(Supplementary material to be made available online)

A multicriteria approach to sort and rank policies based on Delphi qualitative assessments and ELECTRE TRI: the case of smart grids in Brazil

SUPPLEMENTARY MATERIAL

Appendix B. Intermediate results considering all respondents

Table B1. Concordance indices to outrank b^2, i.e. to attain at least category C^3 (all respondents).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	0.5	1	0.75	1	1	0.75	0.75
P2 - Regulatory changes	1	1	1	1	1	1	1
P3 - R&D and demonst.	1	1	1	1	1	1	1
P4 - DSM and DG	1	1	1	1	1	1	1
P5 - Telecom standards	1	1	0.75	0.75	0.5	1	1
P6 - New business models	1	1	1	1	1	1	1
P7 - Smart cities	1	1	1	1	1	1	1
P8 - Smart grid industries	1	1	1	1	1	1	1

Table B2. Concordance indices to outrank b^3 i.e. to attain category C^4 (all respondents).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	0	0.5	0	0	0	0	0
P2 - Regulatory changes	0.25	0.75	0.5	0.75	0.25	0.75	1
P3 - R&D and demonst.	0.25	0.75	0.25	0.25	0.25	0.75	0.75
P4 - DSM and DG	0.75	0.75	0.75	0.75	0.5	0.75	0.75
P5 - Telecom standards	0	0.25	0	0	0	0.25	0
P6 - New business models	0.25	0.75	0.25	0.75	0.75	0.75	0.75
P7 - Smart cities	0.75	0.75	0.25	0.25	0.25	0.75	0.75
P8 - Smart grid industries	0.25	0.75	0.25	0.25	0.25	0.75	0.75

(Supplementary material to be made available online)

Table B3. Minimum and maximum credibility of outranking the lower bounds of C^3 and C^4 considering weight constraints (all respondents).

	$s(.,b^2)$		$s(.,b^3)$	
	min	max	min	max
P1 - Roll out smart meters	0.8	0.86	0.05	0.14
P2 - Regulatory changes	1	1	0.61	0.75
P3 - R&D and demonstration	1	1	0.47	0.58
P4 -DSM and DG	1	1	0.71	0.73
P5 - Telecom standards	0.85	0.91	0.05	0.14
P6 - New business models	1	1	0.57	0.66
P7 - Smart cities	1	1	0.53	0.62
P8 - Smart grid industries	1	1	0.47	0.58

Appendix C. Intermediate results considering the Government perspective

Table C1. Performance table obtained from the Delphi process (Government perspective).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	1	4	2	2	1.5	2	2.5
P2 - Regulatory changes	3	4	4	4	3	4	4.5
P3 - R&D and demonst.	2.5	4	3	2.5	3	3.5	4
P4 - DSM and DG	4.5	4	5	4	3.5	5	4
P5 - Telecom standards	3	3	2.5	2.5	1.5	3.5	4
P6 - New business models	3.5	4	3.5	4.5	4	4	4
P7 - Smart cities	4	3	3	3.5	3	4	4
P8 - Smart grid industries	4	4	3	3	3.5	4	4

Table C2. Concordance indices to outrank b^2, i.e. to attain at least category C^3 (Government perspective).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	0.25	1	0.75	0.75	0.5	0.75	1
P2 - Regulatory changes	1	1	1	1	1	1	1
P3 - R&D and demonst.	1	1	1	1	1	1	1
P4 - DSM and DG	1	1	1	1	1	1	1
P5 - Telecom standards	1	1	1	1	0.5	1	1
P6 - New business models	1	1	1	1	1	1	1
P7 - Smart cities	1	1	1	1	1	1	1
P8 - Smart grid industries	1	1	1	1	1	1	1

Table C3. Concordance indices to outrank b^3 i.e. to attain category C^4 (Government perspective).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	0	0.75	0	0	0	0	0
P2 - Regulatory changes	0.25	0.75	0.75	0.75	0.25	0.75	1
P3 - R&D and demonst.	0	0.75	0.25	0	0.25	0.5	0.75
P4 - DSM and DG	1	0.75	1	0.75	0.5	1	0.75
P5 - Telecom standards	0.25	0.25	0	0	0	0.5	0.75
P6 - New business models	0.5	0.75	0.5	1	0.75	0.75	0.75
P7 - Smart cities	0.75	0.25	0.25	0.5	0.25	0.75	0.75
P8 - Smart grid industries	0.75	0.75	0.25	0.25	0.5	0.75	0.75

Table C4. Discordance indices to outrank b^3 i.e. to attain category C^4 (Government perspective).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	1	0	0	0	0	0	0
P2 - Regulatory changes	0	0	0	0	0	0	0
P3 - R&D and demonst.	0	0	0	0	0	0	0
P4 - DSM and DG	0	0	0	0	0	0	0
P5 - Telecom standards	0	0	0	0	0	0	0
P6 - New business models	0	0	0	0	0	0	0
P7 - Smart cities	0	0	0	0	0	0	0
P8 - Smart grid industries	0	0	0	0	0	0	0

Table C5. Relative importance of the criteria (Government perspective).

Level	**O1 (g_1)** Environ. & human health	**O2 (g_2)** Technol. infra-structure	**O3 (g_3)** Security of supply	**O4 (g_4)** Electricity markets	**O5 (g_5)** Financial benefit to agents	**O6 (g_6)** Benefit to country	**O7 (g_7)** Feasibility & adoption
0	0%	0%	0%	0%	0%	0%	0%
1	0%	0%	14%	0%	0%	14%	0%
2	14%	0%	0%	0%	14%	0%	14%
3	29%	43%	14%	29%	29%	0%	14%
4	43%	29%	14%	29%	43%	14%	43%
5	14%	29%	57%	43%	14%	71%	29%

Table C6. Sorting probabilities considering weight constraints and cutting level bounds (Government perspective).

	C1 Uninteresting	**C2 Wait and see**	**C3 Implement with priority**	**C4 Implement with maximum priority**
P1 - Roll out smart meters	0	0	1.000	0
P2 - Regulatory changes	0	0	0.209	0.791
P3 - R&D and demonstration	0	0	1.000	0
P4 - DSM and DG	0	0	0	1.000
P5 - Telecom standards	0	0	1.000	0
P6 - New business models	0	0	0	1.000
P7 - Smart cities	0	0	1.000	0
P8 - Smart grid industries	0	0	0.981	0.019

Table C7. Minimum and maximum credibility of outranking the lower bounds of C^3 and C^4 considering weight constraints (Government perspective).

	$s(.,b^2)$		$s(.,b^3)$	
	min	max	min	max
P1 - Roll out smart meters	0.71	0.79	0	0
P2 - Regulatory changes	1	1	0.63	0.74
P3 - R&D and demonstration	1	1	0.22	0.41
P4 -DSM and DG	1	1	0.79	0.89
P5 - Telecom standards	0.92	0.96	0.16	0.35
P6 - New business models	1	1	0.68	0.83
P7 - Smart cities	1	1	0.45	0.6
P8 - Smart grid industries	1	1	0.45	0.64

Appendix D. Intermediate results considering the Business perspective

Table D1. Performance table obtained from the Delphi process (Business perspective).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	1.5	3	2	3.5	3.5	2.5	1.5
P2 - Regulatory changes	2.5	4	3.5	4	3	3.5	5
P3 - R&D and demonst.	3	3	3.5	3	2	3.5	4.5
P4 - DSM and DG	3.5	4	4.5	4	3.5	4	4
P5 - Telecom standards	1	2.5	1	1.5	1	2.5	2
P6 - New business models	2	4	2.5	3.5	4	3	5
P7 - Smart cities	3.5	4.5	3.5	3	3.5	4	4.5
P8 - Smart grid industries	3.5	4	4	3.5	3.5	4	4

Table D2. Concordance indices to outrank b^2, i.e. to attain at least category C^3 (Business perspective).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	0.5	1	0.75	1	1	1	0.5
P2 - Regulatory changes	1	1	1	1	1	1	1
P3 - R&D and demonst.	1	1	1	1	0.75	1	1
P4 - DSM and DG	1	1	1	1	1	1	1
P5 - Telecom standards	0.25	1	0.25	0.5	0.25	1	0.75
P6 - New business models	0.75	1	1	1	1	1	1
P7 - Smart cities	1	1	1	1	1	1	1
P8 - Smart grid industries	1	1	1	1	1	1	1

Table D3. Concordance indices to outrank b^3 i.e. to attain category C^4 (Business perspective).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	0	0.25	0	0.5	0.5	0	0
P2 - Regulatory changes	0	0.75	0.5	0.75	0.25	0.5	1
P3 - R&D and demonst.	0.25	0.25	0.5	0.25	0	0.5	1
P4 - DSM and DG	0.5	0.75	1	0.75	0.5	0.75	0.75
P5 - Telecom standards	0	0	0	0	0	0	0
P6 - New business models	0	0.75	0	0.5	0.75	0.25	1
P7 - Smart cities	0.5	1	0.5	0.25	0.5	0.75	1
P8 - Smart grid industries	0.5	0.75	0.75	0.5	0.5	0.75	0.75

Table D4. Discordance indices to outrank b^3 i.e. to attain category C^4 (Business perspective).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	0	0	0	0	0	0	0
P2 - Regulatory changes	0	0	0	0	0	0	0
P3 - R&D and demonst.	0	0	0	0	0	0	0
P4 - DSM and DG	0	0	0	0	0	0	0
P5 - Telecom standards	1	0	0	0	0	0	0
P6 - New business models	0	0	0	0	0	0	0
P7 - Smart cities	0	0	0	0	0	0	0
P8 - Smart grid industries	0	0	0	0	0	0	0

Table D5. Relative importance of the criteria (Business perspective).

Level	**O1 (g_1)** Environ. & human health	**O2 (g_2)** Technol. infra-structure	**O3 (g_3)** Security of supply	**O4 (g_4)** Electricity markets	**O5 (g_5)** Financial benefit to agents	**O6 (g_6)** Benefit to country	**O7 (g_7)** Feasibility & adoption
0	0%	0%	0%	0%	0%	0%	0%
1	13%	0%	0%	0%	0%	0%	0%
2	13%	0%	0%	0%	0%	0%	0%
3	13%	0%	13%	13%	13%	0%	13%
4	25%	38%	38%	50%	38%	13%	25%
5	38%	63%	50%	38%	50%	88%	63%

Table D6. Sorting probabilities considering weight constraints and cutting level bounds (Business perspective).

	C1 Uninteresting	**C2 Wait and see**	**C3 Implement with priority**	**C4 Implement with maximum priority**
P1 - Roll out smart meters	0	0	1.000	0
P2 - Regulatory changes	0	0	0.988	0.012
P3 - R&D and demonstration	0	0	1.000	0
P4 - DSM and DG	0	0	0	1.000
P5 - Telecom standards	0	0.406	0.594	0
P6 - New business models	0	0	1.000	0
P7 - Smart cities	0	0	0.140	0.860
P8 - Smart grid industries	0	0	0.311	0.689

Table D7. Minimum and maximum credibility of outranking the lower bounds of C^3 and C^4 considering weight constraints (Business perspective).

	$s(.,b^2)$		$s(.,b^3)$	
	min	max	min	max
P1 - Roll out smart meters	0.83	0.88	0.12	0.19
P2 - Regulatory changes	1	1	0.53	0.61
P3 - R&D and demonstration	0.96	0.98	0.39	0.46
P4 -DSM and DG	1	1	0.72	0.73
P5 - Telecom standards	0.59	0.72	0	0
P6 - New business models	0.97	0.98	0.4	0.4
P7 - Smart cities	1	1	0.65	0.74
P8 - Smart grid industries	1	1	0.65	0.68

Appendix E. Intermediate results considering the Knowledge perspective

Table E1. Performance table obtained from the Delphi process (Knowledge perspective).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	2	3.5	2	3	2.5	2.5	2.5
P2 - Regulatory changes	3	4	3	4	3	4	4.5
P3 - R&D and demonst.	3	4	3	3	3	4	4
P4 - DSM and DG	4	4	3.5	4	3.5	4	4
P5 - Telecom standards	2.5	3	2	2	2	3	3
P6 - New business models	3	4	2.5	3.5	4	4	4
P7 - Smart cities	4.5	4	3	3	3	4	4
P8 - Smart grid industries	3	3.5	3	3	3	4	4

Table E2. Concordance indices to outrank b^2, i.e. to attain at least category C^3 (Knowledge perspective).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	0.75	1	0.75	1	1	1	1
P2 - Regulatory changes	1	1	1	1	1	1	1
P3 - R&D and demonst.	1	1	1	1	1	1	1
P4 - DSM and DG	1	1	1	1	1	1	1
P5 - Telecom standards	1	1	0.75	0.75	0.75	1	1
P6 - New business models	1	1	1	1	1	1	1
P7 - Smart cities	1	1	1	1	1	1	1
P8 - Smart grid industries	1	1	1	1	1	1	1

Table E3. Concordance indices to outrank b^3 i.e. to attain category C^4 (Knowledge perspective).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	0	0.5	0	0.25	0	0	0
P2 - Regulatory changes	0.25	0.75	0.25	0.75	0.25	0.75	1
P3 - R&D and demonst.	0.25	0.75	0.25	0.25	0.25	0.75	0.75
P4 - DSM and DG	0.75	0.75	0.5	0.75	0.5	0.75	0.75
P5 - Telecom standards	0	0.25	0	0	0	0.25	0.25
P6 - New business models	0.25	0.75	0	0.5	0.75	0.75	0.75
P7 - Smart cities	1	0.75	0.25	0.25	0.25	0.75	0.75
P8 - Smart grid industries	0.25	0.5	0.25	0.25	0.25	0.75	0.75

Table E4. Discordance indices to outrank b^3 i.e. to attain category C^4 (Knowledge perspective).

	O1 Environ. & human health	**O2** Technol. infra-structure	**O3** Security of supply	**O4** Electricity markets	**O5** Financial benefit to agents	**O6** Benefit to country	**O7** Feasibility & adoption
P1 - Roll out smart meters	0	0	0	0	0	0	0
P2 - Regulatory changes	0	0	0	0	0	0	0
P3 - R&D and demonst.	0	0	0	0	0	0	0
P4 - DSM and DG	0	0	0	0	0	0	0
P5 - Telecom standards	0	0	0	0	0	0	0
P6 - New business models	0	0	0	0	0	0	0
P7 - Smart cities	0	0	0	0	0	0	0
P8 - Smart grid industries	0	0	0	0	0	0	0

Table E5. Relative importance of the criteria (Knowledge perspective).

Level	**O1 (g_1)** Environ. & human health	**O2 (g_2)** Technol. infra-structure	**O3 (g_3)** Security of supply	**O4 (g_4)** Electricity markets	**O5 (g_5)** Financial benefit to agents	**O6 (g_6)** Benefit to country	**O7 (g_7)** Feasibility & adoption
0	0%	0%	0%	0%	0%	0%	0%
1	0%	0%	0%	0%	0%	0%	0%
2	15%	0%	0%	0%	0%	0%	0%
3	46%	15%	8%	31%	54%	0%	15%
4	15%	69%	69%	54%	46%	38%	62%
5	23%	15%	23%	15%	0%	62%	23%

Table E6. Sorting probabilities considering weight constraints and cutting level bounds (Knowledge perspective).

	C1 Uninteresting	C2 Wait and see	C3 Implement with priority	C4 Implement with maximum priority
P1 - Roll out smart meters	0	0	1.000	0
P2 - Regulatory changes	0	0	0.817	0.183
P3 - R&D and demonstration	0	0	1.000	0
P4 - DSM and DG	0	0	0.232	0.768
P5 - Telecom standards	0	0	1.000	0
P6 - New business models	0	0	1.000	0
P7 - Smart cities	0	0	0.890	0.110
P8 - Smart grid industries	0	0	1.000	0

Table E7. Minimum and maximum credibility of outranking the lower bounds of C^3 and C^4 considering weight constraints (Knowledge perspective).

	$s(.,b^2)$		$s(.,b^3)$	
	min	max	min	max
P1 - Roll out smart meters	0.91	0.95	0.07	0.12
P2 - Regulatory changes	1	1	0.55	0.64
P3 - R&D and demonstration	1	1	0.47	0.57
P4 -DSM and DG	1	1	0.66	0.7
P5 - Telecom standards	0.89	0.93	0.11	0.16
P6 - New business models	1	1	0.48	0.61
P7 - Smart cities	1	1	0.55	0.63
P8 - Smart grid industries	1	1	0.45	0.54