A LOW CARBON STOCKHOLM - MÄLAR REGION 2050

(Photo: H. Liljenström)

COMPLEX

EU FP7 PROJECT 2012-2016 (Work package 4)

The transition to a low carbon economy by 2050 will involve irreversible changes in the cultural, economic and natural domains. This implies a potential for emergent qualitatively different societal conditions. By the time the low carbon policy has been implemented, many problems conceived today will have been resolved. Some aspects of socio-natural systems will then have been changed irreversibly. Thus, the design of the transformation will have to consider long-term social, environmental and economic conditions.

The Stockholm-Mälar Region Study

This region consists of two NUTS 2 regions and is one of the highly dynamic regions in northern Europe.

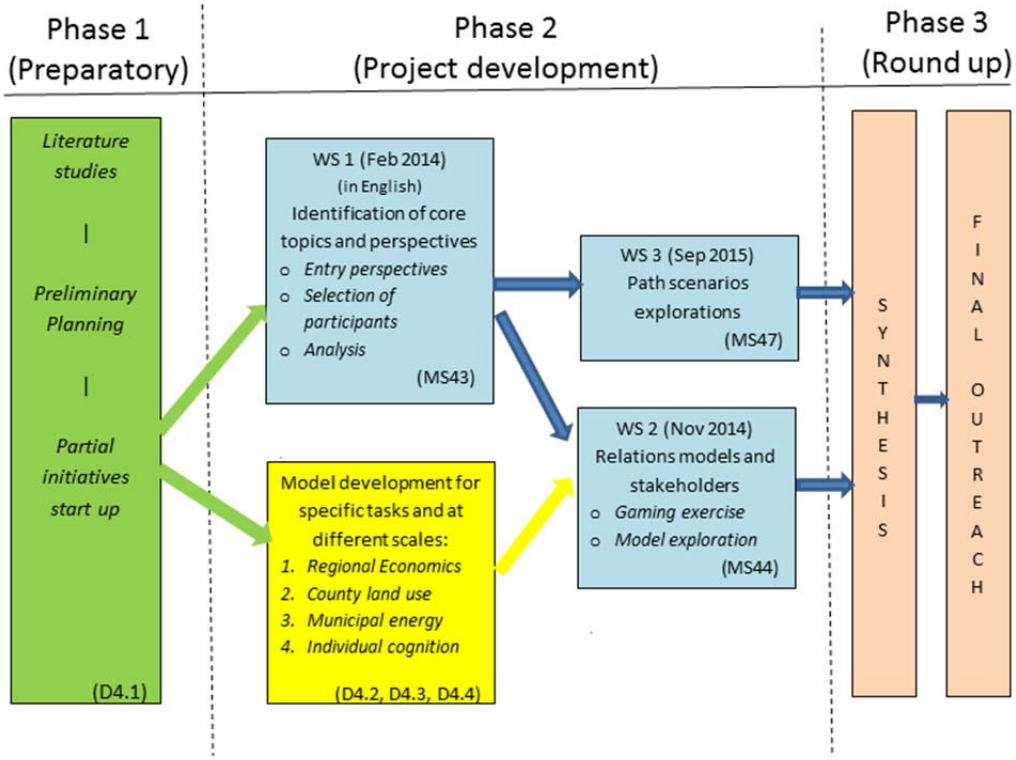
Our Stockholm-Mälar region study within the COMPLEX project provides steps towards a *process understanding* as well as instruments for support of the transition to a low carbon society by 2050.

Strategic societal choices and their consequences have been analyzed. This included the design of a toolkit for analysis 1) of emerging and optimally selected land use patterns, 2) of economic development and the impact of policy instruments, and 3) of the processes connecting the scientific support to the decision making functions at various levels, including policy processes at shorter and longer time scales.

Focus was on finding integrative forms of support to guide the path to a low carbon society under varying climate scenarios and world situations. The integration of social science, natural science and technology has been an important theme.

Different land use patterns will have different effects on the climate - and the climate, in turn, will constrain the options for land use. Whether land is used for agriculture, forestry, housing, industry, energy production, or infrastructure will depend on regional, national and EU policies, but also on cultural values and (sometimes conflicting) interests of various stakeholders. The dynamics of land use change and its environmental and economic impacts require analysis and models that can capture the complexity arising from irreversibilities, thresholds and nonlinearities involved.

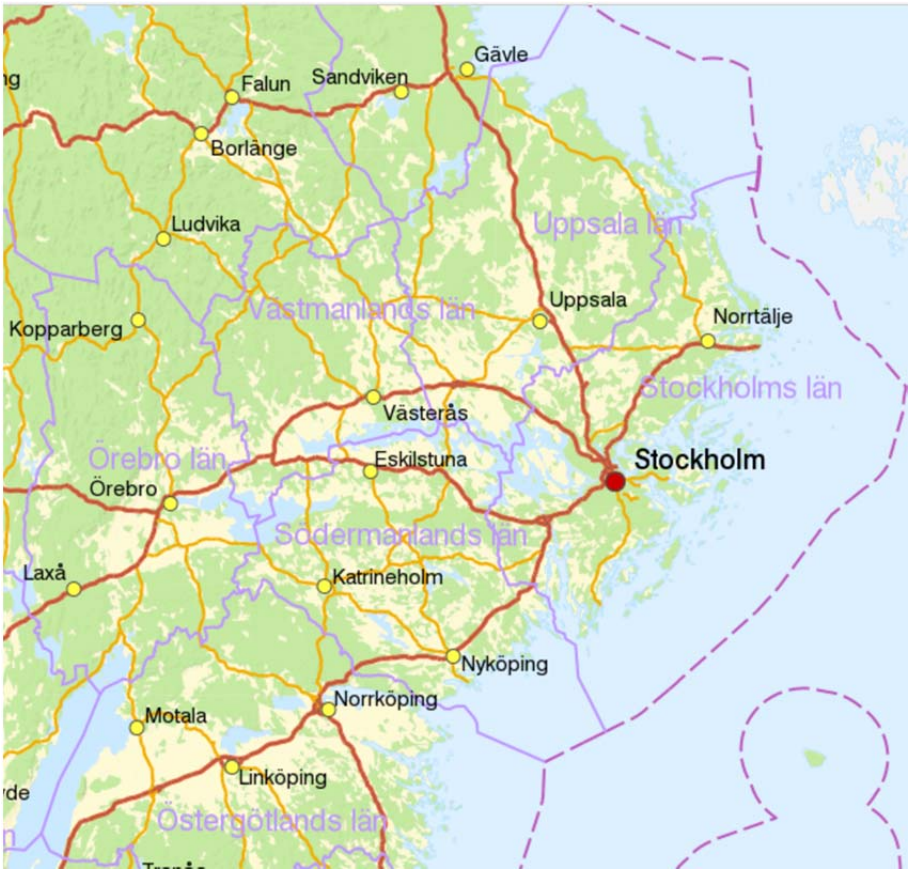
The study explored existing models and developed new ones where needed, taking into account conditions of uncertainty and asymmetric information. The models were intended to aid stakeholders in their decision making, linking policies at the (sub-national) regional level to those at the levels of individuals and municipalities, as well as at national and supra-national levels. We were also interested in decisions made under uncertainty, using e.g. risk cognition and risk-management approaches.



SOCIETAL TRANSFORMATIONS FACING CLIMATE CHANGE – TOWARDS A LOW CARBON MÄLAR REGION 2050

The population of the Mälar Region amounts to approximately 3.6 million, which constitutes about 1/3 of the total population in Sweden. It is divided among 6 different counties and involving 77 municipalities. One of the main characteristics of the region is the location of the capital of Sweden, Stockholm, which has a population of approximately 1 million.

A particular challenge for the Stockholm-Mälar region is the heterogeneity among counties with respect to economic prosperity and environmental performance. This may be perceived as an argument for delegation of decision rights on policy choice and implementation from central to local jurisdiction. One important justification is the gains obtained from local knowledge on economic and environmental performances and formation of local communities pursuing sustainable use of resources. However, the literature points at potential costs; the neglect of impacts on other jurisdictions and the risk resource exhausting competition among jurisdiction. The main task and challenge in reaching a carbon neutral Stockholm-Mälar region is then to identify, quantify, and balance advantages and disadvantages of different policy instruments and jurisdictional delegation levels. A specific consideration is then the current lack of a strong jurisdiction in between the national state and local municipalities



There is a strong focus in the political and planning communities in the region (but also among industrial actors) on transport and physical mobility in combination with issues around workplaces and housing. It is not surprising that an indicator system is given high weight in regional policy that is focused on commuting times to the Arlanda International Airport from different spots in the region. In the current discussions these concerns are slowly also being broadened to include the entire energy-climate-water-food nexus. This

nexus is closely connected to the spatial bio-geographical concerns that relate to climate change impacts on the biomass production (i.e. the future of agriculture and forestry issue). It also relates to matters concerning carbon sinks and in general terms the competition of land uses. Here the concept of ecosystem services has been articulated as an important and emerging indicator to be included in transition models. This means that other types of indicators as those for mobility have only rudimentary been developed (although there are signs of other interests in e.g. ecosystem services approaches).

Culturally oriented drivers for change and the topic of what could in the future constitute "social status" is something that is under emerging concern. This connects to how the GDP measure is used as indicator of progress, and what it reflects (and not). Another concern for further elaboration is the need to innovate novel policies in ways that are informed by cultural perspectives. Given the cognitive landscape of expressed types of interests, a number of policy-oriented concerns are rising as well as the need for reformed indicators of change. The consumption issue is articulated as a very important topic related to this.

Key messages for politics towards a transformation to low carbon society in Sweden

1. **The challenges are "glocal", where local action needs to address global complexities**
2. **Simultaneously address multiple policies at multiple scales**
3. **Cross-sectoral interactions are necessary**
4. **Define new roles and responsibilities to be integrated, combining formal and informal**
5. **Develop mechanism that connect top-down with bottom up approaches**
6. **Focus on incentives for realizing the implementation of policies**
7. **Support inter-disciplinary knowledge generation over time**
8. **A need for highlighting and addressing normative aspects of transformation from individual to societal level.**
9. **Applying an experimental approach for adaptive capacity by continuous learning**
10. **Acknowledging the time aspects by a combination of urgency and long term sustainability**

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Full references: COMPLEX reports D4.1, MS46-47

COST EFFECTIVE ATTAINMENT OF A LOW CARBON ECONOMY IN THE MÄLAR REGION IN 2050

This study investigates if and how the Mälar region in mid Sweden can achieve a low carbon economy in 2050. A low carbon economy is then operationalized as a cost effective achievement of the EU target of 80% reduction from the 1990 emission level to be reached in 2050. We include three classes of abatement measures; reductions in the use of fossil fuel (gasoline, diesel, oil), investment in renewable energy (wind power, solar cells, electric cars, bioenergy, biodiesel, ethanol), and creation of carbon sinks (prolongation of forest rotation period, afforestation). We account for uncertainty in implementing measures, and for technological development. To this end, a numerical dynamic model with uncertainty and technological development is constructed. Uncertainty is accounted for in a safety-first decision framework where decision makers are concerned about reaching the target, which increases costs because of the safety margin in reaching the target. Technological development is modelled as learning from doing where unit costs of abatement decreases as cumulative abatement increases.

The results indicate that a cost effective solution can be reached and the total abatement costs would then correspond to 1 % of cumulative gross regional product in the region when both technological development and uncertainty are acting. Without technological development the cost would be doubled. All classes of abatement measures are needed, but bioenergy, biodiesel, and electric cars are of significant importance. However, because of the asymmetric allocation of emissions in the business as usual case and in abatement costs, the main financial burdens are born by 1/5 of the municipalities in the cost effective solution. Another finding is that only a few counties and municipalities make gains in the overall cost effective solution compared with decision making in isolation. A majority faces lower cost when they implement abatement measures within their own jurisdiction.

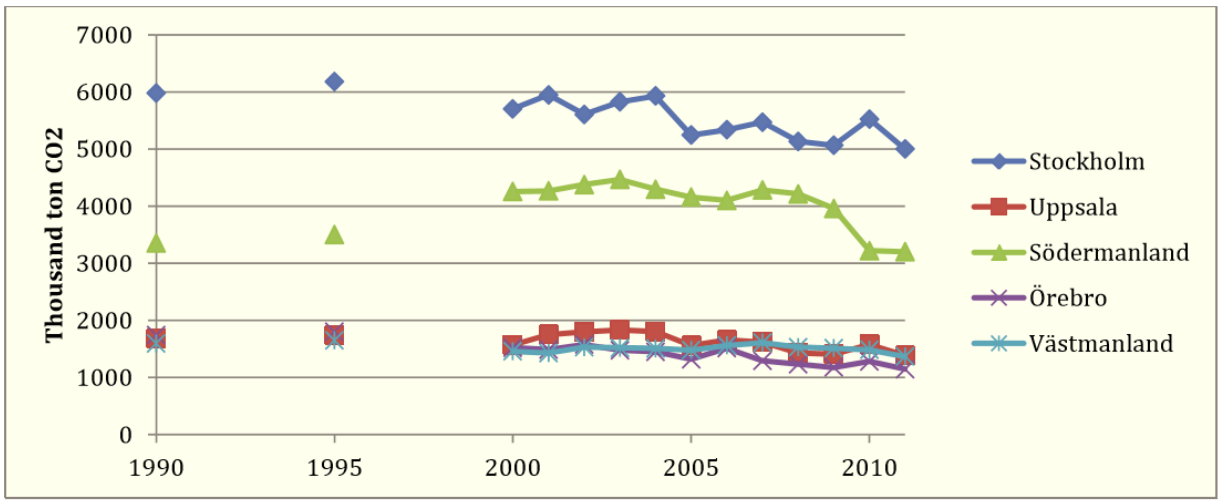

Figure 3: Emissions of CO_2 from fossil fuels
Sources: Swedish Statistics (2013b)

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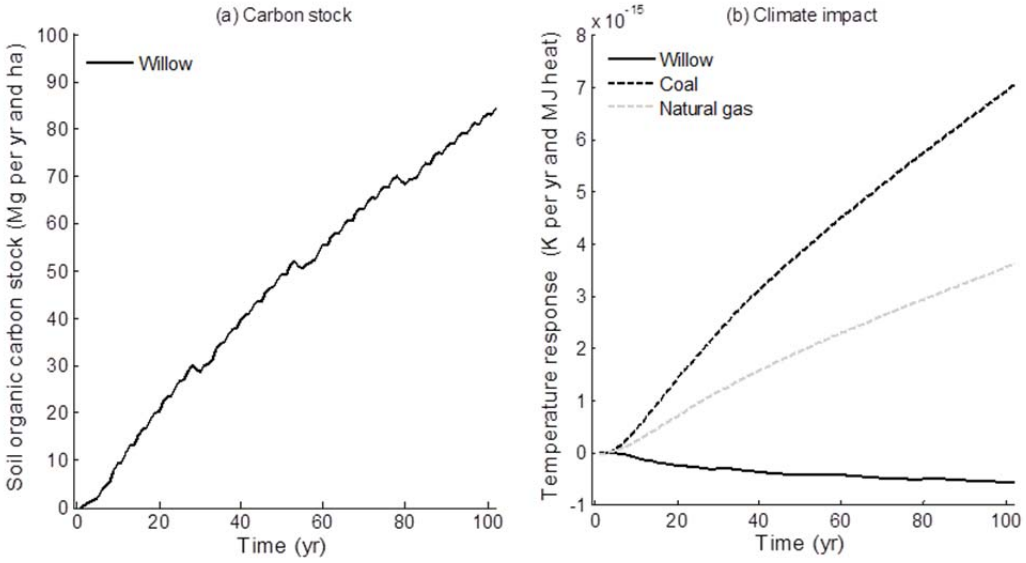
CLIMATE IMPACT OF WILLOW ENERGY CONSIDERING SPATIAL VARIATIONS IN A LANDSCAPE

Bioenergy is one strategy to substitute fossil based energy and thereby mitigate global warming by decreasing emissions of greenhouse gases. Locally produced biomass can also increase the energy security in a region by reducing the dependency on imported fuels. Growing short rotation coppice willow for energy is one option that has shown potentials to produce energy while sequestering carbon from the atmosphere to the soil. The aim of this study was to assess the impact of growing willow on fallow land in a specific region in Sweden, considering spatial variations in terms of transport distances, soil textures and initial carbon content. A time-dependent life cycle assessment method was therefore combined with GIS mapping. Uppsala County was chosen as study site since around 10% of the agricultural land in the region is fallow land, which could be utilised for willow without displacing land used for food production.

The result showed that even when considering spatial variations in the region, the climate impact of growing willow for energy purposes was negative, meaning that due to increased carbon content in standing biomass and soil (Fig. 1a), more carbon dioxide is taken up than released which gives a cooling effect on the temperature (Fig. 1b). Willow energy can thus be grown on all fields in the region to supply the local community with as much energy as possible, while being beneficial for the climate. If the effect of replacing fossil fuels (coal or natural gas) is considered, the climate mitigation potential is even higher.



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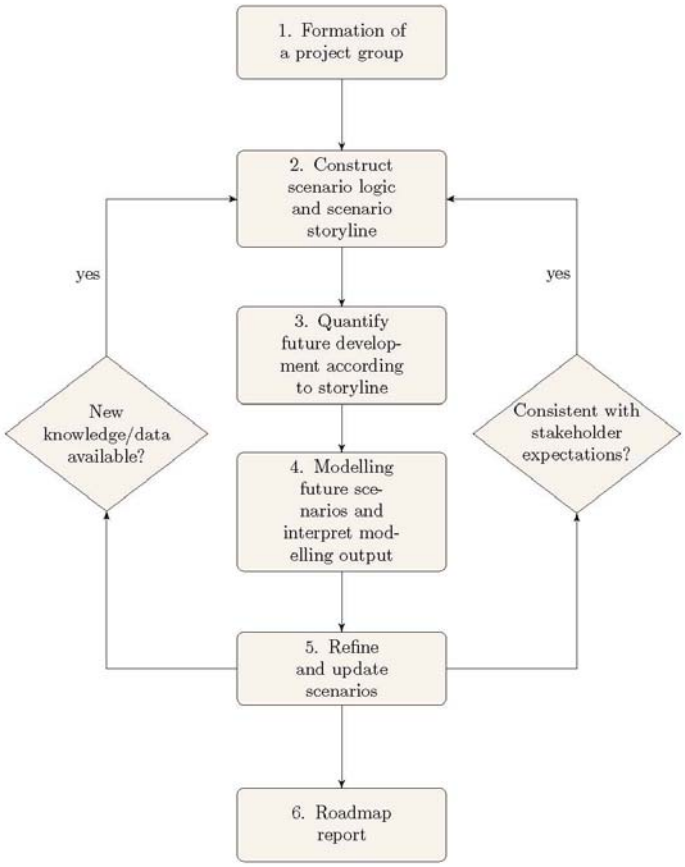
MODELLING THE FUTURE ENERGY SYSTEM AND CLIMATE IMPACT OF UPPSALA, SWEDEN

In 2010, the municipality of Uppsala initiated the Uppsala Climate Protocol (UCP) with the purpose to involve local and regional stakeholders and decision makers in a joint effort to reach the local energy and climate goals. The 25-30 private and public organizations, including Uppsala´s two universities, participate in energy and climate efficiency actions that are accessed through collaboration (http://klimatprotokollet.uppsala.se/). The UCP members commit to systematically reducing climate impact within its own operations, implementing and declaring climate mitigation measures, contributing with knowledge and collaborating with other members to reach their own as well as the municipality's climate targets. Short-term targets for climate impact reduction are set every three years and the progress is reported at advisory round table meetings that are held at least once annually with top executives and environmental managers. Cooperative projects take place in working groups in areas such as solar energy, waste management, sustainable transports, communication and energy management, which are open also to organizations outside the UCP. The UCP is managed by a project management group and a group of environmental managers.

The Uppsala roadmap project was initiated in 2013 within the framework of the UCP, aiming to analyze potential pathways and measures to reach the municipality's long-term climate objective. It was funded by the Swedish Energy Agency and COMPLEX. As a central piece of the project, the Uppsala roadmap model was developed with the intention to provide an overview of the current energy system and indicate possible trajectories towards the realization of a low-carbon society. The roadmap contains a number of future scenarios where emissions and energy demand are simulated. An inclusive process was initiated, bringing together members of the climate protocol and adopting a 'whole system' approach, including technical requirements, social learning and adaption, policy and legislation. The stakeholders involved include universities, the municipality, local energy companies, politicians, non-profit associations, local residential corporations, academic building corporations and municipal companies including waste and water management. Workshops were organized to identify possible measures for local future scenarios, focusing on issues such as electricity generation, smart grids, bioenergy production and district heating generation. Results from the workshops fed into the scenario building and modeling of future energy systems, which was performed by the researchers in the project.



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Full reference: COMPLEX D6.5 report

GAMING APPROACHES BRIDGING DECISION MAKERS AND MODELS

The task to focus on a general level process to explore how decision makers in a practical case could make use of a very large decision support model with regard to path decisions of overriding political nature in order to move towards a low carbon society. The target of this study was the relationships between the decision makers and the model. Thus we used a gaming approach, adapting an off-the-shelf computer game (Democracy) and "trimming" it to serve our specific purpose (i.e. Swedish decision making with regard to tasks related to low carbon societal transitions - especially oriented at centrally positioned political actors, or actors with tasks across sectors). We arranged a sequence of small theme-oriented seminars for experts in various fields in order to identify the required changes in the Democracy software package (i.e. to make it more "Swedish" in relevance and to improve and expand its sectorial coverage to better mirror the climate change issues). Some of the findings around this experiment with the stakeholder-model interaction (with regard to our target of non fossil societal path decisions) are:

- The interplay with the model was used to support reflections about conditions to political choice. Thus it is not primarily the predictive power (which may be limited under the complicated and unsettled circumstances at hand) that is at the center for the exercise, but the capacity of the specific experimental gaming environment to be used as a didactic reflective tool.
- The systems aspects were strongly highlighted. This was less due to the specificities of the large model, but more through the initiation of reflections about the limitations that the model world exposed, e.g. causality related issues, not least connected to risk assessment and handling of uncertainties of different kinds.
- The use of the software model interaction experiences with regard e.g. to the importance of time sequencing of policy and in general the role of "timing" in application of policy action are examples of issues emerging in the discussions. Specifically attention arose towards an improved understanding of subtle aspects of what could be meant by "political capital" (which under certain circumstances could be lost very quickly, whereas under other circumstances such losses could be avoided or limited - or the time development of this "capital" may be different). The model served as an introducer to the topic and provider of a "playground" for reflection, but less as a predictive tool.
- Another realm of experience dealt with how the particular focus on the path to low carbon society is embedded in a broader political frame (e.g. more general environmental policy concerns, foreign and national policy general considerations, economic and financial policies and styles under which these are exercised – and with regard also to an understanding about which policy features may not be so central or having limited impact under certain conditions for the low carbon policy arena).

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Full reference: COMPLEX D6.5 report

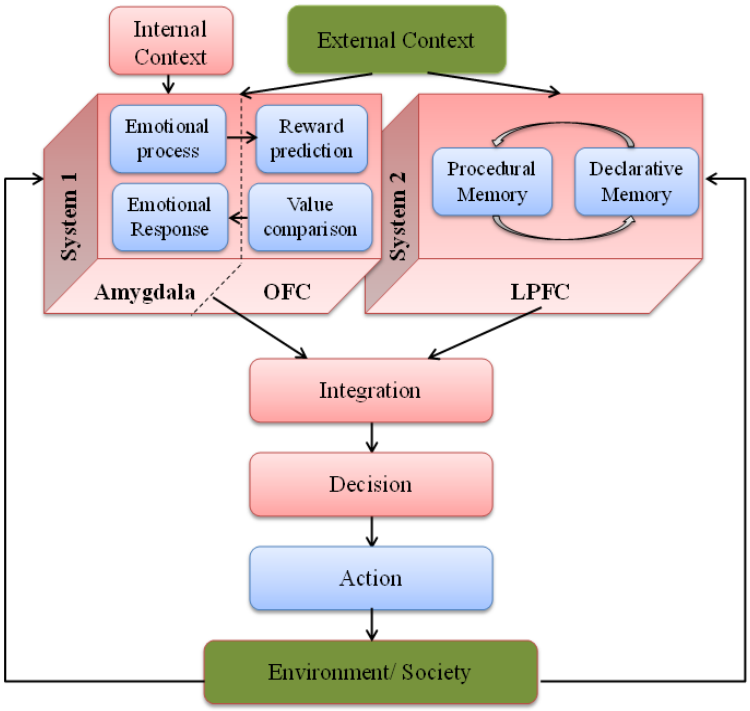
Raghothama, J & Meijer, S, 2015. *What do policy makers talk about when talking about simulations?* ISAGA Proceedings, Japan 2015 (a full paper is under preparation).

A CORTICAL NETWORK MODEL FOR COGNITIVE AND EMOTIONAL INFLUENCES IN HUMAN DECISION MAKING

A central issue related to climate change and the regional path to a low carbon society is how we can change our mind-sets, including our associated behavioral patterns.

Individual decision making is a complex process that involves both cognition and emotion. This part of the study concerns the development and application of a *neuro-cognitive model* with a focus on the decision making process (DM) of an individual in a social context. The objective is to contribute to an understanding of the relation between individual decisions of citizens and the decisions to be taken by policy makers. Our computational model includes effects of *personal factors*, *behavior* and *environmental factors*, based on neural structures, dynamics and functions. Based on the developed neuro-cognitive model, we also model interaction of several individuals for social decision making, exemplified by choice of transport from home to work.

Our model is intended to give insights on the emotional and cognitive processes involved in DM under various internal and external contexts. We are also interested in the relation between short and long term decisions, where individual preferences and attitudes play a crucial role. Knowledge and experience of the outcome of our decisions and actions can eventually result in changes in our neural structures, attitudes and behavior. In such a feedback loop between individuals and environment/society trust is an important parameter that we explore further. Our trust to public transport systems is important if we, for example, are to change our travel behavior from using car from home to work, to taking bus or train instead. Simulations with our model suggest that individuals may be more or less sensitive to reliability of public transport, depending on attitudes and preferences – and can shift behavior more or less rapidly if external circumstances, such as cost, time and availability changes.



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Full reference: Hassannejad Nazir A and Liljenström H, 2015. A cortical network model of cognitive and emotional influences in human decision making. Biosystems. 136:128-41.

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