# Evaluation of policies and incentive actions to foster technological innovations in the electricity sector
# - structuring criteria

Carlos Henggeler Antunes [1,3], Luís Dias [2, 3], Guilherme Dantas [4], João Mathias [5], Lucca Zamboni [6]

1 Dept. of Electrical and Computer Engineering, University of Coimbra, Portugal, ch@deec.uc.pt
2 Faculty of Economics, University of Coimbra, Portugal, lmcdias@fe.uc.pt
3 INESC Coimbra, Coimbra, Portugal
4 GESEL, Federal University of Rio de Janeiro, Brazil, guilhermecrvg@yahoo.com.br
5 GESEL, Federal University of Rio de Janeiro, Brazil, mathias@ie.ufrj.br
6 EDP Brasil, Brazil, lucca.zamboni@edpbr.com.br

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# The context

Sustainable and reliable electricity system: evolution to smart grids, demand side management, increase of distributed (micro-)generation, diffusion of electric mobility, introduction of storage systems.

Technological development vectors represent new business opportunities: should be considered by regulation guidelines to make viable the smart grids evolution process in the pursuit of technical efficiency, economic viability and tariff moderation.

The diffusion of smart grids is not just a technological innovation: a technological transition is at stake → analysis of the technological variables, considering the interests of the different stakeholders involved.

# The problem

Policies and incentive actions to foster technological innovations in the electricity sector are needed. What should be the structure of an evaluation model of those policies and incentive actions?

→ take into account aspects of distinct nature (technological, economic, financial, social, regulatory), several of them of intangible nature, in the evaluation models → Multi-Criteria Decision Aid (MCDA)

Structuring the problem is an essential step to develop evaluation models.

DMs spend much time discussing alternatives without firstly structuring their objectives.

# Problem structuring

→ the first step in decision support processes: gather in an organized manner all the relevant information, improve the understanding of the overall decision situation and clearly define the problem to be tackled.

→ identify the essential characteristics of the decision situation, establish the scope and the boundaries of the analysis, recognize the stakeholders involved, as well as their main motivations and objectives, and understand which actions can be carried out.

→ offer all participants into the process of a common view and an operational basis from which the identification of the fundamental points of view, the operational criteria, and the potential actions to be evaluated will emerge.

# Problem structuring methods

- multiple actors and multiple perspectives,
- non-consensual or even antagonistic interests,
- different measurement units of the impacts,
- evaluation aspects of intangible nature,
- uncertainty over several elements of the decision situation.

Facilitation: offer an environment in which the debate between the participants is duly oriented, enabling to clarify the understanding of the decision situation.

Structuring: process of organization of the elements unveiled during debate, advancing on a common basis of knowledge about the problem, contributing to improve the quality of the decision making process.

# Soft Systems Methodology (SSM)

PSM foster a better understanding of the role of each actor, his/her degree of intervention and power to influence decisions, the relationships between the different actors and the identification of their values, objectives and concerns.

SSM is a general system analysis method developed from systems engineering concepts → complex and ill-defined problems with multiple inter-related issues not clearly defined, multiple world views and multiple conflicting objectives pertaining to the stakeholders.

SSM → systemic framework to carry out process analysis in which technological issues and the intervention of DMs are interdependent.

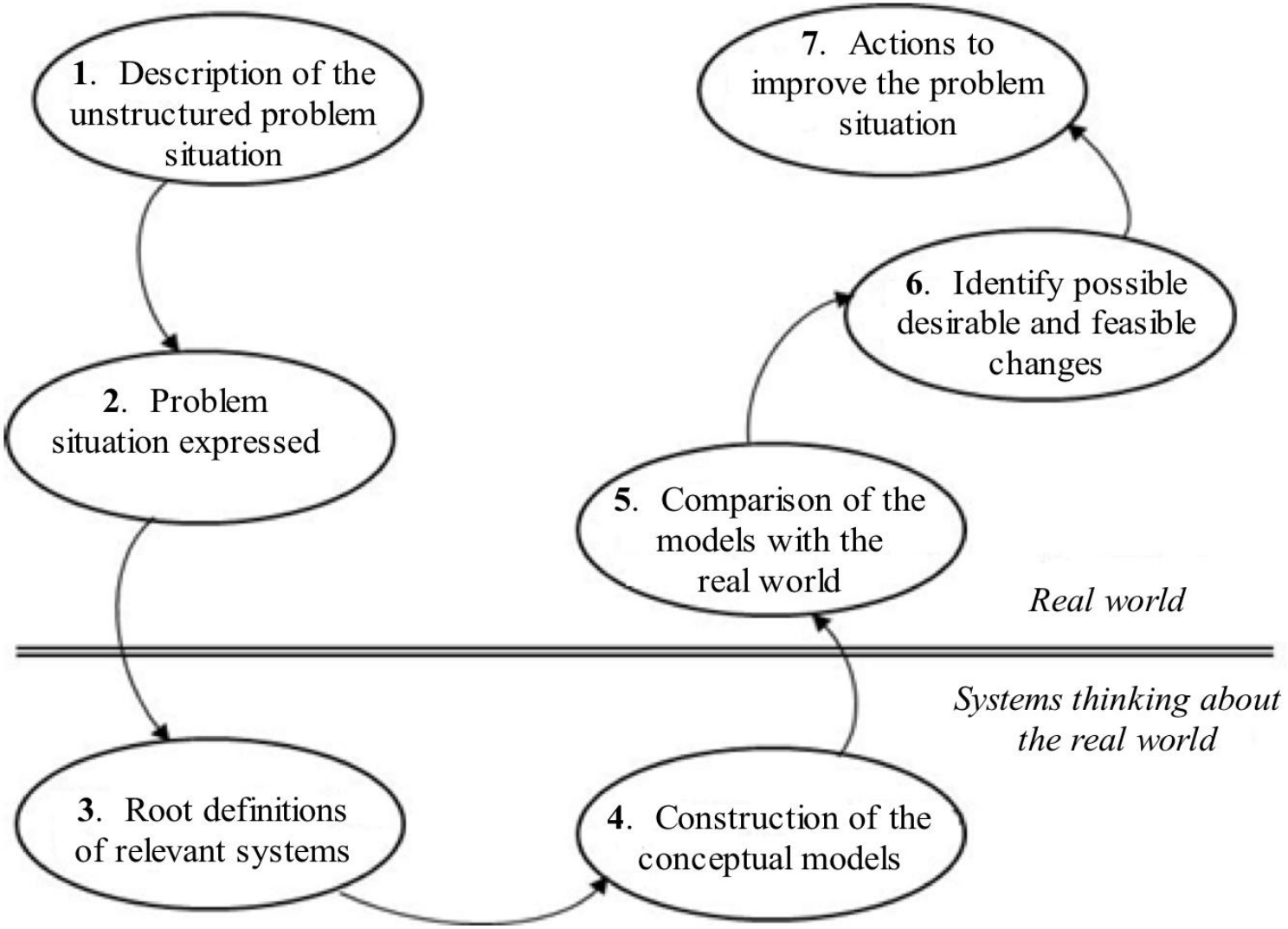
# From SSM to MCDA

SSM enables the linkage between the structuring and alternative evaluation steps, contributing to shed light on the main issues of distinct nature that should be incorporated in the MCDA model.

MCDA: potential alternatives (courses of action) should be judged according to different axes that are explicitly considered in the model.

MCDA models enable to include evaluation criteria of different nature, which are generally conflicting and incommensurate, taking into account the points of view of different stakeholders, each one displaying in the decision process his/her own values, preferences and criteria.

# The steps of SSM



# SSM at work

Diagnosis of the existing situation, identifying participants and their relationships → graphical representation of the problem: “rich picture”.

Building of conceptual models: clear and objective definition of the system to be modeled → as root definition

CATWOE components:

- **C**ustomers,
- **A**ctors,
- **T**ransformation process,
- **W**eltanschauung (world view),
- **O**wner, and
- **E**nvironmental constraints.

# Root definition – CATWOE

Client – the immediate beneficiaries or victims of the system results.
Actors – the participants in the transformation, i.e. those who carry out activities within the system.
Transformation – the core of the human activity system, in which some inputs are converted in outputs and given to the clients. Actors play a role in this transformation process.
Weltanschauung (world view) – the perspective or point of view that makes sense of the root definition being developed.
Owner – the individual or group responsible for the proposed system. He/she has the power to modify or even stop the system, overlapping other system actors.
Environmental constraints – the human activity systems work under some constraints imposed by the external environment, as

# MCDA

MCDA paradigm: considers explicitly multiple evaluation criteria

- allows a solid base for dialogue by acknowledging the concerns of all stakeholders,
- encourages joint ownership of the evaluation models,
- breaks down the problem facilitating the definition of assessment instruments and uncertainty modelling,
- invites DMs to consider any choice as a compromise between conflicting objectives, since there is rarely an option better than all the rest on every evaluation criterion.

Main stages of a decision process under an MCDA paradigm: problem structuring, construction of the evaluation model, and exploitation of the model.

# Value-focused thinking in MCDA

DMs should focus on objectives first and then alternatives → foster creativity in designing new alternatives and ensures the evaluation criteria are aligned with an individual's or an organization's objectives.

Constructing the evaluation model: evaluating the performance of each alternative according to each evaluation criteria.

Scales:

- quantitative (costs € or pollutant emissions *Gg* $CO_2$)
- qualitative (degree of opposition of the population, aesthetic perception of the landscape – *negligible, moderate, strong*).

# Fundamental objectives (points of view)

Fundamental objectives: controllable, essential, concise, specific and understandable.

not means to a higher-level concern → an end in themselves,

often comprehend different sub-objectives,

possible to assess alternatives on each fundamental objective, one at a time, independently of the other fundamental objectives.

Ask the DM why is reducing the consumption of electrical energy important → the answer might reveal the objective of reducing

# Hierarchy of objectives

Top-down: identifying the fundamental objectives, which are then decomposed into lower level sub-objectives, down to the relevant attributes of the alternatives → focuses on the main concerns behind the evaluation process, but risks omitting a few relevant sub-objectives.

Bottom-up: considering a set of many attributes of the alternatives that are considered to be relevant for the decision process, and then these attributes are successively coalesced into higher-level objectives → allows discussing objectives at a more concrete and understandable level, but it risks missing a broader perspective.

Combining the advantages of bottom-up and top-down approaches:

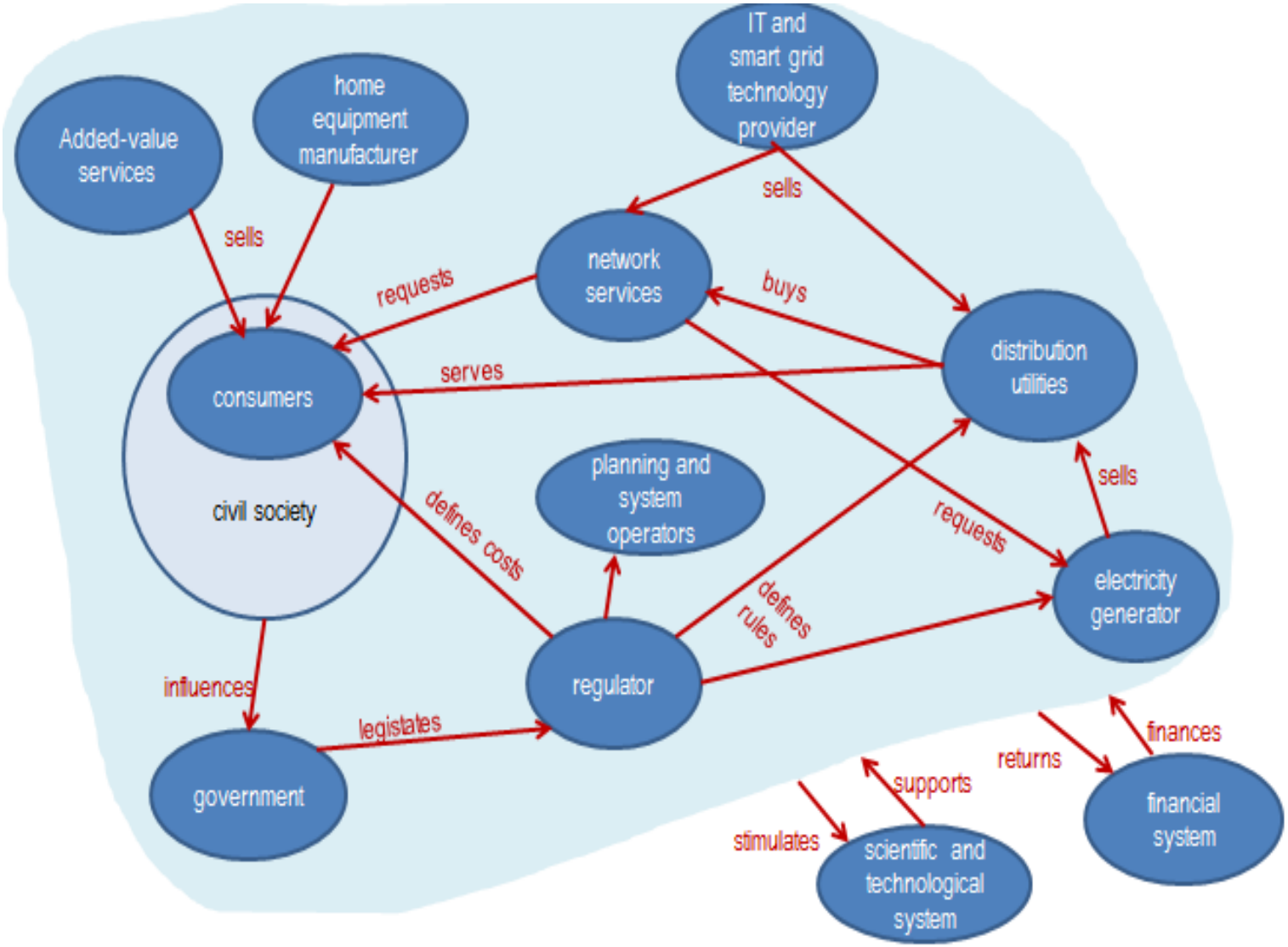
# MCDA methods to exploit models

Performance table (assessment of each alternative on each criterion) → deriving a recommendation using an aggregation method.

Aggregation of single-criterion performances:

- overall synthesis value (allowing to rank all the alternatives),
- binary relation (not necessarily complete) comparing alternatives in a pairwise way,
- interactive approaches.

# SSM rich picture



# Perspectives of analysis

Perspectives under which it is relevant to promote smart grids and the associate technological developments:

a) SG as an instrument to optimize resources - generation and distribution capacity + more efficient use of electricity by consumers.

b) SG as opportunity of development and business - fostering the creation of new businesses promoting technological innovation.

c) SG to foster environmentally friendly technologies – energy efficiency, higher integration of renewable sources in the energy mix.

d) SG to empower consumers / micro-generators - increase the

| | |
|---|---|
| **Clients**<br><br>System operator,<br>Distributor<br><br><br><br>Society | **What are the benefits and the disadvantages and why are they important?**<br>(+) Lower costs, better quality of service, better information/monitoring, management flexibility, lower technical risks<br>(-) Cyber risks<br>(+) Lower costs and losses, better quality of service<br>(-) Lower privacy, lower equity |
| **Actors**<br>System operator, Generator, Distributor<br><br><br><br>Consumer | **What is a good/bad performance?**<br>(+) Lower costs, higher resiliency and reliability<br>(-) Collapse/network dysfunction, loss of sensitive information, loss of commitment<br>(-) Fraud/crime, loss of commitment, lack of collaboration |
| ***Weltanschauung***<br>Smart grids contribute to avoid/mitigate inefficiencies | **Objectives unveiled**<br>Efficient utilization of installed capacity<br>More efficient market |
| **Owner**<br>Government, Regulator | **Why stop or change the activity?**<br>Social acceptance, lack of funding, unverified economic benefits |
| **Environmental constraints**<br>Financial resources<br>Present technological basis<br>Existing know-how<br>Existing potential | **Objectives unveiled**<br>Modernize the network<br>Form qualified staff e develop R&D<br>Technological diffusion<br>Security of supply |

# Objectives

1 - To benefit the environment and human health.

2 - To increase the flexibility and capabilities of the electricity system's technological infrastructure.

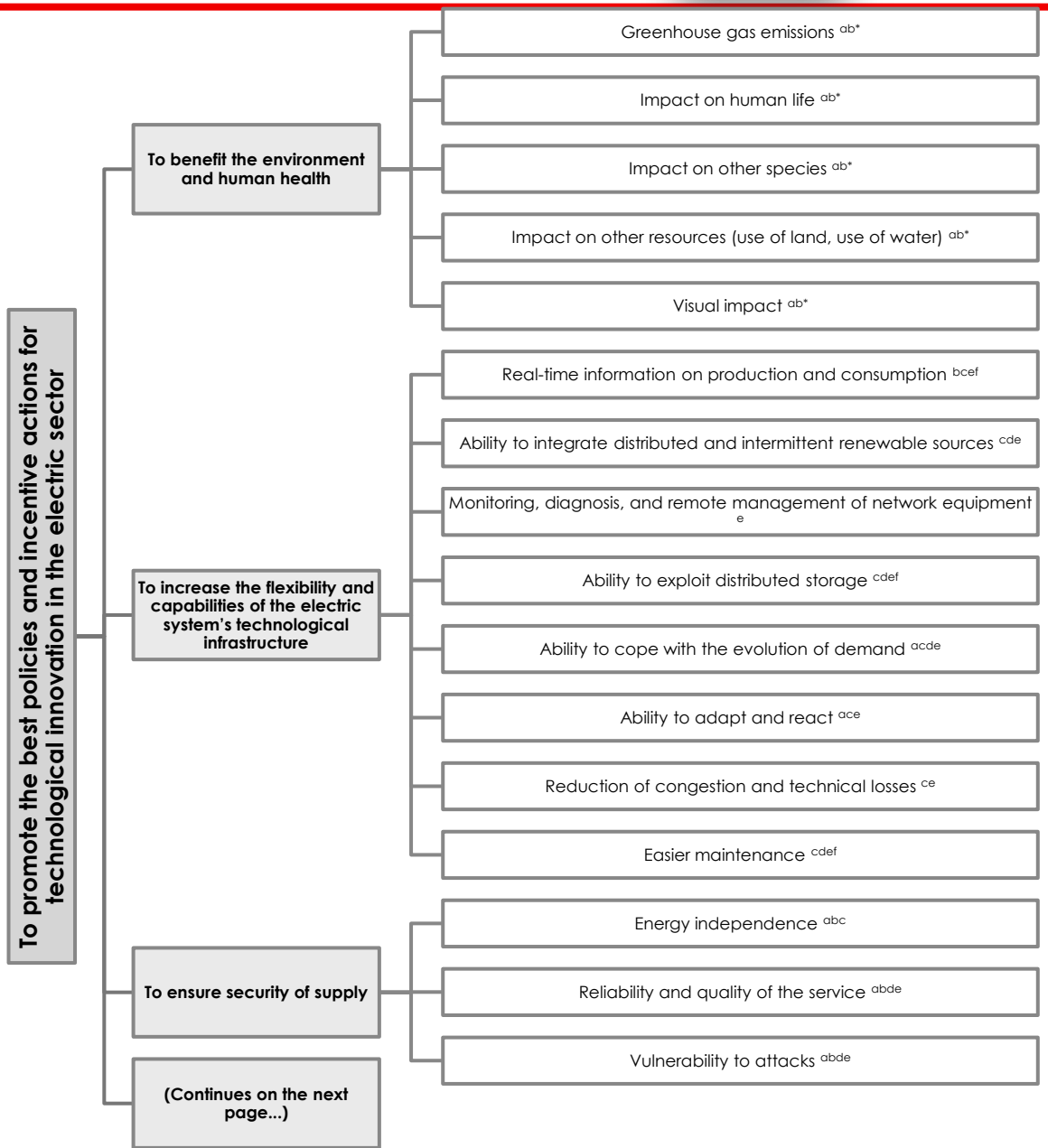
3 - To ensure security of supply.

4 - To ensure openness, fairness, transparency and efficiency of the electricity markets.

5 - To provide financial benefit to the agents involved.

6 - To provide economic and social benefit to the country.

7 – To ensure feasibility and encourage adoption of technological innovations.


To promote the best policies and incentive actions for technological innovation in the electric sector
To benefit the environment and human health
Greenhouse gas emissions ab*
Impact on human life ab*
Impact on other species ab*
Impact on other resources (use of land, use of water) ab*
Visual impact ab*
To increase the flexibility and capabilities of the electric system's technological infrastructure
Real-time information on production and consumption bcef
Ability to integrate distributed and intermittent renewable sources cde
Monitoring, diagnosis, and remote management of network equipment e
Ability to exploit distributed storage cdef
Ability to cope with the evolution of demand acde
Ability to adapt and react ace
Reduction of congestion and technical losses ce
Easier maintenance cdef
To ensure security of supply
Energy independence abc
Reliability and quality of the service abde
Vulnerability to attacks abde
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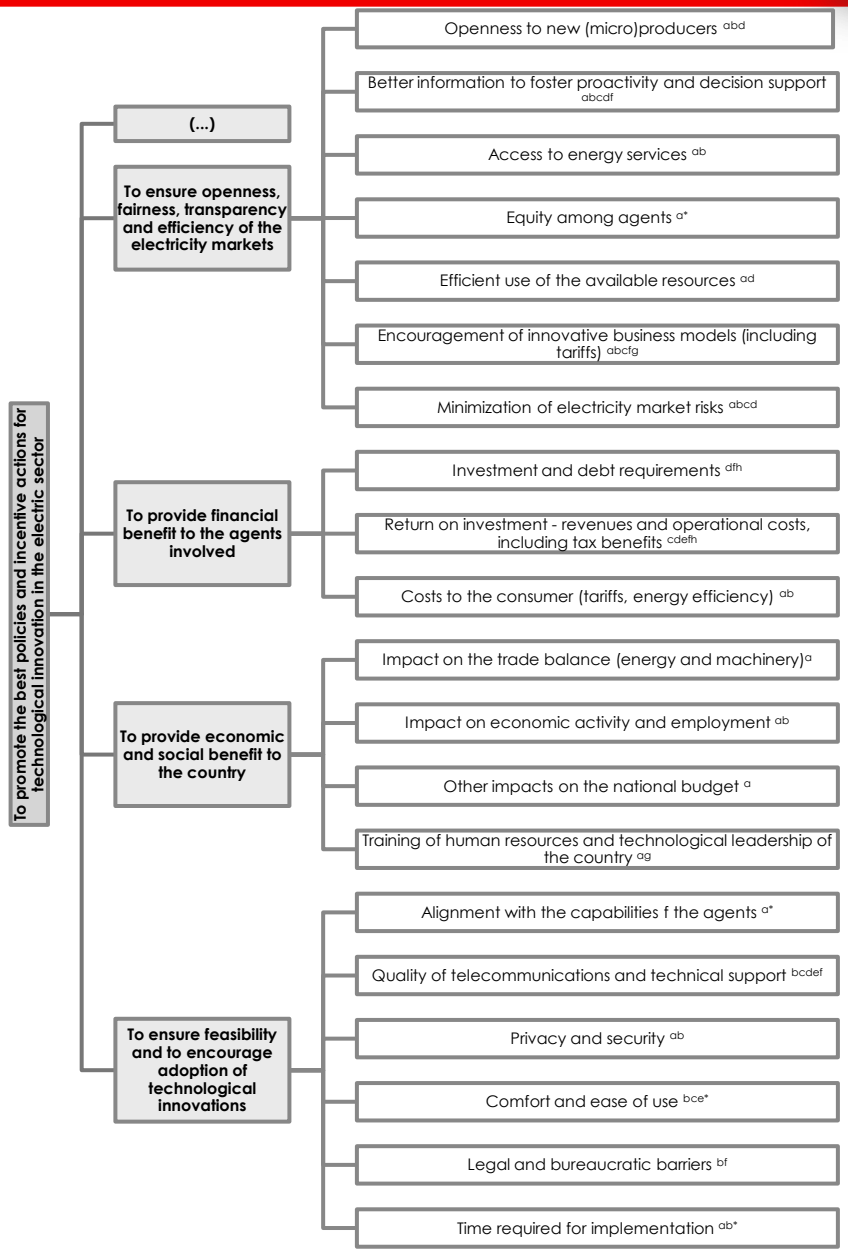
To promote the best policies and incentive actions for technological innovation in the electric sector
(...)
To ensure openness, fairness, transparency and efficiency of the electricity markets
Openness to new (micro)producers abd
Better information to foster proactivity and decision support abcdf
Access to energy services ab
Equity among agents a*
Efficient use of the available resources ad
Encouragement of innovative business models (including tariffs) abcfg
Minimization of electricity market risks abcd
To provide financial benefit to the agents involved
Investment and debt requirements dfh
Return on investment - revenues and operational costs, including tax benefits cdefh
Costs to the consumer (tariffs, energy efficiency) ab
To provide economic and social benefit to the country
Impact on the trade balance (energy and machinery)a
Impact on economic activity and employment ab
Other impacts on the national budget a
Training of human resources and technological leadership of the country ag
To ensure feasibility and to encourage adoption of technological innovations
Alignment with the capabilities f the agents a*
Quality of telecommunications and technical support bcdef
Privacy and security ab
Comfort and ease of use bce*
Legal and bureaucratic barriers bf
Time required for implementation ab*

# Conclusions and work in progress

Develop and structure a set of fundamental objectives to promote innovation (R&D project "Policies and incentive actions for technological innovation in the electricity sector: analysis of international experience and proposals for Brazil").

Literature reviews, technical visits, workshops → SSM generated a dispersed cloud of aspects initially listed as potential concerns and criteria for the evaluation.

Bottom-up approach followed by a top-down approach aimed at breaking down each objective into sub-objectives clarifying the issues at stake under each perspective.

# Conclusions and work in progress

→ 7 key objectives in line with priorities for technological innovation in the energy sector.

→ essential basis for the construction of the evaluation model: performance indicators for each objective and definition of aggregation mechanisms to derive recommendations.

→ Delphi process

→ Alternatives: Mandatory roll-out of smart meters; Regulatory changes incentivizing innovations; Improving R&D and demonstration project schemes; Incentivizing demand side management, micro-generation and storage; Improving quality standards for the telecommunications industry; Regulation of new business models; Development plan of smart cities; National development plan of smart grid industries.