A COMPUTATIONAL APPROACH TO ENERGY POLICY FORMATION FOR SUSTAINABLE DEVELOPMENT IN THE MENA REGION

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SCIENTIFIC BACKGROUND

Senior Research Scholar at IIASA, Austria

Professor in Computer and Systems Sciences at Stockholm University, Sweden

UNESCO Chair

PhD in Mathematics

PhD in Computer and Systems Sciences

INTERNATIONAL INSTITUTE FOR SYSTEMS ANALYSIS (IIASA), AUSTRIA

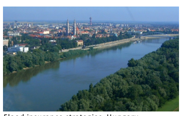
DEPT. OF COMPUTER AND SYSTEMS SCIENCES, STOCKHOLM UNIVERSITY

WORKING WITH


City planning, Stockholm


Measures for contaminated river, Örebro


Mine action, Cambodia


Flood insurance strategies, Hungary

SOME REAL LIFE CASES

Storing spent nuclear waste in Sweden (SKN, Statens Kärnbränslenämnd)

Large purchasing decisions at the Swedish Rail Administration (Banverket, around 1 billion Euro)

Choice of effective orthopedic forms of treatment (The Swedish National Board of Health and Welfare)

Model for risk management regarding evaluation of cost- and accessibility in cases of unplanned traffic disturbances (Swedish Telecom)

Public-private flood insurance system for Hungary (IIASA and the Hungarian Academy of Sciences)

Land planning (Nacka Municipality)

Public Decision Making (National Government funds)

SOME REAL LIFE CASES

City infrastructure development (City of Stockholm)

Smurfit Kappa (Investment decision analysis)

Intrum Justitia (Project management support for business intelligence)

Geneva International Centre for Humanitarian Demining (Decision model for demining activities)

Municipality of Örebro, Sweden (Decision analysis in environmental management)

Sundsvall Energy (Method for analysing risk premium)

SCA Packaging Research (Risk factor classification)

Ericsson (Risk analysis for portfolios)

Procurement (Various Authorities)

Vattenfall (Energy Efficience)

etc

ENERGY DEMANDS

Middle Eastern and North African (MENA) countries have to:

- address the increasing demand for energy
- tackle socio-economic development, climate change and political transformation

An important prerequisite for overcoming these challenges is the deployment of new electricity infrastructures

REQUIREMENTS

and they must find an electricity pathway that:

- is cost-effective
- can support multiple development objectives
- is conflict-sensitive

REQUIREMENTS

but there is high uncertainty how investments into different electricity pathways will interact with social, economic, political and environmental dimensions at multiple scales

ARAB SPRING

it is particularly important to frame national electricity policies so that they incorporate societal demands

while avoid further political destabilization

SO IMPORTANT HERE:

WHERE IS THE PUBLIC?

IN THE TIME OF

………social alienation and commodity fetishism

PUBLIC INVOLVEMENT

A well-known parallel is, for instance, the rapid transformation of Western city centers caused protests over insensitive rebuilding schemes and gentrification

…decided by power elites without dialogue with residents in the local communities.

SOLUTION

a participatory and distributed approach

PUBLIC INVOLVEMENT

The formal planner should ideally be a facilitator who stimulates also underrepresented groups to actively participate in the processes.

To enable this, a broad engagement in the political discourse is essential.

THUS, WE

- need a real interdisciplinary research
- otherwise the capacity for transparent communication will be largely hampered
- contemporary processes are using quite few modalities

HOW

we must obviously enhance

- efficiency
- transparency
- comprehension
- and rationality

RATONALITY

Formalise processes, methods and algorithms for preparing recommendations for decision makers.

WHY?

Provides the potential for an improved communication with decision makers on the basis for recommendations

SO THAT IS THE BASIS FOR OUR WORK

MENA SELECT

Middle East North Africa
Sustainable Electricity Trajectories

MENA SELECT

focuses on socio-economic impacts, risks and opportunities,

and potential for conflict, of different electricity scenarios and power production technologies

in Morocco, Jordan and Tunisia

MENA SELECT

a participatory approach with local stakeholders

to suggest a policy to national decision-makers

and debate potential pathways for sustainable energy policies

THE IDEA

developing support systems clarifying the different interests, opinions and facts involved

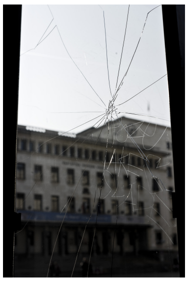
TO

decrease the risk of inconsistency and irrationality

even when the background information is imprecise

and actually suggest something that is "best"

in the sense of "not too stupid"



AND

also make clear how representative the preferences are for different stakeholders

MORE CONCRETELY THIS MEANS

information collection

process development

tool production

COLLECTING INFORMATION

expert surveys

multi-stakeholder groups

opinion mining

OPTIONS

- Utility PV
- Concentrated Solar Power
- Onshore Wind
- Utility Hydro
- Nuclear
- Coal
- Gas
- Oil Shale
- Oil

CRITERIA

- Use of Domestic Energy Sources
- Global Warming Potential
- Domestic Value Chain Integration
- Technology and Knowledge Transfer
- Electricity System CostOn-Site
- Job Creation
- Pressure on Local Land Resources
- Pressure on Local Water Security
- Occurrence and Manageability of Non-Emission
- Hazardous Waste
- Local Air Pollution
- Health
- Safety

Criterion 1: Use of Domestic Energy Sources

The dependence on foreign energy imports can be decreased by tapping into domestic resources that are either available today or could be exploited in the mid- to long-term

- Current domestic potential of each technology's energy carrier to decrease energy import dependence today
- Future domestic potential of each technology's energy carrier to decrease energy import dependence by 2040/50

Criterion 2: Global Warming Potential

The technology should contribute to the mitigation of climate change
- *Total lifecycle GHG emissions (CO_2-eq) per generated kWh*

Criterion 4: Technology and Knowledge Transfer

Based on existing policies, the technology should have a high potential to benefit from technology and knowledge transfer in order to stimulate future domestic value-added in electricity generation
- *Effectiveness of educational policies to foster skill development and R&D*
- *Effectiveness of industrial policies to enhance industry linkages between domestic and foreign firms geared towards horizontal technology transfer*

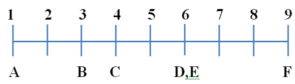
MULTI-STAKEHOLDER GROUPS

various representatives from:
- young leaders
- national NGOs
- local communities
- academia
- finance/Industry
- policy-makers
- compromise

AN ITERATIVE PROCESS

- Introduction to the process and the analysis in particular
- Stakeholders identified the criteria collectively
- Decision alternatives and assessments of their effects with respect to the criteria
- Main criteria priority weights elicitation using cardinal ranking
- Discussion of the appropriateness and modification

CARDINAL RANKING



SURROGATE WEIGHT ASSIGNMENTS

$$w_i^{RS} = \frac{N+1-i}{\sum_{j=1}^{N}(N+1-j)}$$

$$w_i^{RR} = \frac{1/i}{\sum_{j=1}^{N}\frac{1}{j}}$$

$$w_i^{ROC} = 1/N \sum_{j=i}^{N}\frac{1}{j}$$

$$w_i^{SR} = \frac{1/i+\frac{N+1-i}{N}}{\sum_{j=1}^{N}\left(1/j+\frac{N+1-j}{N}\right)}$$

$$w_i^{CRS} = \frac{Q+1-p(i)}{\sum_{j=1}^{N}(Q+1-p(j))}$$

$$w_i^{CRR} = \frac{\frac{1}{p(i)}}{\sum_{j=1}^{N}\frac{1}{p(j)}}$$

$$w_i^{CRC} = \frac{\sum_{j=p(i)}^{Q}\frac{1}{j}}{\sum_{k=1}^{N}\left(\sum_{j=p(k)}^{Q}\frac{1}{j}\right)}$$

$$w_i^{SR} = \frac{1/i+\frac{N+1-i}{N}}{\sum_{j=1}^{N} w_j}$$

$$w_i^{CSR} = \frac{1/p(i)+\frac{Q+1-p(i)}{Q}}{\sum_{j=1}^{N}\left(1/p(j)+\frac{Q+1-p(j)}{Q}\right)}$$

SURROGATE WEIGHT ASSIGNMENTS

Final scores	SMART	AHP	CAR	O+C	C+O	O+O
Total	79.1	80.0	86.4	82.0	75.7	74.0
Rank	4	3	1	2	5	6

Final score	ROC	SR	CRC	CRS	CRR	CSR	S1	S2A	S2B
Score	74.9	80.7	80.9	80.2	77.4	85.9	78.3	79.8	79.8
Rank	9	3	2	4	8	1	7	6	5

CARDINAL RANKING

electricty sys. Cost		21,174
	2	
use of dom. Energy sources		11,765
	0	
tech transfer		11,765
	0	
Pressure on local water resources		11,765
	0	
local air pollution/heath		11,765
	0	
on-site job creation		11,765
	3	
domestic value chain integration		6,471
	0	
safety		6,471
	3	
Global warming potential		2,353
	0	
non-emission hazardous waste		2,353
	0	
pressure on local land resources		2,353

PICKING THE PREFERRED ALTERNATIVE

- For an *N*-dimensional problem, generate a random weight vector with *N* components. This is called the TRUE weight vector. Determine the order between the weights in the vector. For each method **X'**, use the order to generate a weight vector $w^{X'}$.
- Given *M* alternatives, generate $M \times N$ random values with value v_{ij} belonging to alternative *j* under criterion *i*.
- Let w_i^X be the weight from weighting method **X** for criterion *i* (where **X** is either **X'** or TRUE). For each method **X**, calculate $V_j^X = \sum_i w_i^X v_{ij}$. Each method produces a preferred alternative, i.e. the one with the highest V_j^X.
- For each method **X'**, assess whether **X'** yielded the same decision (i.e. the same preferred alternative) as TRUE. If so, record a hit.

CARDINAL RANKING

We generalise the most well-known ordinal methods such as Rank sum, Rank reciprocal and ROC but also SR and in particular, invent CRC – a cardinalisation of ROC

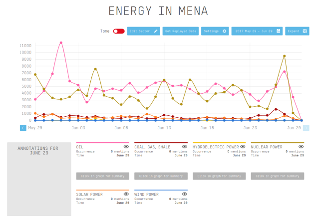
$$w_i^{\mathrm{CRC}} = \frac{\sum_{j=p(i)}^{Q} \frac{1}{j}}{\sum_{k=1}^{N} \left(\sum_{j=p(k)}^{Q} \frac{1}{j} \right)}$$

and CSR, the cardinalisation of SR

$$w_i^{\mathrm{CSR}} = \frac{{}^{1}/_{p(i)} + \frac{Q+1-p(i)}{Q}}{\sum_{j=1}^{N} \left({}^{1}/_{p(j)} + \frac{Q+1-p(j)}{Q} \right)}$$

We show that CRC/CSR are more accurate and robust than any ordinal surrogate weights

OPINION MINING



TOOL SUPPORT

handling impreciseness

not impossible demands on the decision maker

balance theoretical precision vs. real-life usability

no violations of reasonable requirements

no combinatorical explosion in sensitivity analyses

some trade-off support

intuitive decision rules

robust

THE DANGER OF MEANINGLESS PRECISENESS

Possibility theory (Dubois and Prade, Cooman...)

Capacities (Choquet, Huber and Strassen, Denneberg...)

Evidence theory and belief functions (Dempster, Shafer, Yager, Smets...)

Various kinds of logic (Nilsson, Wilson...)

Upper and lower estimates (Smith, Hodges and Lehmann, Hurwicz, Wald, Walley, Kyburg, Weichselberger and Pöhlman, Malmnäs, Danielson and Ekenberg…)

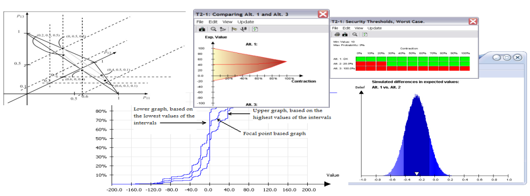
Sets of measures (Good, Levi...)

Second-order theories (Gärdenfors and Sahlin, Good, Utkin, Ekenberg and Thorbiörnson…)

THE DECIDEIT DECISION TOOL

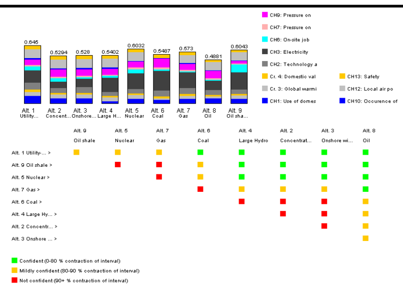
The information, such as probabilities and values, available to decision makers is often vague and imprecise.

We develop concepts, models, and evaluation methods extending the expressibility to represent and evaluate numerically imprecise information in decision situations. This includes evaluation algorithms and computational aspects.



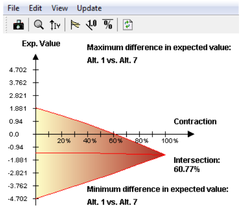
Interval probabilities, probability boxes, probabilities on probabilities, sensitivity analysis.

EVALUATION



Conclusion: "Alt. 1 Utility-scale Photovoltaic (PV)" is the best alternative, with "Alt. 9 Oil shale" as runner up.
The Alt. 1 > Alt. 9 statement is mildly confident, since the information provided in this decision basis supports a strict ranking with a degree of 10 %, whereas the reverse statement is not supported.

EVALUATION



SO WE ARE TRYING TO

Provide the potential for an improved policy making with decision makers of the basis for policy recommendations

As far as possible formalise many of the informal processes already followed by people in preparing recommendations

Provide a quite flexible set of analysis tools

Discipline ourselves so we do not believe that our models would solve everything

CONCLUSIONS

In our policy work we are bridging two fields, analytic decision support and public participation

by addressing both the problem of representation

and that of modeling and analysis of decision alternatives

It is neither easy nor fully obvious how to do it all

And pure technology is never the solution