessment (i.e. EU Joint Research Centre - JRC)

Evaluates the options on 3 different areas



# The evaluation procedure



[1] Multi - Criteria Analysis \ Multi-Attribute Decision Making

## Planning activity management

Choose planning activity:

TestCaseB01\_280319  
TestCaseB02\_280319  
TestCaseC01\_280319  
TestCaseC02\_280319  
TestCaseC03\_280319  
TestCaseDieci\_290319  
TestCaseDieci\_290319\_2  
pa1  
Test06052019\_AEIT  
Test06052019\_AEITb

Load

Delete

← Load an existing planning activity

← Delete an existing planning activity

New planning activity

Clone planning activity

Create a new planning activity:

Templates:

- ☒ Empty  
☐ Template Test  
☐ StorageADN


Create

← Create a new evaluation process

← Clone an existing planning activity

# ISGAN smart grid evaluation toolkit





Welcome, UserZero. [Log out](#)

Current PA: Test Storage [Change PA](#)

## Planning Activity Overview

### Structural parameters

Details

Description:  
test case 01 - it concerns the active network distribution planning with storage devices  
<https://doi.org/10.23919/AEIT.2018.8577399>

Insert description of planning activity.

Tags:  
storage, ADN,  
Insert tags of planning activity separated by comma.

☒ Economic criteria  
☒ Net Present Value: ☐ Internal Rate of Return: ☐ Cost-Benefit Ratio:

☒ Smartgrid criteria  

Criterion	KPI
Network connectivity	Operational flexibility
Supply security and quality	Duration of interruptions
Supply security and quality	Voltage quality
Supply security and quality	Frequency of interruptions
Supply security and quality	System stability
Service and grid operation	Network losses

Network capacity

Select kpi  
DERs capacity  
Maximum power injection  
Energy not withdrawn from DERs

✓ Add

☐ Externalities criteria  
Number of alternatives:   
Weights algorithm: 

Manual weights algorithm

Save structure

Show tree

Eval current PA

Reset

Download planning activity

### Help

- Download templates
- Help palette
- Manage custom palette

### Todo

Load from file or complete the following steps:

- ✓ Structural parameters
- ✓ Branch weights
- ✓ Economic criteria weights
- ✓ Performances on economic criteria
- ✓ Performances on smart grid KPIs

## Dashboard of the evaluation activity

- Simple user interface that guide the user during the evaluation process
- No specific expertise is required
- Only output based data on projects and stakeholder view information is demanded

The user can

- Select and/or define the evaluation criteria
- Define the number of planning alternatives
- Check the evaluation progress
- Save the defined structure
- Watch the defined criteria tree
- See the evaluation result

27-29 May 2019

Joint ISGAN-MI IC#1 event

8

# Building the tree of criteria

The **evaluation criteria** can be selected from the **default palette** and the **custom palette**

Tree of criteria is **interactive** and **responsive**

Gives an **overview of the whole hierarchy**

## ☒ Economic criteria

☒ Net Present Value:

☐ Internal Rate of Return:

☐ Cost-Benefit Ratio:

## ☒ Smartgrid criteria

Criterion	KPI
Network connectivity	Operational flexibility
Supply security and quality	Duration of interruptions
Supply security and quality	Voltage quality
Supply security and quality	Frequency of interruptions
Supply security and quality	System stability
Service and grid operation	Network losses



Network capacity

Select kpi

Add

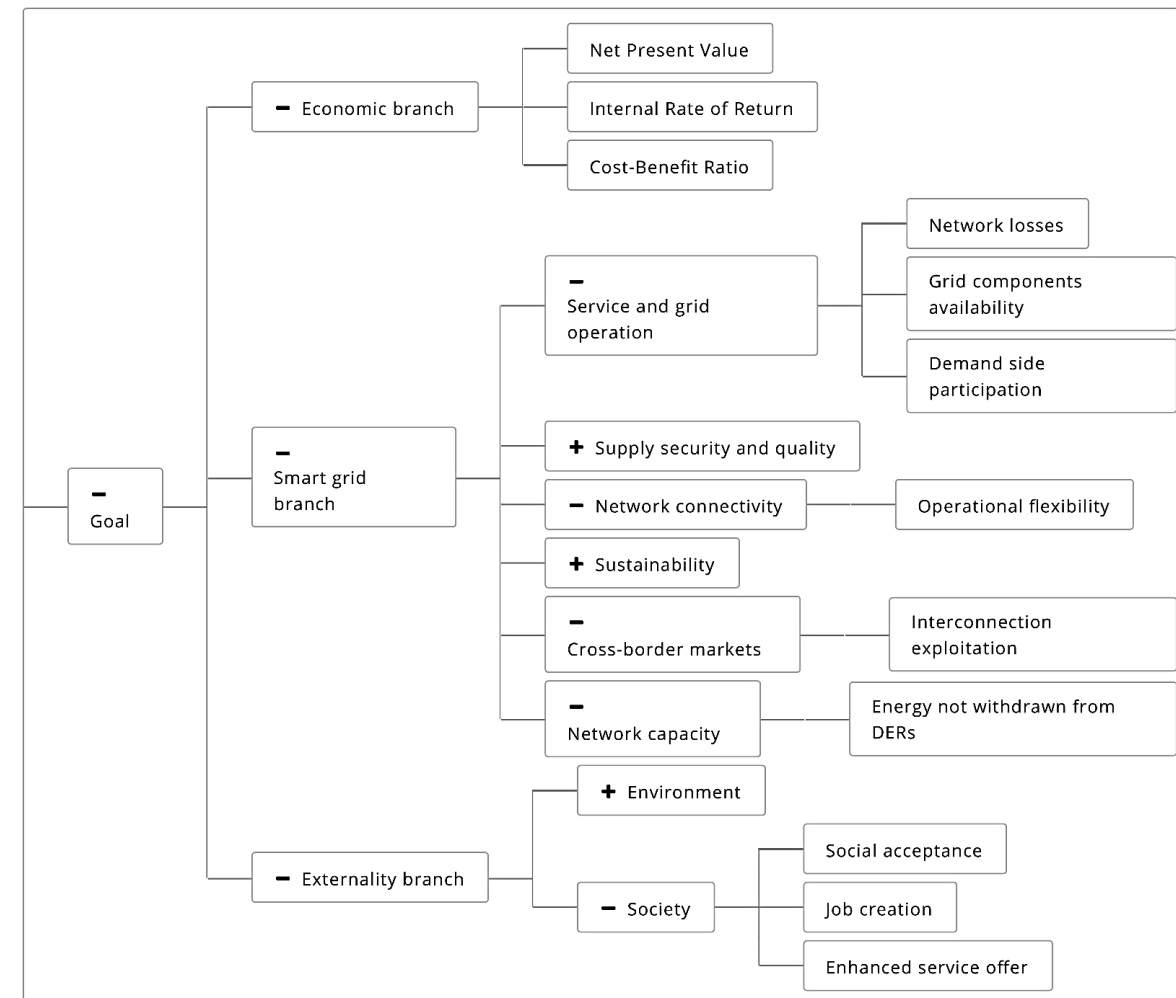
DERs capacity  
Maximum power injection  
Energy not withdrawn from DERs

## ☐ Externalities criteria

Number of alternatives:

5

## Tree of criteria





# Scoring of the alternatives

## Performances on smart grid KPIs

### Quantitative scoring

Quantitative scoring: Choose file No file chosen

Done

### Qualitative scoring

#### Service and grid operation

Grid components availability

	Alt1	Alt2	Alt3
Alt1	1	Select a value	1
Alt2	1	9	1
Alt3	1	8	1

> Network losses

Submit

Back

The **evaluation of each criterion** can be based on

- Quantitative performance **indicators**

by loading **spreadsheets**



or

- A **qualitative assessment** of the performances based on the **AHP<sup>[1]</sup> pairwise comparison**

[1] T. L. Saaty, 'How to make a decision: The analytic hierarchy process', *Eur. J. Oper. Res.*, vol. 48, no. 1, pp. 9–26, Sep. 1990.

# Weighting the evaluation criteria

Weights of the criteria can be assigned manually

by attributing the local priority vector or by using the Saaty's preference matrix <sup>[1]</sup>

## Main criteria weights

economic branch: 1,1741    Smart grid branch: 0,4013    Externality branch: 0,4246

Done Cancel

## Matrix weights

### First level

	Society	Environment
Society	1	1
Environment	1	1

Or can be calculated according to selected algorithms on the basis of the performances of the alternatives

Weights algorithm: Hybrid entropy weights

Weights algorithm type: Product

Weights algorithm alpha: 0,5

## Weighting algorithms:

- Entropy weights
- Standard deviation weights
- Ideal Point weights
- Hybrid weighting

[1] T. L. Saaty, 'How to make a decision: The analytic hierarchy process', *Eur. J. Oper. Res.*, vol. 48, no. 1, pp. 9–26, Sep. 1990.

# Results of the evaluation

## Overall ranking

[Download output file](#)

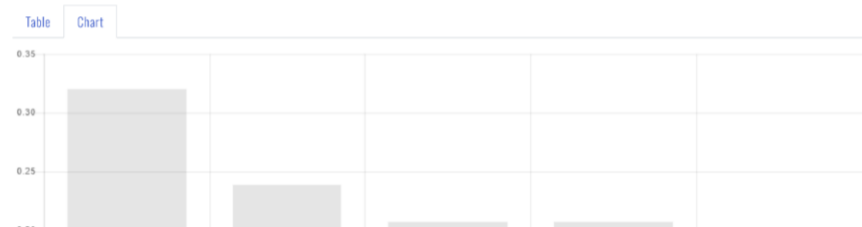


## Overall ranking for synthetic weights

Table Chart

	Alternatives	Scores
1	alt5	0.2698
2	alt3	0.2419
3	alt4	0.2392
4	alt2	0.2224
5	alt1	0.0267

## Economic branch partial ranking



Each alternative obtains an **overall score** which depends on its **merit** on the evaluation criteria

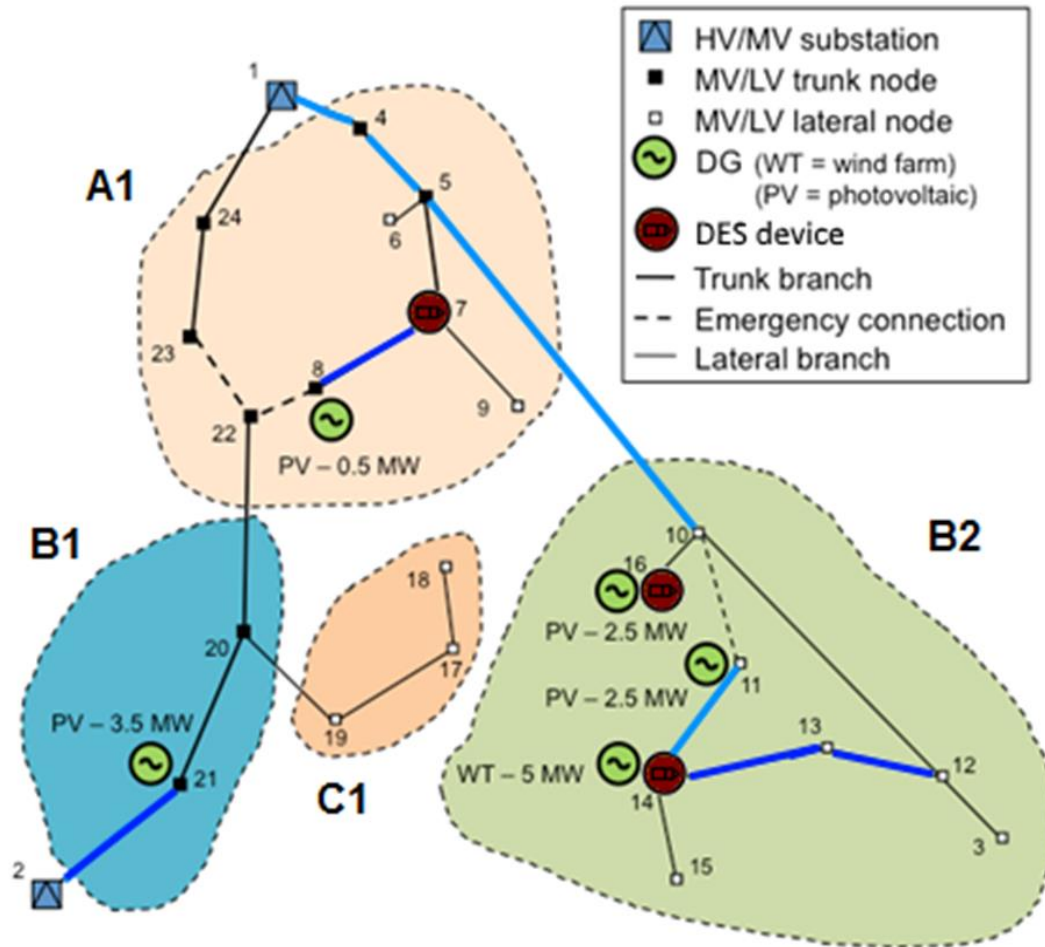
The **Best alternative** has the **Highest score**

Outcome:

- Overall ranking according to **subjective weights**
- Overall ranking according to **objective weights**
- Overall ranking according to **combined weights**
- Partial ranking according to **each branch**
- Flat weights for the **terminal criteria**
- **Stability index** of the first position in the ranking

Brief and **extensive information** for the decision maker

# Case study: distribution grid planning of a MV rural grid



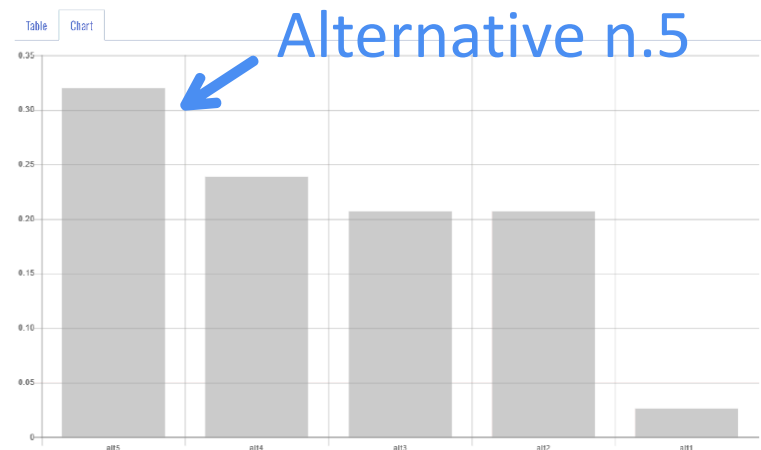
Evaluation of several **Active Distribution Network (ADN)** planning options devised by a multi-objective algorithm (NSGA-II)

Each considered planning option consists in:

- traditional **network reinforcement**
- siting and sizing of **distributed energy storage (DES)**
  - Time horizon: 10 years
  - Topology of the network is fixed
  - Load growth rate: 3% for each bus
  - Operation is evaluated by a probabilistic load flow

# Results for the case study

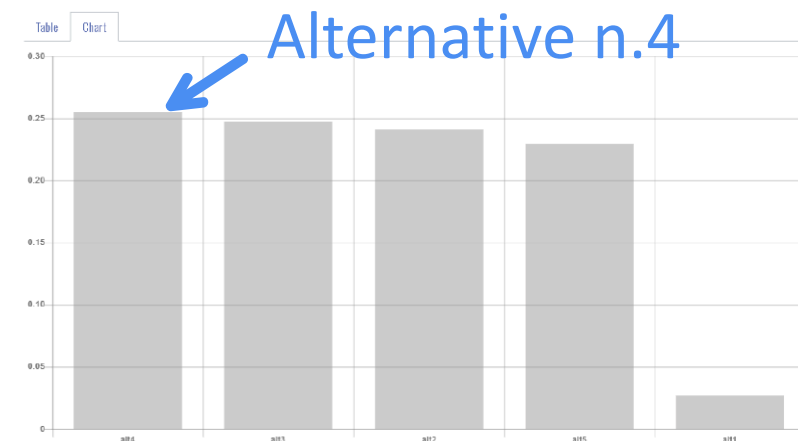
Economic branch partial ranking



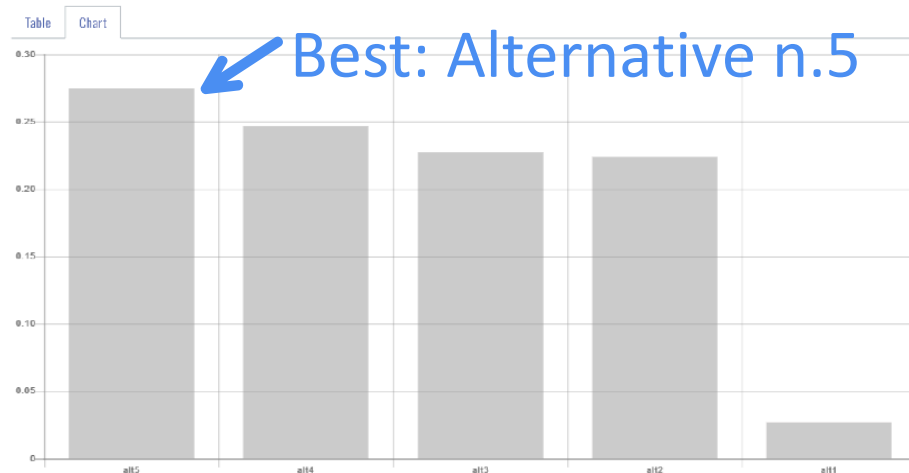
DES Topology information

Alt.	Bus equipped with DES	P <sub>DES</sub> [kW]	E <sub>DES</sub> [kWh]
A_1	No DES	0	0
A_2	7	100	100
A_3	14	200	400
A_4	16	100	100
A_5	14	100	100

Smartgrid branch partial ranking

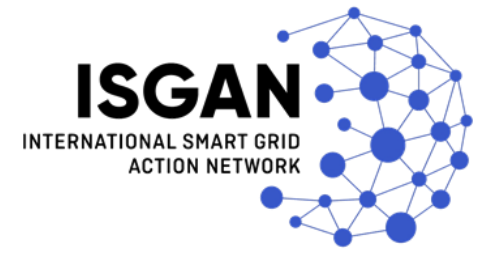


Overall ranking



[Download output file](#)

# ISGAN smart grid evaluation toolkit



## The ISGAN smart grid evaluation toolkit:

- Provides a **simple framework** for project assessment with the aim to overcome the gap between users and tools
- **Promotes data sharing** about smart grid initiatives for improving the effectiveness of the assessment frameworks

The aim is to develop an

**open structure** for **sharing data**, **point of views**, and **results**  
build a **collaborative community** for promoting the smart grid development by **supporting the strategic decision making** of government bodies and companies

# How to get it?



Request [your invitation code](mailto:info.smartgrideval@gmail.com) by writing at: [info.smartgrideval@gmail.com](mailto:info.smartgrideval@gmail.com)



Check your e-mail, in a while you will receive [your personal invitation code](#)



Go to the website: <http://smartgrideval.infora.it/>



Log-in in the website with username: [smartgrideval](#) and password: [smartgrideval](#)

Signup

Click on the [Signup](#) button



Fill the gaps in the [Signup](#) page

Signup

Click on the [Signup button](#) on the bottom of the [Signup](#) page



Registration completed, you can log-in with your credentials at: <http://smartgrideval.infora.it/>

# Thank you

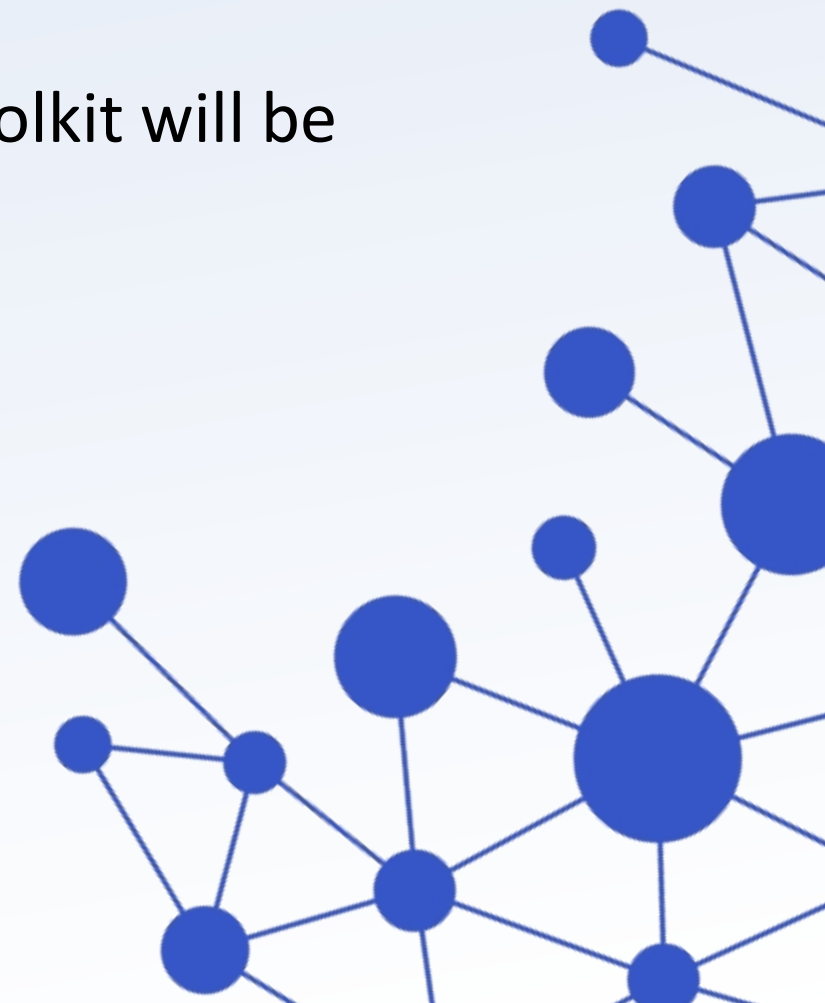
A webinar on the ISGAN smart grid evaluation toolkit will be available soon...

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