Sorting and ranking policies to foster technological innovations in the electricity sector in Brazil: A Delphi-based multi-criteria approach

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Building Expertise for Innovation

Conference on Innovation Decision Support

Using Structured Expert Judgement

Aalto University, Espoo, 25-27 April 2017

Context

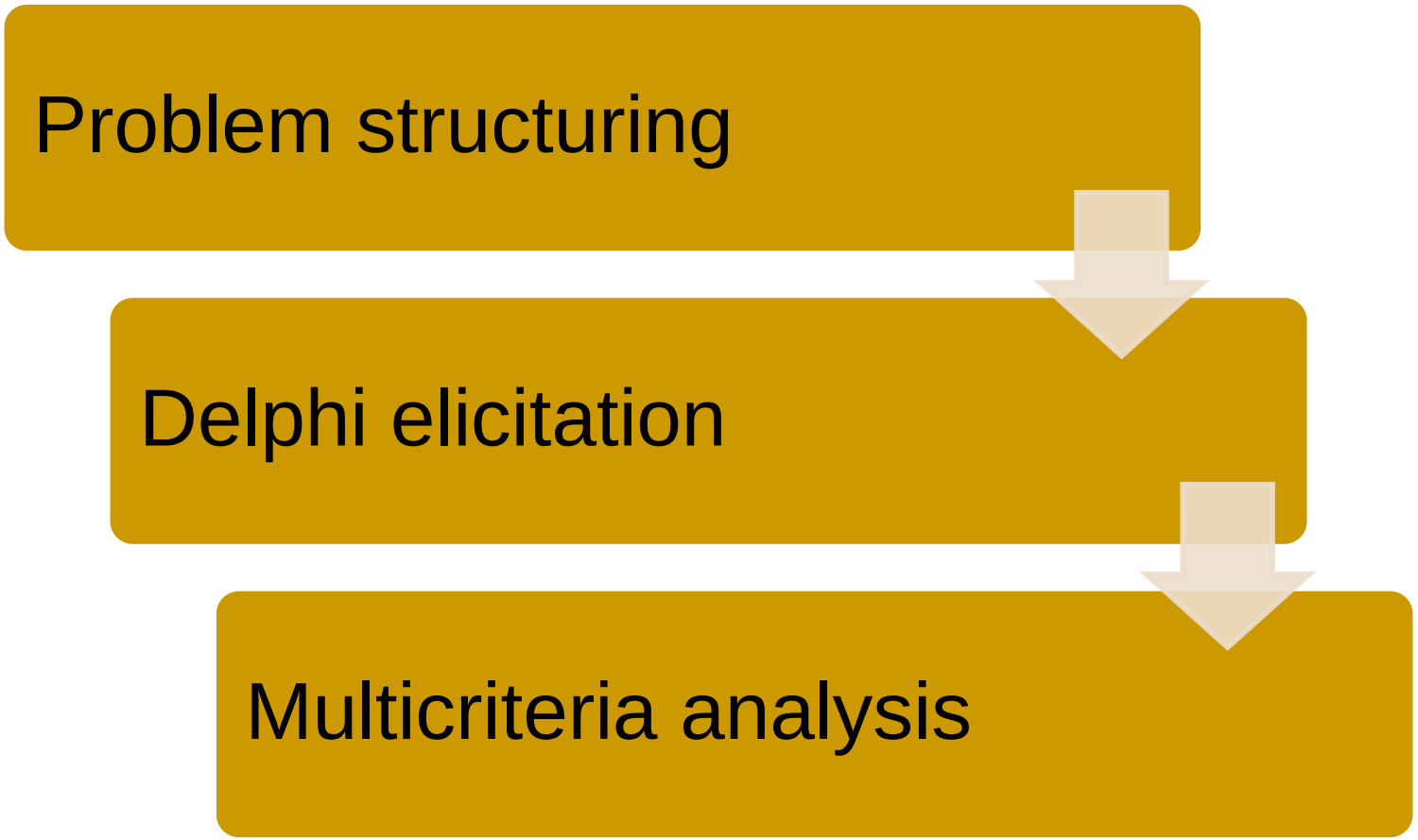
Modernization of electricity systems

Significant investments for innovation

Which incentive policies are the most interesting?

- Brazilian reality (informed by experience of other countries)
- Project sponsored by the regulator and a company

Methods


Problem structuring
Delphi elicitation
Multicriteria analysis

Structuring process: evaluation criteria and policies

- Literature review on experiences from 18 countries
- Technical visits to Germany, Italy, France and Portugal
- Meetings with main players in Brazil: regulator, electricity companies, grid operator, academia, development bank
- International seminar in Coimbra
- Research workshop
- Peter Checkland's *Soft Systems Methodology*

Structuring:
Soft Systems Methodology CATWOE analysis

CATWOE perspectives:

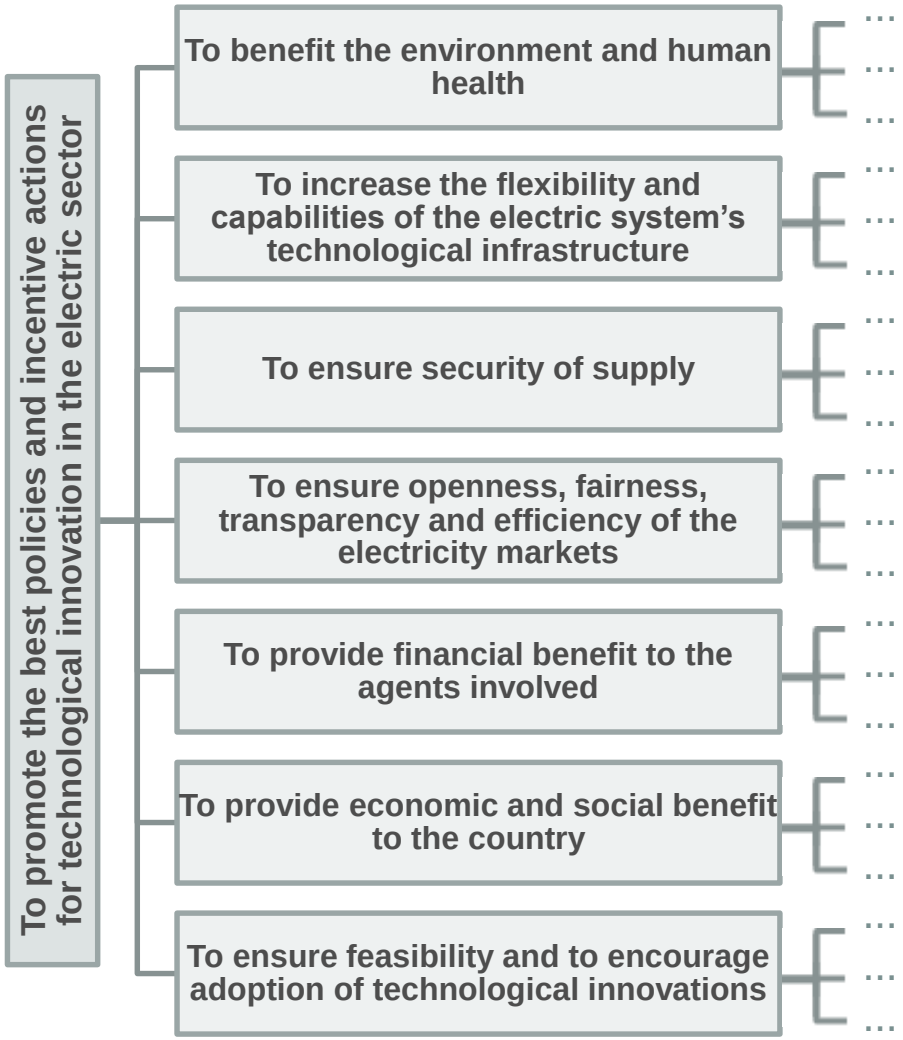
- The smart grids as an instrument to optimize resources
- The smart grids as opportunity of development and business
- The smart grids to foster environmentally friendly technologies
- The smart grids to empower consumers and micro-generators

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

Structuring a hierarchy of objectives

~100 issues found in the literature, meetings and workshops (SSM)

- Clustering by semantic analysis
- Top-level categories associated with functional value



Structuring: policies to assess

P1 Mandatory roll out of smart meters

P2 Regulatory changes for technological innovation

P3 Support for R&D

P4 Incentives for demand management, distributed generation and storage

P5 Definition of mandatory telecommunication quality requirements

P6 Regulatory changes for new business models

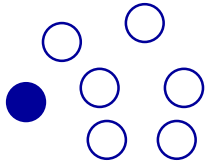
P7 Smart cities development plan

P8 National policy to develop a smart grid industry

Type of synthesis ("problématiques")

Choice / Selection: select best

- e.g., selecting a single policy
- among alternative proposals



Ranking: rank from best to worst

- e.g., prioritization of policies
- (from highest to lowest priority)

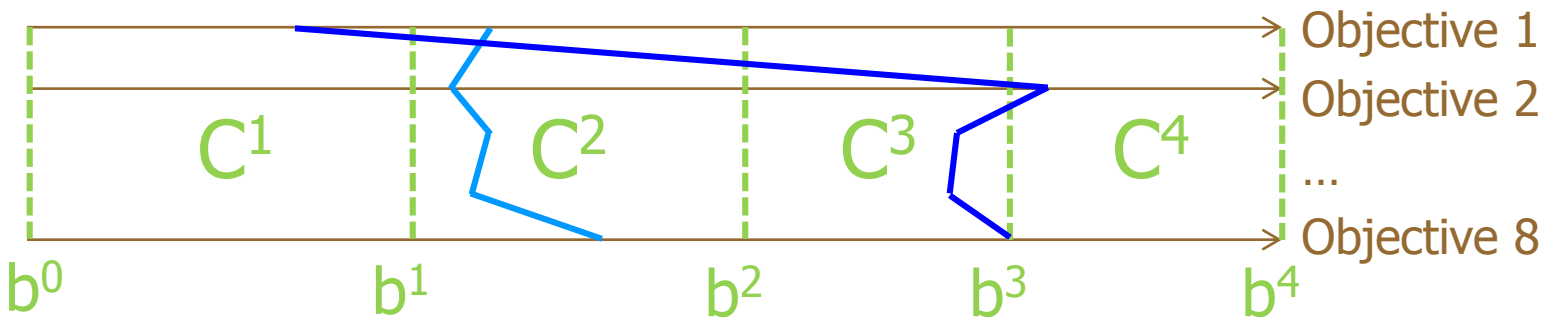
Classification / Sorting: assign to categories

- e.g., assigning policies to priority levels:
- *Uninteresting* | *Wait* | *Priority* | *Max Prior.*

ELECTRE TRI Sorting approach

a_i belongs to class $C^c \Leftrightarrow$

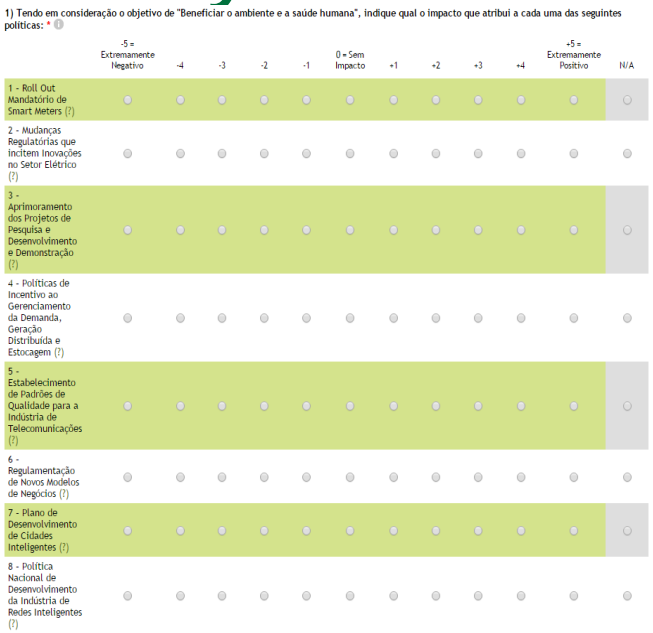
a_i outranks b^{c-1} but does not outrank b^c



a_i outranks a lower bound b^c only if:

- The majority of the criteria agrees (considering their weights and a majority threshold)
- No criterion opposes a veto (considering veto thresholds)

Assessment of policies, weights and veto thresholds: Delphi survey


1) Tendo em consideração o objetivo de "Beneficiar o ambiente e a saúde humana", indique qual o impacto que atribui a cada uma das seguintes políticas: *

	-5 = Extremamente Negativo	-4	-3	-2	-1	0 = Sem Impacto	+1	+2	+3	+4	+5 = Extremamente Positivo	N/A
1 - Roll Out Mandatório de Smart Meters (?)												
2 - Mudanças Regulatórias que incitem Inovações no Setor Elétrico (?)												
3 - Aprimoramento dos Projetos de Pesquisa e Desenvolvimento e Demonstração (?)												
4 - Políticas de Incentivo ao Gerenciamento da Demanda, Geração Distribuída e Estocagem (?)												
5 - Estabelecimento de Padrões de Qualidade para a Indústria de Telecomunicações (?)												
6 - Regulamentação de Novos Modelos de Negócios (?)												
7 - Plano de Desenvolvimento de Cidades Inteligentes (?)												
8 - Política Nacional de Desenvolvimento da Indústria de Redes Inteligentes (?)												

Two rounds

28 participants

- 7 from governmental organizations
- 8 from companies
- 13 from academia and consultants

How much does each policy contribute to each one of the higher level objectives?

What is a bad enough level to veto implementation?

What is the relative importance of each criterion?

Assessment of policies: Delphi survey

- How much does each policy contribute to each one of the higher level objectives:

Impact	P1 Mandatory roll out of smart meters	P2 Regulatory changes for technological innovation	P3 Support for R&D	P4 Incentives for demand mgt, distrib. generation and storage	P5 Mandatory telecom quality requirements	P6 Regulatory changes for new business models	P7 Smart cities development plan	P8 National policy to smart grid industry
-5 extremely negative	0%	0%	0%	0%	0%	0%	0%	0%
-4 very strong negat.	0%	0%	0%	0%	0%	0%	0%	0%
-3 strong negative	0%	0%	0%	0%	4%	0%	0%	0%
-2 moderately negat.	4%	0%	0%	0%	0%	0%	0%	0%
-1 slightly negative	4%	0%	0%	0%	0%	0%	0%	0%
0 no impact	18%	0%	7%	0%	15%	14%	7%	7%
1 slightly positive	25%	14%	14%	4%	15%	7%	4%	4%
2 moderately positive	32%	18%	18%	11%	15%	14%	7%	21%
3 strong positive	14%	36%	29%	18%	26%	29%	11%	21%
4 very strong positive	0%	21%	25%	32%	22%	25%	29%	32%
5 extremely positive	4%	11%	7%	36%	4%	11%	43%	14%
Performance level	1,5	3	3	4	2,5	3	4	3
% above	50%	32%	39%	32%	48%	36%	29%	32%
% below	50%	32%	32%	36%	52%	36%	43%	46%

Veto power: Delphi survey

- Indicate for each objective what impact levels you would consider negative enough to discard implementation:

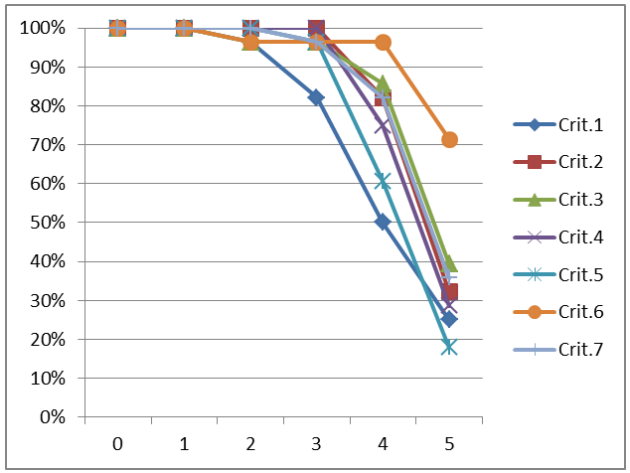
Impact	Crit.1 Environment & health	Crit.2 Infrastructure capability	Crit.3 Security of supply	Crit.4 Electric energy markets	Crit.5 Benefit to agents	Crit.6 Benefit to country	Crit.7 Feasibility and adoption
-5 extremely negative	8%	0%	4%	4%	4%	19%	4%
-4 very strong negat.	4%	15%	12%	8%	8%	0%	12%
-3 strong negative	8%	27%	19%	35%	27%	12%	27%
-2 moderately negat.	31%	31%	31%	27%	42%	35%	31%
-1 slightly negative	19%	12%	19%	12%	0%	19%	8%
0 no impact	31%	15%	15%	15%	19%	15%	19%
1 slightly positive	0%	0%	0%	0%	0%	0%	0%
2 moderately positive	0%	0%	0%	0%	0%	0%	0%
3 strong positive	0%	0%	0%	0%	0%	0%	0%
4 very strong positive	0%	0%	0%	0%	0%	0%	0%
5 extremely positive	0%	0%	0%	0%	0%	0%	0%
Performance level	**-1,5**	**-2**	**-2**	**-2**	**-2**	**-2**	**-2**
% above	50%	42%	35%	46%	38%	31%	42%
% below	50%	27%	35%	27%	19%	35%	27%

Criteria weights: Delphi survey

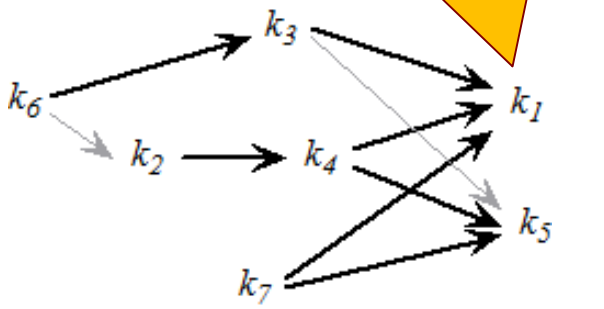
What is the relative importance of each criterion:

	Crit.1 Environment & health		Crit.2 Infrastructure capability		Crit.3 Security of supply		Crit.4 Electric energy markets		Crit.5 Benefit to agents		Crit.6 Benefit to country		Crit.7 Feasibility and adoption	
0 negligible importance	0%		0%		0%		0%		0%		0%		0%	
1 little importance	4%	100%	0%	100%	4%	100%	0%	100%	0%	100%	4%	100%	0%	100%
2 moderately important	14%	96%	0%	100%	0%	96%	0%	100%	4%	100%	0%	96%	4%	100%
3 very important	32%	82%	18%	100%	11%	96%	25%	100%	36%	96%	0%	96%	14%	96%
4 strongly important	25%	50%	50%	82%	46%	86%	46%	75%	43%	61%	25%	96%	46%	82%
5 extremely important	25%	25%	32%	32%	39%	39%	29%	29%	18%	18%	71%	71%	36%	36%

% agreeing that level is at least 1, 2, 3, 4 or 5



Greatest veto power!



Stochastic parameter analysis

Hit & Run Monte-Carlo simulation complying with constraints on weights and required majority in [4/7, 5/7] (uniform distributions)

Classification probabilities

	C1 Uninter-esting	C2 Wait & see	C3 Low priority	C4 High priority
P1 - Roll Out Smart Meters	0	0	**1.000**	0
P2 - Regulatory changes	0	0	**0.391**	**0.609**
P3 - Support for R&D	0	0	**1.000**	0
P4 – Demand Management	0	0	0	**1.000**
P5 – Telecom standards	0	0	**1.000**	0
P6 – New business models	0	0	**0.567**	**0.433**
P7 – Smart cities	0	0	**0.962**	**0.038**
P8 – Smart grid industry	0	0	**1.000**	0

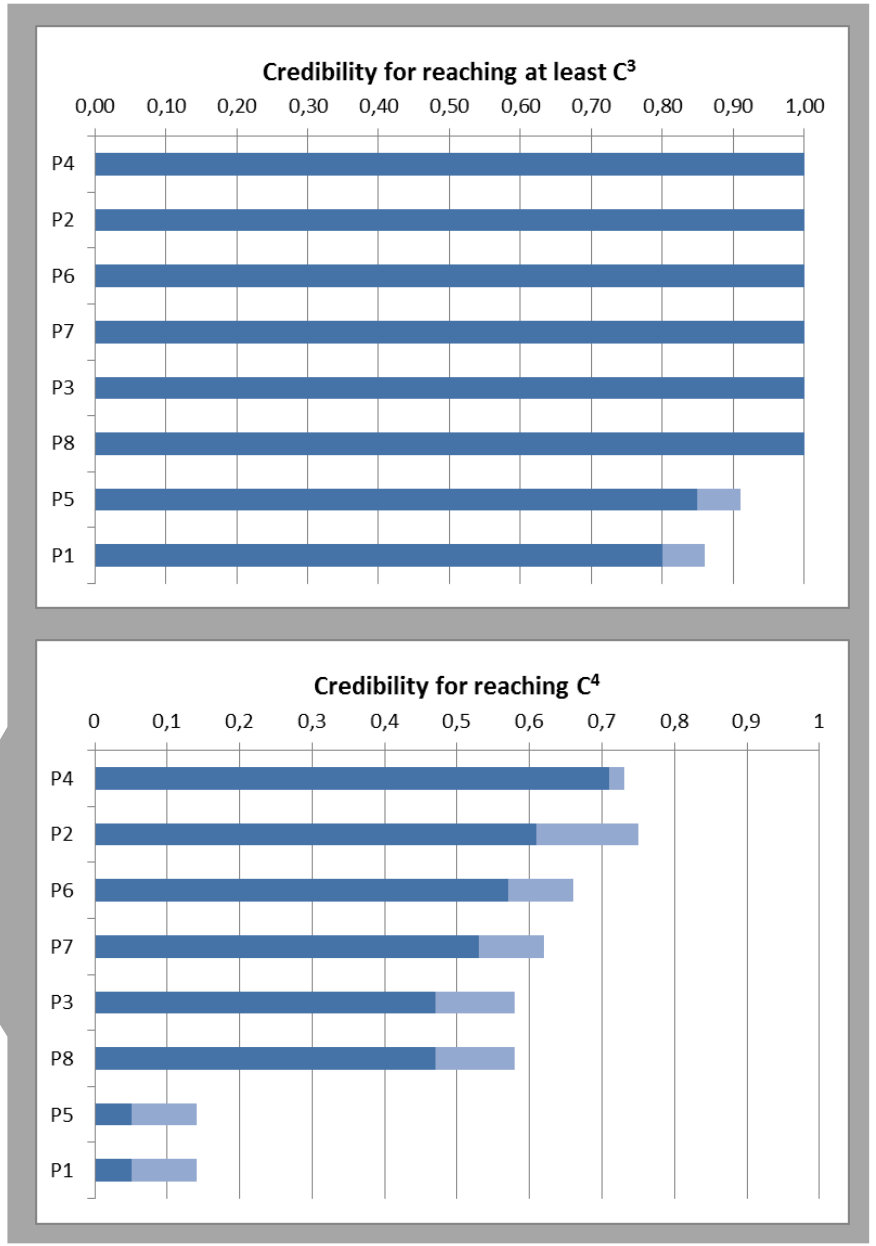
	Sorting (based on stochastic analysis)
P1 - Roll out smart meters	Implement with priority
P2 - Regulatory changes	Implement with high priority(*)
P3 - R&D and demonstration	Implement with priority
P4 - DSM/DG/S incentives	Implement with maximum priority
P5 - Telecom standards	Implement with priority
P6 - New business models	Implement with high priority(*)
P7 - Smart cities	Implement with high priority(*)
P8 - Smart grid industries	Implement with priority

(*) Sorting varies between “Implement with priority” and “Implement with maximum priority”

Exact range analysis

Maximize and minimize outranking credibility complying with constraints on weights (linear programs)

	W(.)	B(.)	Ranking
P4 -DSM/DG/S incentives	4	4	1st
P2 - Regulatory changes	3	4	2nd
P6 - New business models	3	4	3rd
P7 - Smart cities	3	4	4th
P3 - R&D and demonstration	3	3	5/6th
P8 - Smart grid industries	3	3	5/6th
P5 - Telecom standards	3	3	7th
P1 - Roll out smart meters	3	3	8th



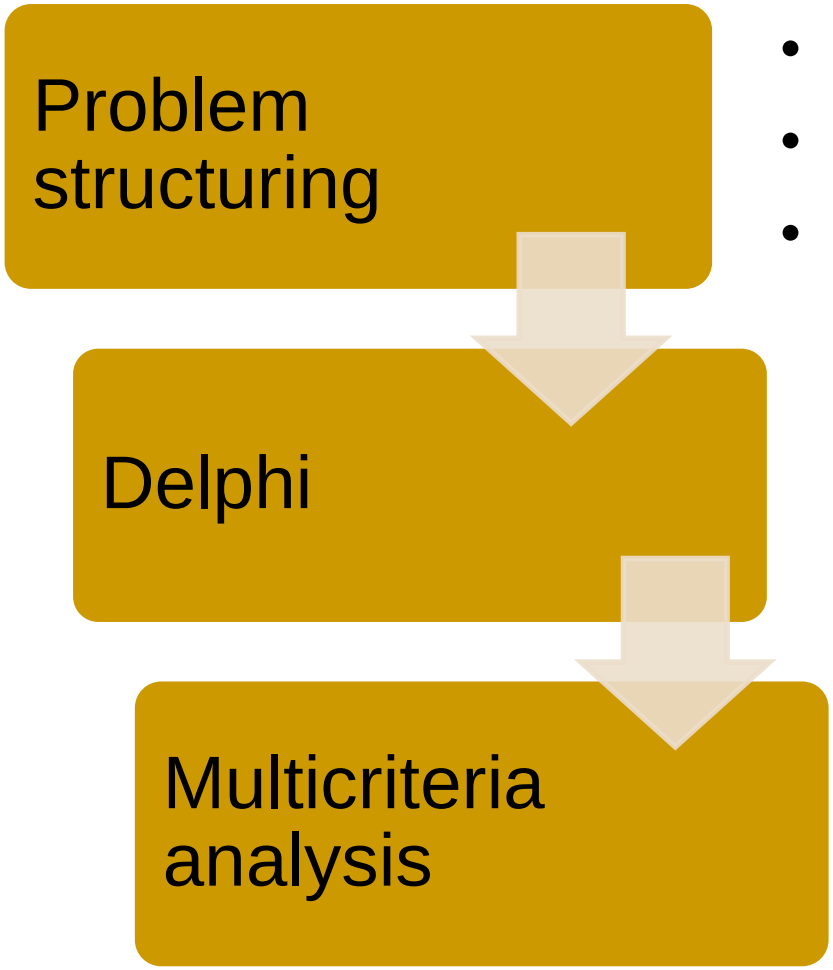
Summary of results

	Ranking
P4 - DSM/DG/S incentives	1st
P2 - Regulatory changes	2nd
P6 - New business models	3rd
P7 - Smart cities	4th
P3 - R&D and demonstration	5/6th
P8 - Smart grid industries	5/6th
P5 - Telecom standards	7th
P1 - Roll out smart meters	8th

Rank	Government perspective	Business perspective	Knowledge perspective
1st	P4 - DSM/DG/S incentives	P4 - DSM/DG/S incentives	P4 - DSM/DG/S incentives
2nd	P6 - New business models	P7 - Smart cities(*)	P2 - Regulatory changes(*)
3rd	P2 - Regulatory changes	P8 - Smart grid industries(*)	P7 - Smart cities(*)
4th	P8 - Smart grid industries	P2 - Regulatory changes	P6 - New business models
5th	P7 - Smart cities	P6 - New business models	P3 - R&D and demonstration
6th	P3 - R&D and demonstration	P3 - R&D and demonstration	P8 - Smart grid industries
7th	P5 - Telecom standards	P1 - Roll out smart meters	P1 - Roll out smart meters
8th	P1 - Roll out smart meters	P5 - Telecom standards	P5 - Telecom standards

(*) *ex-aequo*

Methodology summary



- Stakeholder participation
- SSM to elicit concerns
- Criteria hierarchy development

- Qualitative assessments
- Stakeholder participation
- Three groups (perspectives)

- Multiple perspectives
- Constraints on weights
- Stochastic analysis → classes
- Robustness → ranking within classes

Summary of results

All policies are deemed worthy of implementation

P4 - DSM/DG/S incentives has maximum priority

P2 - Regulatory changes has high priority for all perspectives

P6 - New business models is ranked 3rd, but with uneven support

P7 - Smart cities program has high priority, but not very strong support from the Government perspective.

P1, P3 and P5 have less priority, but are still interesting

Thank you!

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