Modelling energy security?

A framework

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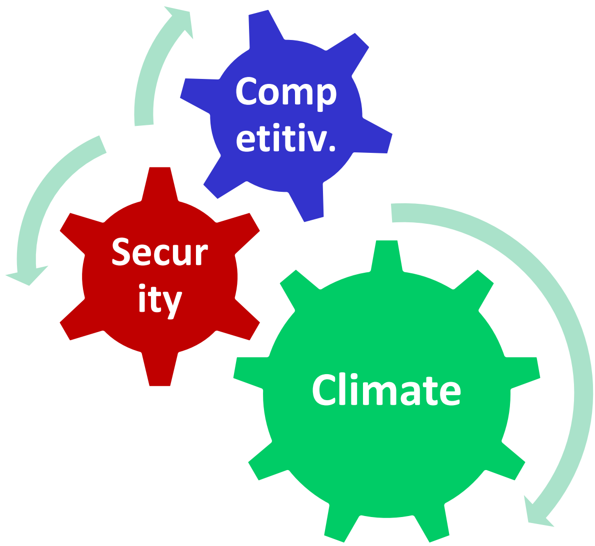
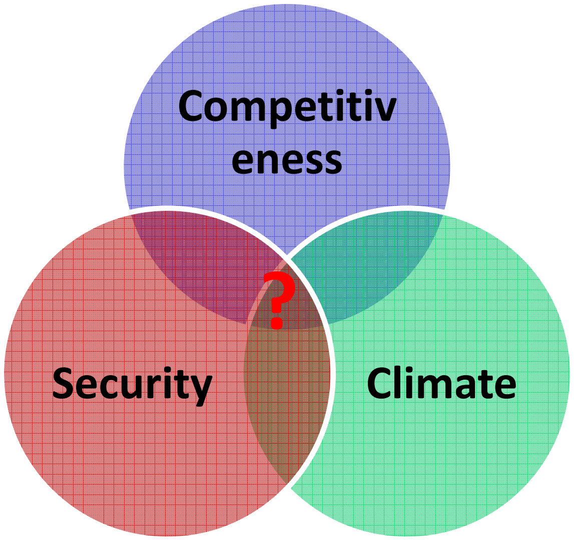
Background

- “While **EU** has been successful in institutionalizing a climate policy, it **has not been able to formulate a successful energy security policy**” (Mitchell 2009)
- “In contrast to other energy policy objectives, there is **no obvious or universally accepted measure** of supply security” (UK-DBERR, 2007)
- “the concept of energy security is frequently **used to justify various policies** or actions at the same time” (Loschel et al. 2009)
- “in numerous countries far reaching **interventions** in the market have been established in order to secure energy supplies, **often without any economically rational justification**” (Schmitt 2009)
- “there is an **increasingly urgent need for a framework** within which to analyse: the impact of specific security events, the level of risk attached to such events, and the cost of measures which would provide insurance against them”. (…) **“In the absence** of such a framework, **any statement about energy security is meaningless.”** (Stern 2004)



Aims

- **To develop a framework containing procedures and a range of different models for a rigorous, transparent and quantitative analysis of energy security**, then apply this framework with regard to a number of possible measures directed at increasing the energy security in EU



- To inform strategic decisions of EU Institutions through rigorous analytical assessments, by **selecting energy security economically rational strategies**
- To define the **multidimensional conditions** for a shift towards a **EU energy system 'low-carbon' and 'secure'**, by taking into account synergies and trade-offs between energy security and other goals

Literature

Outcome-based assessments: "the actual outcome of energy insecurity. In an ideal world an outcome-based indicator would measure the actual welfare impact of energy insecurity (UK-DBERR)"

- **economically efficient level of ES**
- **minimum loss-of-supply**

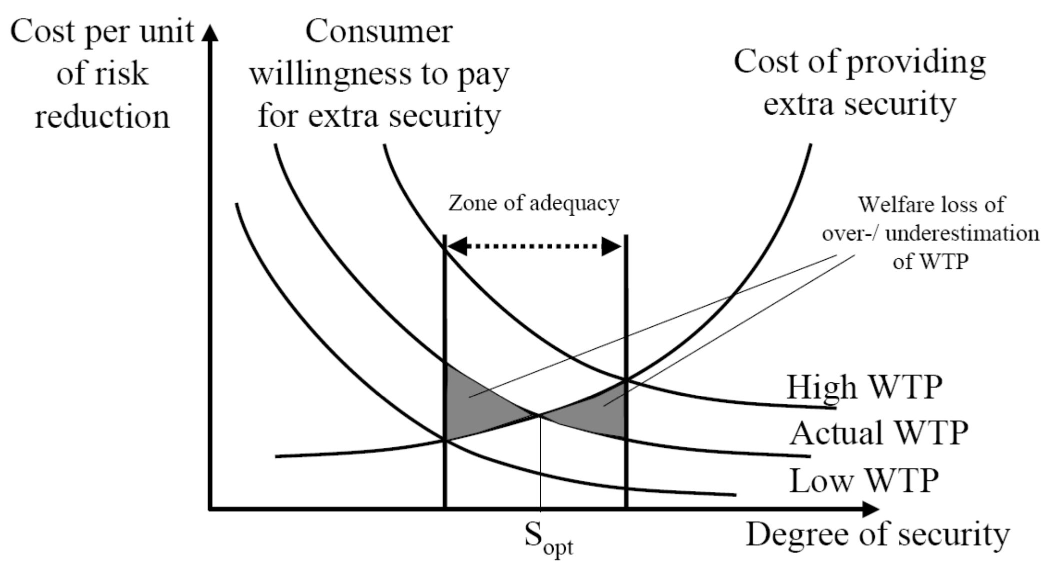
- model based scenario analysis
- indicators
- costs/benefits of policies
- ex-post estimations (of shocks)

Diversity-based assessments: measuring inputs that can be considered a proxy for the potential (ex-ante) risk and/or magnitude of an energy security impact, should it actually occur

- model based scenario analysis
- indicators

A conceptualisation (i)

i) all energy systems deliver some level of security for consumers: **the question is the 'adequate' level of security, based on balance between costs and benefits of reducing insecurity** (DBERR 2007, NERA 2002)



A conceptualisation (ii)

ii) **energy security is a property of dynamic energy systems** (Barret et al. 2010, Tosato 2008, Helm 2003), which implies that the concept of energy supply security is restrictive, and that the concept of **"energy system security"** should be adopted instead (Jansen 2009, DBERR 2007):

- **as energy systems are complex systems**, i.e. sets of interacting/interdependent components forming an integrated whole, **their behaviour cannot be explained in terms of the behaviour of the parts**: the *adequate* level of energy system security depends on system capacity "to tolerate disturbance and to continue to deliver affordable energy services to consumers" (Chaudry et al. 2010)
- **energy systems, and their properties, are dynamic, i.e. constantly changing**: the evolution of energy sources, technologies, (internal and international) markets, institutions, energy policies, agents' behavior is constantly reshaping the structural characteristics of the system

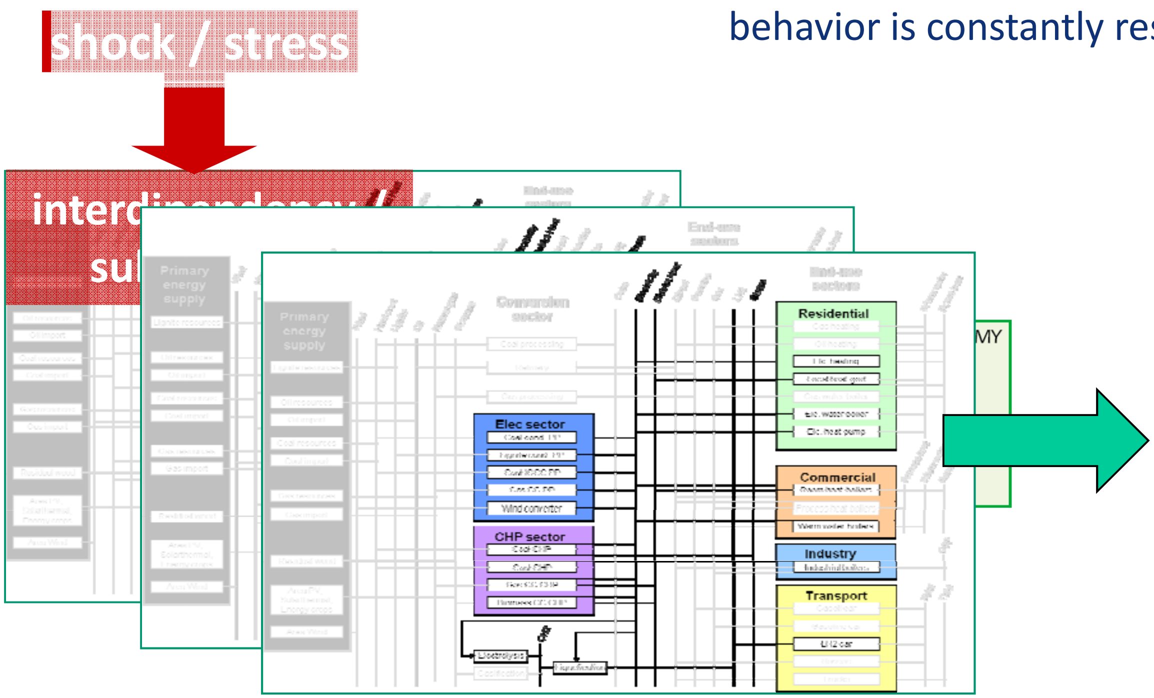
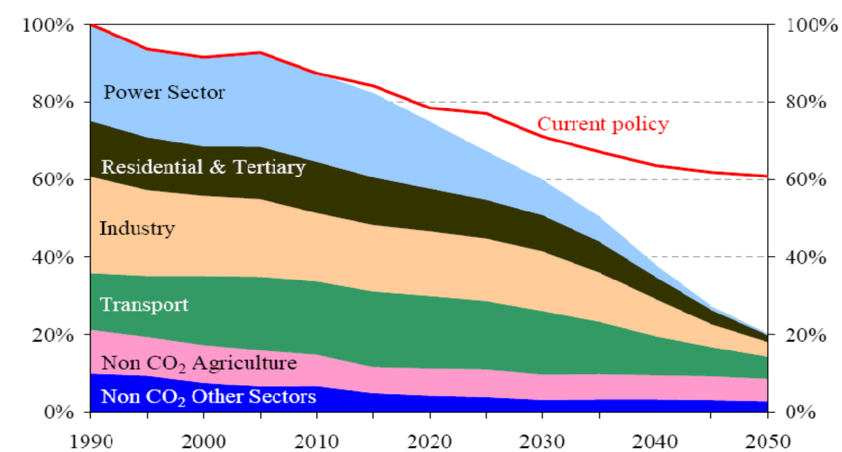


Figure 1: EU GHG emissions towards an 80% domestic reduction (100% =1990)



Modeling energy security (1)

A "secure" energy system is a system evolving over time along a path characterized by a constantly adequate level of stability/resilience

- Not meaningful to assess the security of particular components of these systems in isolation. **Need to consider all the relations and interactions between the elements of the system, all the synergies and the integral nature of the system** ➔ people and their institutions as well as technologies and energy sources, …
- **Need to identify and "model" all the elements of the system under study that contribute to explain the way the system behaves after an adverse event** ➔ any quantitative method failing to consider these elements won't be able to provide a rigorous assessment
- Need to consider the constantly evolving structural properties of the system, by **keeping together sub-sectoral detail with whole system, short-term with medium-term:**
  - properties of any sub-sector depend on the dynamics of the whole system
  - effectiveness and efficiency of policies directed to change systems characteristics, i.e. its resilience/robustness

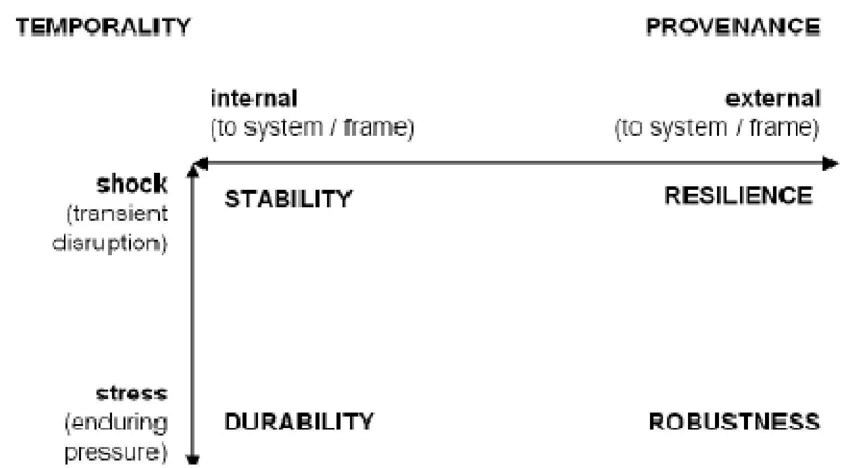
Modeling energy security (2.1) – Identification of key elements to be modelled

Main dimension	*Sub-dimension*	*Possible options*	*Relevance for energy security assessments*
Scope / System boundary	**Sector**	Economy/Macro, Energy System, Energy sector	*substitution between energy and K/L in the whole economy, impact of threats on the economy / the energy system*
	Energy market	Multi-energy markets, Single-energy market	*substitution between energy fuels, links between energy prices*
	Geographical scope	Global/Multi-country, EU/Multi-country, Regional, Country	*competition between sources of supply and possibility of diversification*
	Dynamics / Time horizon	Short-term, Medium-term, Long-term / Static, Dynamic	*dimension of ES: reliability, affordability/adequacy, sustainablity*
Granularity	**Technology representation**	black box, tech-by-tech	*technological potential for fuel substitution*
	Supply Chain	Upstream, Transformation, Storage, Supply, Final Demand	*substitution between energy technologies and fuels within the energy system*
	Enviromental detail	Emissions, Water, Biodiversity	*trade-off between security and environmental goals*
	Infrastructures and network	Network type, Transportation type, None	*operational balance short-term flow of disrupted commodities*
	Energy technology transition	AEEI (Exogenous), Endogenous, None	*dynamic nature of energy systems (technical/behavioural changes)*
	Time step	Hours, Intra-day, Day, Week, Season, Year	*"operational" / "strategic" focus*
Realism	**Market description / imperfections**	Perfect competition, Strategic behaviour	*sources of market power*
	Agents behavoiur	Perfect rationality, Bounded rationality, Not considered	*Role of information and interacting agents*
	Price formation	Endogenous, Exogenous, Not considered	*prices allowed/not allowed to adjust, in the short/medium term*
	Out-of-equilibrium dynamics	yes, no	*convergence to and/or stability of an equilibrium*

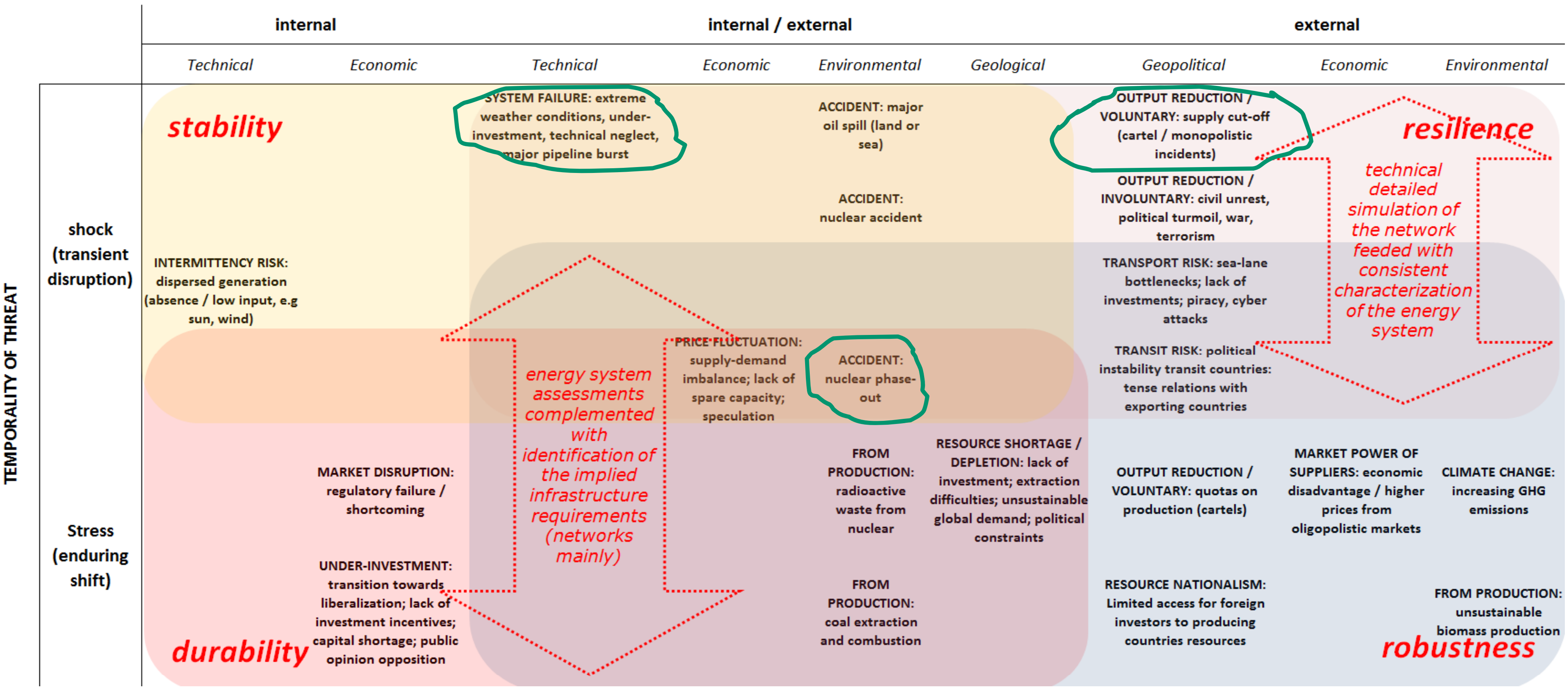
Modeling energy security (2.2) – Selection of the tool: threats and system properties

- Energy systems are subject to **a range of different risks or threats** to energy security – and these vary with **geography** (e.g. conflicts abroad vs. infrastructure failures at home) and **timescale** (e.g. oil price shocks vs. long term changes in the availability of oil).
- There is **a range of strategies** that governments and other actors can use to try to deal with the **causes of insecurity** – or to strengthen an energy system's **ability to withstand** disruptions

Figure 2: Dynamic system properties – across time (temporality) and origin (provenance)



Modeling energy security (2.2) – Selection of the tool: threats and system properties



An example:
short and medium-term security of gas supply