Work Package 3: Tools Selection Methodology

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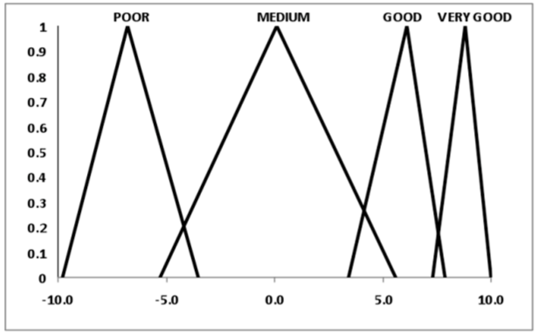
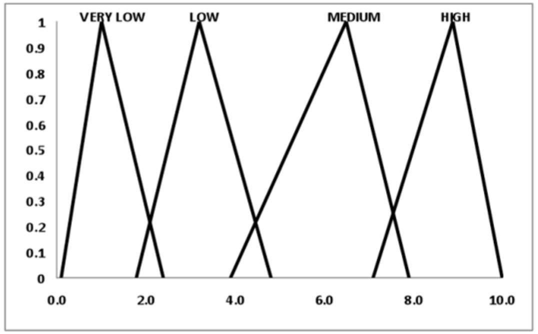
Tool Selection Methodology

- Prework of the methodology
  - WP1: Consultation with SET-Plan stakeholders to define basic specification.
  - WP2:Characterisation of existing tools-Identified needed characterisations -Apply the characterisation on the identified tools.
- Summary of the methodology
  - The elements of the methodology are:
    a) Models
    b) Specifications
    c) Policy Questions
  - Specifications are being assessed by
    a) Model perspective, i.e. the usefulness of the model in answering a specification
    b) Policy Question perspective, the importance of the specification in answering a policy question

Methodology Steps – Step 1&2

- Step 1: Define fuzzy sets
  - Why fuzzy sets?
  - What is the outcome of step 1?





- Step 2: Assign values to models according to their usefulness in answering a specification.
  - Ranks: {None, Poor,Medium, Good, Very Good}
  - The evaluation of each model was conducted by two partners independently, and was based on: questionnaires answered by the model developers, literature reviews and knowledge of the models by the project team

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Methodology Steps – Step 3

- Step 3: Ranking Specifications according to their ability to answer policy questions
- Each policy question implies a specific view of the aspects involved in the evolution of the energy system.
- The importance evaluation of the specifications has been conducted by the project team, with the care of verifying inputs by two partners at least.
- Up to step 3 two matrices have been created
  - 2-dimensional matrix {specification x number of models(110 x 87)},
  - 2-dimensional matrix {specification x policy_question(110 x 8)}

Methodology Steps – Step 4

- These two matrices are used as the base to extend the evaluation in finding the optimal combination of models
- Step 4: Identify applicable combinations of tools that can answer a certain policy question
  - Key point 1: Handling of "numerous" possible combinations required an efficient setup for the prequalification of models according to the policy question
  - Key point 2: A new set of binary type (yes/no) qualification criteria has been established for all the models and the policy questions

Technology Rich	CCS	Gas	EU level
Wind	Fuel Cells	Electricity	MS level
Photovoltaic	Smart grids	Transport	Regional level
CSP	Energy Eff	Industry	Local Level
Biofuels	Coal	Buildings	Systemic
Nuclear IV	Oil	World	Macroeconomic

Methodology Steps – Step 4

- Key point 3: Models enter in the combination creation phase if and only if their responses in the “orange coloured” criteria matches exactly with the relevant setup requirements of the policy question

- Key point 4: Systemic or macroeconomic models are represented at most by one model of their category

- Key point 5: Approved combinations are the ones that are fully compatible with the setup of the policy question to answer, e.g. if the set up of the policy question requires the presence of technology rich models then all combination that do not include at least one technology rich model don’t qualify and therefore not evaluated

Methodology Steps – Step 5

- Step 5: Creation of the decision matrix and evaluation of the eligible combinations
  - Each combination is ranked for every specification according to the highest score of the models that participate in the combination
  - weighted sum approach is used for the quantification of the evaluation results

$$u_j = \sum_{i=1}^{m} w_i \cdot r_{ij} = \left(w_1 \otimes r_{1j}\right) \oplus \ldots \oplus \left(w_i \otimes r_{ij}\right) \oplus .. \oplus \left(w_m \otimes r_{mj}\right)$$

  - Distance measure is provided from the next best linguistic weight value

$$d(x,y) = \left(\sum_{i=1}^{3} (x_i - y_i)^3\right)^{\frac{1}{3}}$$

Methodology - Considerations

- The mechanics of linking models are not efficiently represented in the evaluation method
- Positive/negative synergies cannot be traced and quantified(see WP5)
- Decision of cardinality for the combination cannot be rigorously assessed

Methodology - Capabilities

- Methodology offers
  - A flexible framework that translates results according to the subjective judgement of the evaluator
  - Extensive number of specifications
  - Policy question oriented
  - A range of criteria to refine the evaluation process

Implementation Overview

- 87 models(of which 17 systemic and 26 CGE-macroeconomic)
- 110 criteria for the evaluation & 24 criteria for the qualification of models
- 8 policy questions
- Three runs per policy question according to cardinality(4,5,6)
- Code is written in programming language C, using a variety of algorithmic optimization techniques to correspond the high complexity of the problem (NP – hard problem)

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Results – Policy Question 1

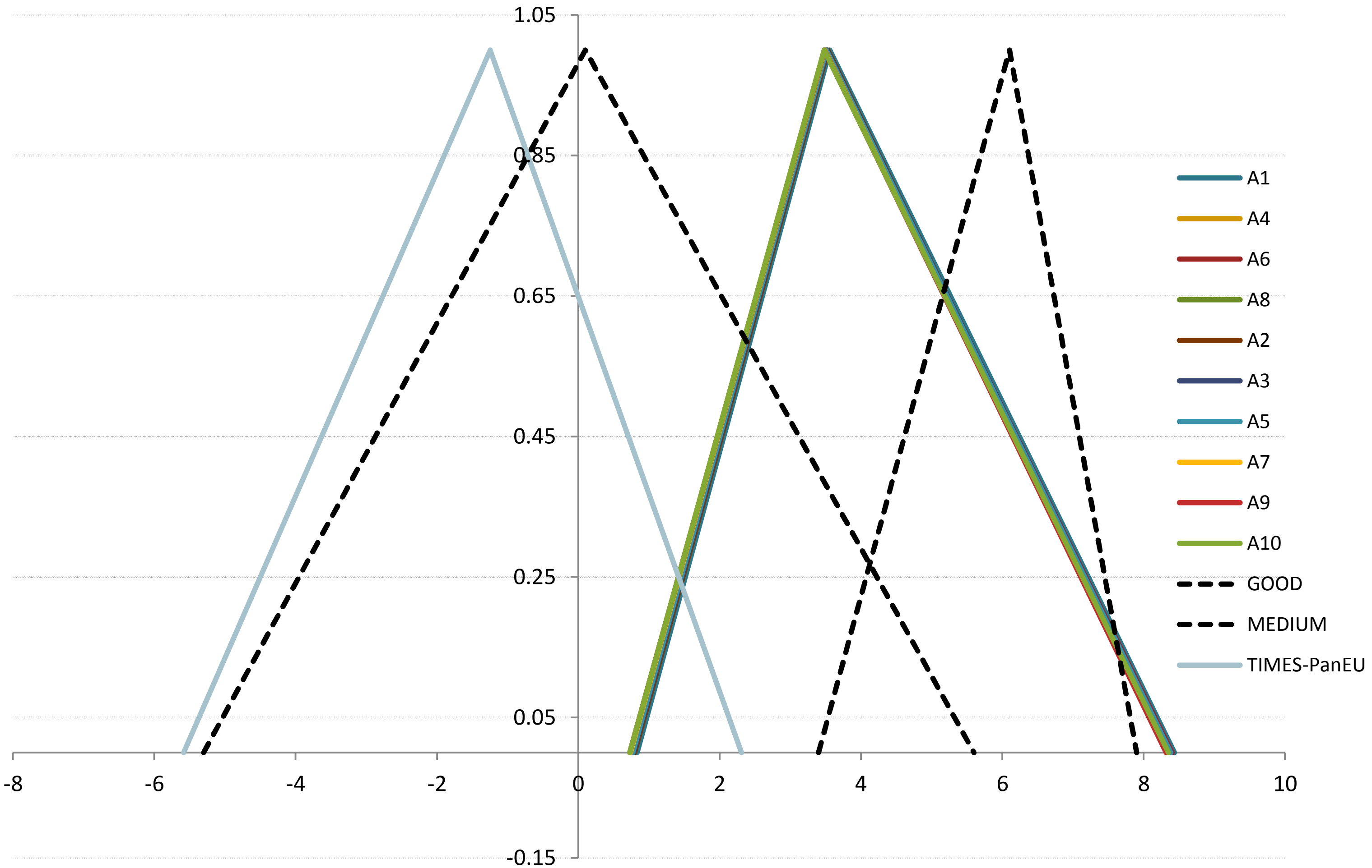
PQ1 : How to achieve a low cost and low emissions energy mix

							a	**b**	**c**	**distance**
A1	GEME3	MDM-E3	RESOLVE-E	STSc	Horizonscan	More_Hys	0.83263	3.55702	8.43809	3.2144
A2	GEME3	MDM-E3	RESOLVE-E	Horizonscan	Behave	More_Hys	0.79362	3.52977	8.37578	3.25786
A3	GEME3	PRIMES	RESOLVE-E	STSc	Horizonscan	More_Hys	0.77602	3.5154	8.38673	3.27783
A4	GEME3	MDM-E3	RESOLVE-E	MECHanisms	Horizonscan	More_Hys	0.76801	3.51227	8.3347	3.28593
A5	GEME3	PRIMES	IER_Transmission	RESOLVE-E	STSc	Horizonscan	0.7682	3.5102	8.38136	3.28619
A6	GEME3	IER_Transmission	MDM-E3	RESOLVE-E	STSc	Horizonscan	0.74505	3.50897	8.40467	3.30133
A7	GEME3	PRIMES	RESOLVE-E	Horizonscan	Behave	More_Hys	0.73701	3.48814	8.32442	3.32095
A8	GEME3	NEMS	MDM-E3	RESOLVE-E	STSc	Horizonscan	0.73074	3.48195	8.35935	3.3282
A9	GEME3	PRIMES	IER_Transmission	RESOLVE-E	Horizonscan	Behave	0.72919	3.48294	8.31904	3.32929
A10	GEME3	COMPETES	RESOLVE-E	STSc	Horizonscan	More_Hys	0.73027	3.4806	8.34848	3.32954
standalone models that enter the evaluation										
						TIMES-PanEU	-5.58296	-1.2474	2.31174	
						TIMES-NORDIC	-5.92276	-1.4338	2.24048	
						PRIMES	-6.06852	-1.4959	2.16804	
						TIMES-FI	-6.24251	-1.6389	2.0166	
						ENPEP	-7.43305	*-2.8831*	0.28368	
						GEME3	-7.63428	-2.9946	*0.1068*	
									combination gains (measured by distance):	8.457215

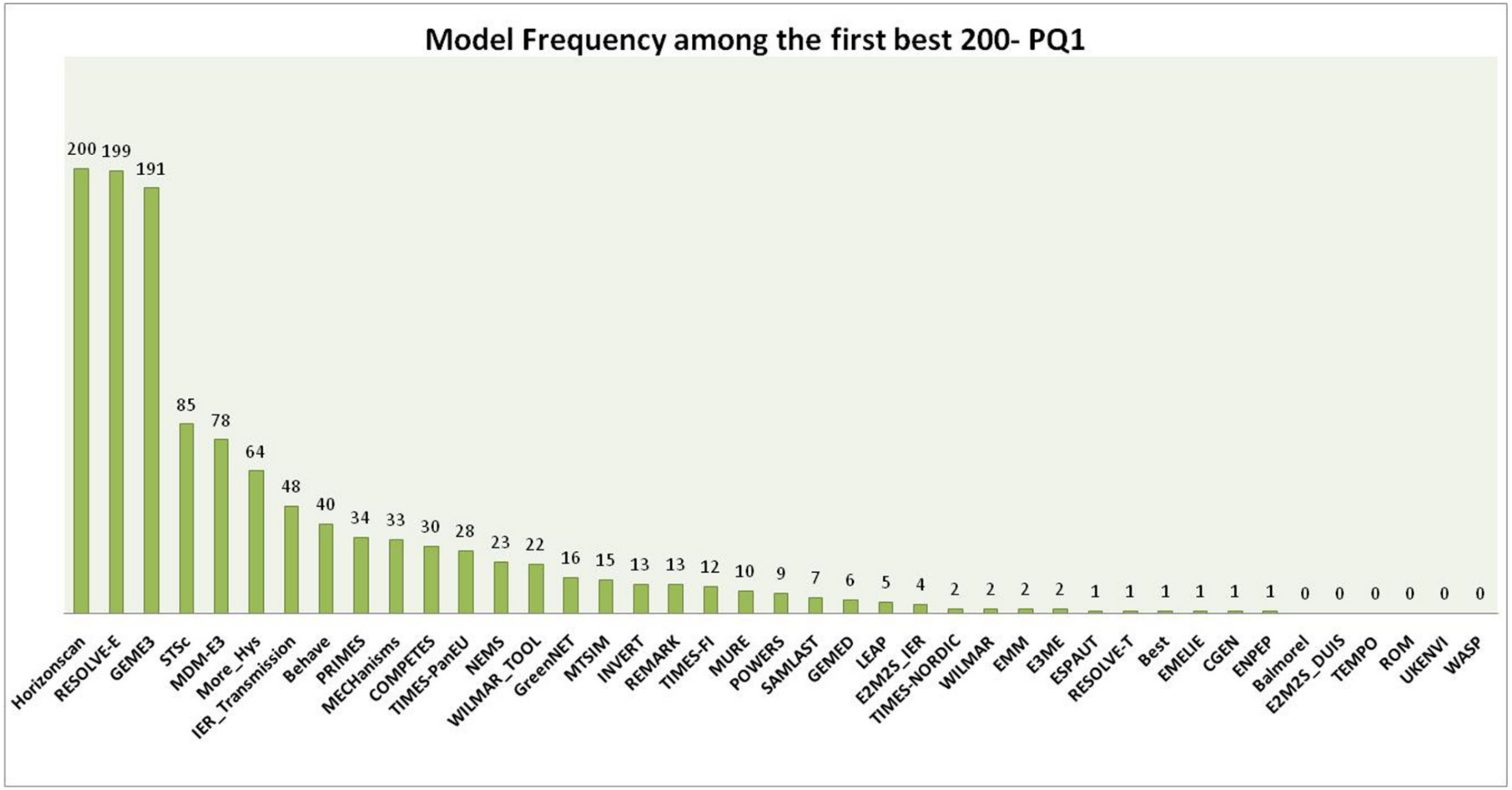
total number of combinations : **1,561,915**

models that pass the preselection criteria : {Horizonscan, RESOLVE-E, GEME3, STSc, MDM-E3,More_Hys,IER_Transmission, Behave, PRIMES, MECHanisms, COMPETES, TIMES-PanEU,NEMS,WILMAR_TOOL, GreenNET, MTSIM, INVERT, REMARK, TIMES-FI,MURE,POWERS, SAMLAST, GEMED, LEAP, E2M2S_IER, TIMES-NORDIC,WILMAR,EMM, E3ME, ESPAUT, RESOLVE-T, Best, EMELIE,CGEN,ENPEP, Balmorel, E2M2S_DUIS, TEMPO, ROM, UKENVI,WASP}

Results PQ1 – Fuzzy Triangles



Results PQ1 - Statistics



Results PQ1 – Key Points

- The first 10 combinations almost coincide
- Key models :
  - {Horizonscan} – for cardinality: 2-6
  - {GEM-E3, RESOLVE-E} –for cardinality 3-6
  - TIMES-PanEU – for cardinality 2 & 4
  - {MDM-E3, MoreHys} – for cardinality 5 – 6
  - STSc – for cardinality 6
- Moving to larger cardinality leads to the substitution of systemic models with more specialized ones

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Results – Policy Question 3

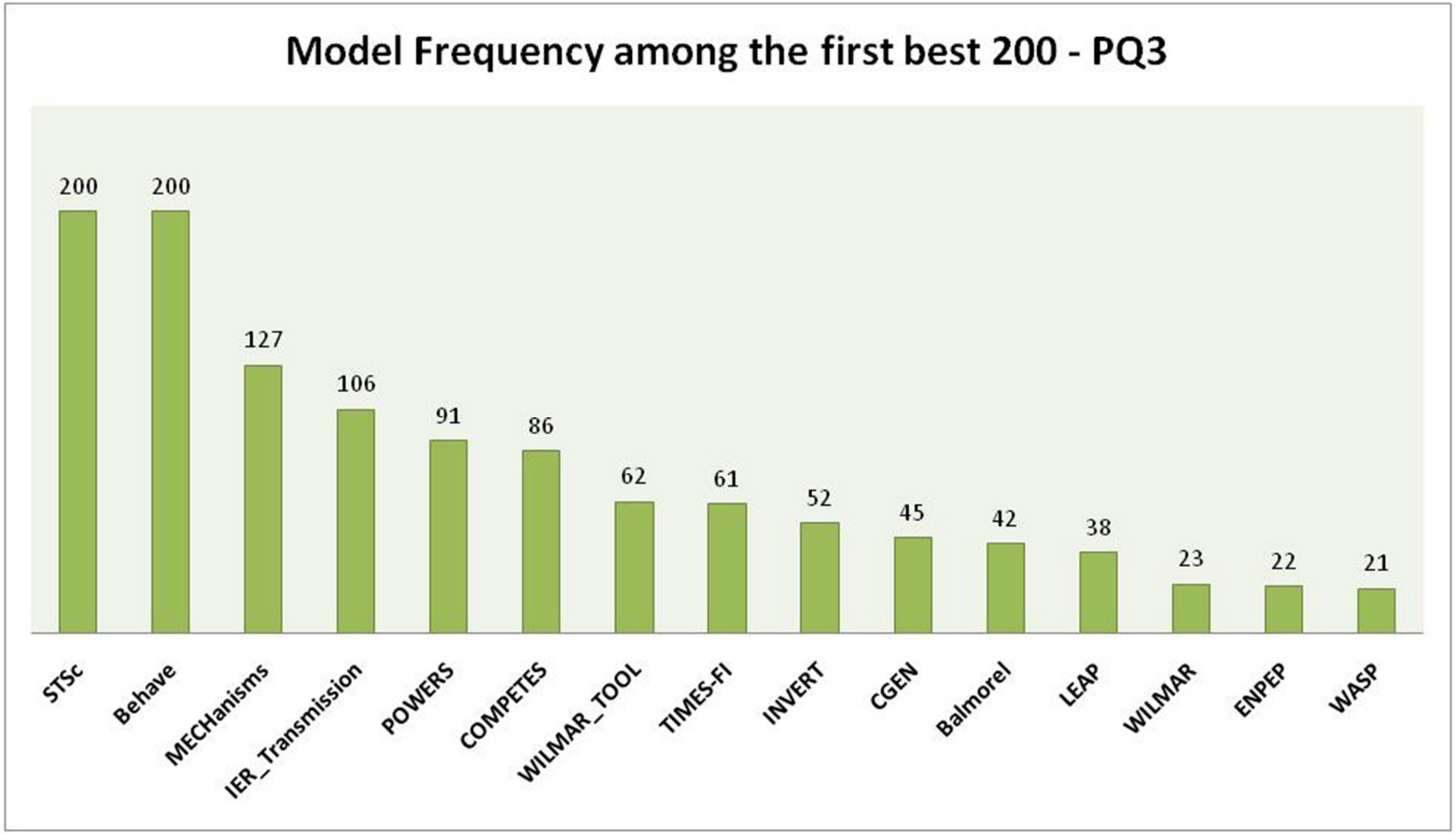
PQ3 : How to achieve an energy mix that has the maximum societal acceptance

							a	b	c	distance
A1	TIMES-FI	IER_Transmission	POWERS	STSc	MECHanisms	Behave	-0.36763	2.82099	7.78712	4.46036
A2	TIMES-FI	COMPETES	IER_Transmission	STSc	MECHanisms	Behave	-0.38438	2.80451	7.80254	4.48121
A3	TIMES-FI	WILMAR_TOOL	POWERS	STSc	MECHanisms	Behave	-0.40029	2.77442	7.71729	4.50894
A4	LEAP	IER_Transmission	POWERS	STSc	MECHanisms	Behave	-0.44647	2.76811	7.71842	4.54529
A5	COMPETES	IER_Transmission	POWERS	STSc	MECHanisms	Behave	-0.47187	2.76275	7.71654	4.5664
A6	IER_Transmission	POWERS	STSc	MECHanisms	Behave	INVERT	-0.47442	2.76333	7.71736	4.56792
A7	TIMES-FI	COMPETES	WILMAR_TOOL	STSc	MECHanisms	Behave	-0.44352	2.71959	7.68184	4.56958
A8	LEAP	COMPETES	IER_Transmission	STSc	MECHanisms	Behave	-0.47249	2.73872	7.7195	4.57972
A9	TIMES-FI	IER_Transmission	WILMAR_TOOL	STSc	MECHanisms	Behave	-0.49161	2.74294	7.72168	4.59117
A10	TIMES-FI	Balmorel	IER_Transmission	STSc	MECHanisms	Behave	-0.49205	2.73902	7.71058	4.5936
standalone models that enter the evaluation										
						TIMES-FI	-7.44159	-2.8009	0.57063	
						ENPEP	-7.88359	-3.2156	-0.1113	
						LEAP	-8.37475	-3.7723	-0.8444	
								combination gains (measured by distance):		9.6816

total number of combinations : **5,581**

models that pass the preselection criteria : {STSc, Behave, MECHanisms, IER_Transmission, POWERS WILMAR_TOOL, TIMES-FI, INVERT, CGEN, Balmorel, LEAP, WILMAR ENPEP, WASP}

Results PQ3 - Statistics



Results PQ3 – Key Points

- The first 10 combinations almost coincide
- Key models :
  - {STSc} –for cardinality 2-6
  - {TIMES-FI,Behave} – for cardinality: 3-6
  - {IER-Transmission} – for cardinality 4-6
  - {MECHansims} – for cardinality 5-6
  - {POWERS} – for cardinality 2 & 6
- Behavioural and lifecycle analysis models seems to be very competitive when combined with a systemic one. Specialized models help to improve the overall evaluation ranking

Results – Policy Question 7

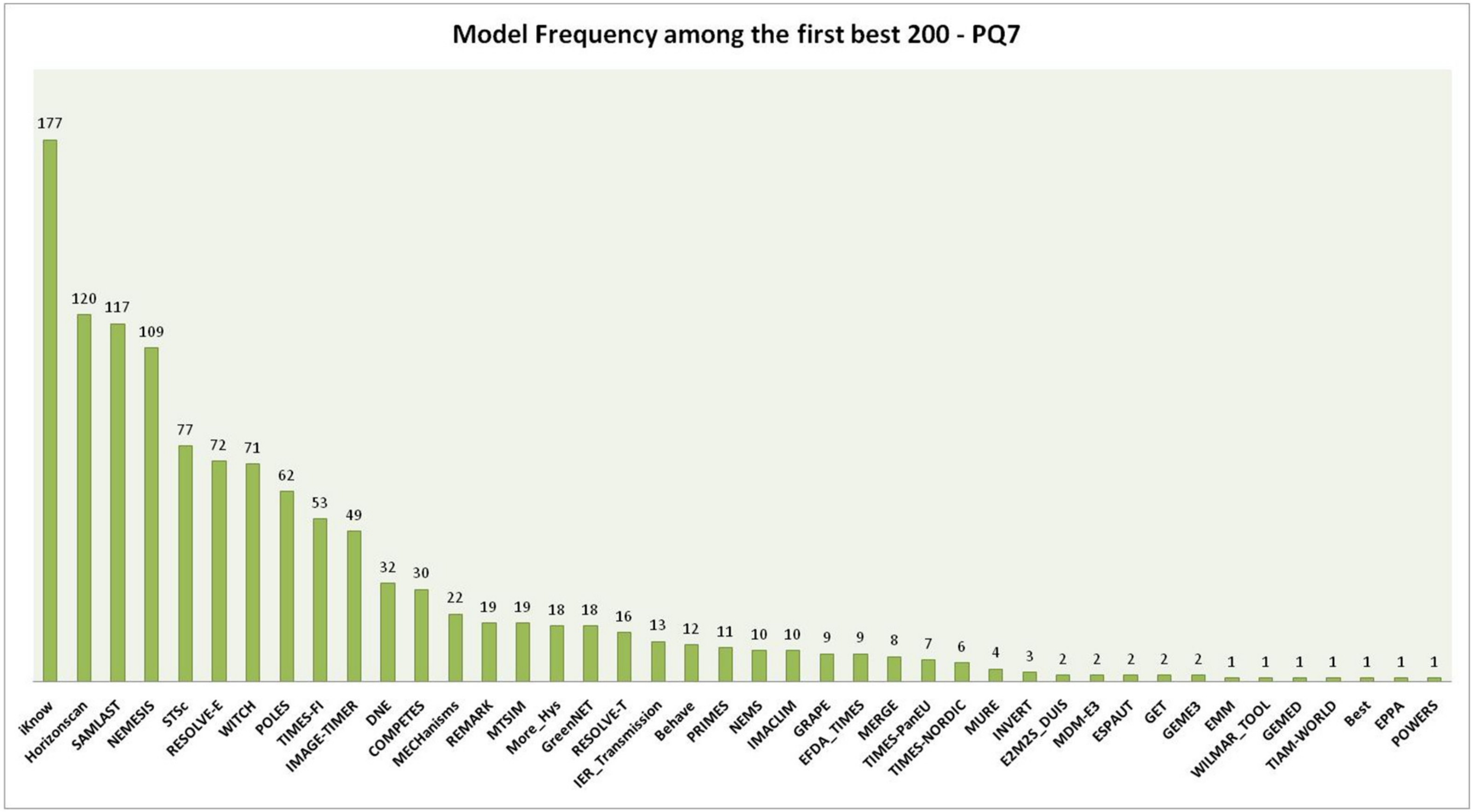
PQ7 : How should a country develop energy interconnections with other European and non European countries

							a	b	c	distance
A1	NEMESIS	POLES	COMPETES	Horizonscan	iKnow	SAMLAST	1.56015	4.15239	9.24968	2.23451
A2	NEMESIS	POLES	IMAGE-TIMER	Horizonscan	iKnow	SAMLAST	1.529267	4.14807	9.24948	2.2589
A3	NEMESIS	POLES	RESOLVE-E	Horizonscan	iKnow	SAMLAST	1.518238	4.14074	9.24189	2.27458
A4	NEMESIS	POLES	Horizonscan	iKnow	SAMLAST	GreenNET	1.51617	4.13127	9.22962	2.28722
A5	MERGE	POLES	IMAGE-TIMER	Horizonscan	iKnow	SAMLAST	1.515368	4.14204	9.2031	2.28861
A6	NEMESIS	TIMES-FI	COMPETES	IMAGE-TIMER	STSc	iKnow	1.524539	4.12574	9.21167	2.29166
A7	WITCH	TIMES-FI	RESOLVE-E	STSc	iKnow	More_Hys	1.502615	4.13792	9.22627	2.29269
A8	NEMESIS	NEMS	COMPETES	RESOLVE-E	Horizonscan	iKnow	1.483777	4.15107	9.23503	2.2932
A9	NEMESIS	NEMS	RESOLVE-E	Horizonscan	iKnow	GreenNET	1.492852	4.14106	9.22466	2.29764
A10	WITCH	POLES	RESOLVE-E	Horizonscan	iKnow	SAMLAST	1.511346	4.12485	9.20723	2.30261

total number of combinations : **20,127,594**

models that pass the preselection criteria : **all models**

Results PQ7 - Statistics



Results PQ7 – Key Points

- Under this policy question the qualification rules have been relaxed, resulting to the participation of all the models in the evaluation
- Key models :
  - {Horizonscan} - participates in 120 of the first best 200 combinations
  - {SAMLAST} - participates in 117 of the first best 200 combinations
  - {NEMESIS} - participates in 109 of the first best 200 combinations
  - One systemic model participates in almost all the first best 200 combinations
  - DNE, STSc while they don't participate as much as the previous ones are a on the top combination for cardinality 5

Conclusions

- The implemented methodology provides:
  - A navigation map – Ask the policy you need to study and it can give an appropriate list of model combinations that are able to answer it
  - A method that inherits only the uncertainty of the evaluator's subjective judgement and without generating new uncertainty by its structure(with the exception of linking mechanics)
  - The capability of conducting sensitivity runs in a reasonable time frame to refine results
  - The ability to trace gaps or trade offs between models
  - A starting point for a methodology that can capture linking mechanics issues