Review of existing indicators of energy security

2nd Meeting CEPS Task Force
Securing European Energy Supplies: Making the Right Choices
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Structure of presentation

i. Context of review
ii. Indicators reviewed
iii. Summary of review
iv. Examples of our use of existing indicators

Background

- Project for DG Environment (6 months to ~July 2009)
  - "Analysis of Impacts of Climate Change Policies on Energy Security"
  - Consortium led by Ecofys with ERAS, Redpoint Energy and 2 associates responsible for earlier IEA work in this area
- Main aims
  - Develop a base methodology to analyse impacts of policy on ES in 2020/30 to help guide policy making
  - Primarily quantitative – focused around use of indicators
  - Initial analysis of new climate package (at EU / MS level) based on energy system modeling undertaken for EC IAs
- Review of indicators within context of project's ES framework

ES Framework (v.short version)

- 2 main approaches in literature
  - Economic vs policy perspective
  - Complex / uncertain vs inherently subjective
  - Limited guidance for our needs - project aims to provide quantitative tools to assist policy makers
- Bottom-up approach – typology of **root causes** of energy insecurity based on country experience
  - Extreme events (weather, terrorism, etc)
  - 'Inadequate market structures' (insufficient investment in new capacity and load balancing failure)
  - Supply shortfall associated with resource concentration

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ES Framework (v.short version - 2)

- Bottom-up approach: from root cause to welfare impact
- Generic characterisation of ES causal mechanisms

Stage I Event / Trigger point → **Stage II** Impact on sector of supply chain → **Stage III** Knock-on impacts on other sectors of supply chain → **Stage IV** Impact on demand sector → **Stage V** Impact on Welfare

- Translated into supply chain assessment for different energy types

Review of existing indicators

- **Systematic** review of existing Energy Security indicators
- Indicators mapped within context of our ES framework
  - Physical elements of energy supply chain addressed
  - Root cause(s) they are trying to measure
  - Stages of causal mechanisms being targeted
- Indicators qualitatively evaluated against criteria and results used to inform our proposed approach

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Criteria for evaluation

- **Suitability:** How well does the indicator measure the relevant aspect(s) of the ES framework?
- **Transparency:** How transparent and objective is the indicator, to what extent is expert judgement required?
- **Availability of data:** Is sufficient & robust data available to compile the indicator at both the EU and MS level?
- **Ability to forecast:** some variables are particularly difficult to project and do not form part of standard EU modelling assessments

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Two main types of indicator

- **Vulnerability-based**: only measure inputs that can be considered a proxy for the *potential* risk and/or magnitude of an energy security impact

- **Outcome-based**: by contrast, these aim to measure the actual outcome of energy insecurity
  - Ideally measure welfare impact, but given uncertainties normally estimate physical unavailability of energy
  - But rely on complex probabilistic assessments or are integrated directly within modelling approaches.

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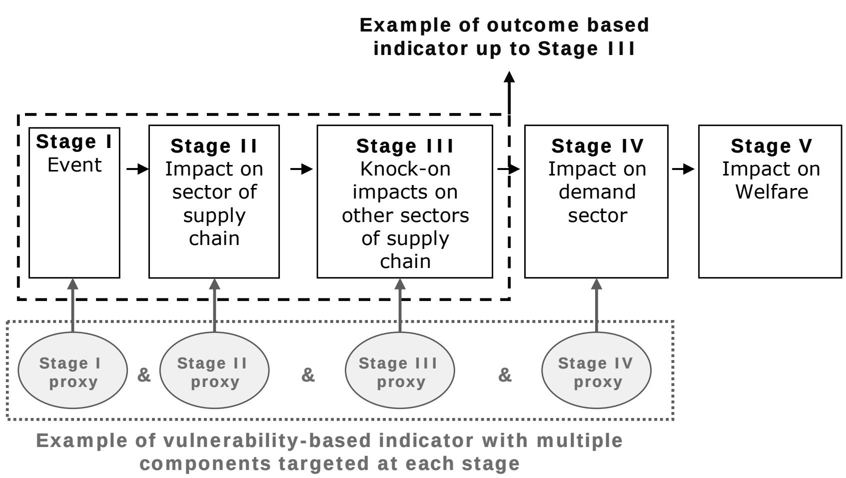
Link between type and causal mechanism



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Indicators reviewed

- Vulnerability indicators (~18)– focusing on a specific energy security issue and / or stage
  - Infrastructure capacity and reserve indicators (e.g. critical stocks of fuels)
  - Measures of the importance of energy in the economy (% in TPES, energy intensity, etc)
  - Dependence on non-domestic production (e.g. NEID / cost of imports)
  - Indicators of investment in adequate supply (general business indicators, turnover to investment, market price signals, etc)
  - Measures of diversity: within or supply to a market (HHI, SWI) and MVP
  - Other vulnerability indicators (market liquidity, political stability, RPRs, crisis capability index)

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Indicators reviewed (2)

- Vulnerability indicators (~8) - overall system and hybrid approaches - combining elements from previous indicators
  - Adequacy of energy supply to demand (e.g. energy / peak capacity / de-rated peak capacity margin)
  - Net import dependence and diversity in a market
  - Diversity in both supply to and within a market
  - Long-term energy security indicator
  - IEA Energy Security Index
  - ECN Supply / Demand Index
- Outcome based indicators (3)
  - Expected energy unserved
  - Security of supply function for the MERGE model
  - Cost failure of the electricity system.

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Summary of review

- Wide range of existing simple and hybrid indicators
  - Most indicators are vulnerability-based
  - Outcome-based require complex situation specific modelling – less relevant to our approach
- Many indicators not linked clearly to specific root causes of energy insecurity which limits their suitability - e.g. NEID by itself
  - Proxy for upper bound / worst case of physical unavailability
  - Less relevant in markets such as oil where price impacts dominate
- Particular gaps in relation to extreme events and insufficient investment in new capacity
- Trade-offs in aggregation and transparency
- Simple analysis of vulnerability of more generic parts of energy system at Stage III and IV

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Indicator	Elements of energy supply chain	Root causes (category / types)	Causal Stages	Suitability	Transparency	Availability of data	Ability to forecast
Peak capacity margin	Domestic electricity generation (centralized and distributed)	Inadequate market structure – proxy for both price / physical unavailability impacts	I – for load balancing II – for insufficient investment IV – both root cause types	✓✓	✓✓ / ✓✓✓	✓✓✓	✓ / ✓✓
Peak de-rated capacity margin	Domestic electricity generation (centralized and distributed)	Inadequate market structure and extreme events – proxy for both price / physical unavailability impacts	I – for load balancing II – for insufficient investment and extreme events IV – both root cause types	✓✓ / ✓✓✓	✓✓	✓ / ✓✓	✓ / ✓✓
Energy margin	International production /processing, imports, domestic production, storage, end-use – all energy sources.	All - proxy for all root causes leading to physical unavailability impacts	II, III, IV	✓✓	✓✓	✓ / ✓✓	✓ / ✓✓
Net import dependence and diversity in a market	International production /processing, import, end-use – all energy sources.	All - proxy for all root causes leading to physical unavailability impacts	II, IV	✓ / ✓✓	✓✓	✓✓ / ✓✓✓	✓✓ / ✓✓✓
Measuring diversity in both supply to a market and within the market	International production / processing, imports, end-use – for all energy sources.	Resource concentration – proxy for price impacts	I, IV	✓✓	✓ / ✓✓	✓✓	✓✓
Long-term energy security indicator	International production / processing, imports, end-use – for all energy sources	All – proxy for physical unavailability impacts Resource concentration – proxy for price impacts	I, II, IV	✓ / ✓✓	✓ / ✓✓	✓✓	✓ / ✓✓
IEA energy security index (ESI_{price} and ESI_{volume})	International production / processing, imports, end-use – oil, gas, coal	Resource concentration – ESI_{price} proxy for price impacts, and ESI_{volume} proxy for physical unavailability impacts	I, IV for ESI_{price} II, III, IV for ESI_{volume}	✓✓ / ✓✓✓	✓✓	✓✓	✓✓
Supply / Demand Index	All aspects	Load balancing – proxy for price / physical unavailability impacts Resource concentration – proxy for physical unavailability impacts	I for load balancing II for resource concentration Also III and IV	✓ / ✓✓	✓	✓✓	✓ / ✓✓

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Our use of existing indicators

- Adapt / combine existing vulnerability indicators under some basic principles
- Suitability – want good proxies for specific root causes of energy insecurity
  - Separate indicators for each
  - Ideally have proxies at each stage of causal mechanism to give better indication of final welfare impact
- Transparency
  - Want simplest indicator that is still a good proxy for ES issue
  - Minimise need / scope for subjective inputs as far as possible
- Data availability / ability to forecast
  - Balance robustness of indicator vs feasibility
  - Consider existing modeling outputs / other data sources

Examples – extreme events

- Stage I – Event – no direct proxy but can affect both
  - Demand – e.g. 1 in 50 weather event to scale up peak demand for heating
  - Supply – e.g. loss of largest supplier / route / plant due to event
- Stage II – primary impact on supply chain
  - Use of **energy margin** indicator (available daily supply vs peak demand) for primary fuels
  - Adjust supply for loss of single largest X, or peak demand
  - Similarly **de-rated peak capacity margin** for electricity with adjustment for peak demand or further de-rating for loss of plant capacity / transmission line, etc

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Examples – extreme events (2)

- Stage III – knock-on impacts / flexibility in rest of system
  - Primary fuel – use available storage capacity to convert supply shortfall from energy margin to measure of **short-run availability**
  - Electricity – further de-rating given short-run loss of fuel for power generation
- Stage IV – impact at demand-side
  - Currently share of energy type in total primary / final consumption
  - Simplest proxy for 'importance' of energy type in economy
  - Looking at better proxies (e.g. account for demand side participation / substitution possibilities)
- Combine components at Stages II-IV to create vulnerability indicator

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Examples – Load balancing failure

- De-rated peak capacity margin (Stage I) coupled with share of elec in final consumption (Stage IV)
  - Stage II / III (physical impact of failure throughout system) not possible to address with simple proxy
- But shrinking capacity margin only one aspect of vulnerability in this case
  - Also proposed separate 'flexibility margin' (Stage I)
  - Ability of system to respond to sudden changes in demand given loss of intermittent generation
  - Based on assumptions about 'ramp' rates of technologies
  - Same Stage IV and issues with II / III

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Examples – insufficient investment in new capacity

- No indicators in literature considered suitable
- Outcome-based preferable
  - E.g. required new capacity vs expected new capacity (probabilistic / build on existing short-term plans)
  - But complex and difficult to extend to 2020 / 2030
- Most energy system modelling not appropriate
  - Assumes necessary capacity is actually built & cost varies
- Some possible ‘vulnerability’ measures (issue considered most acute for electricity sector)
  - Overall new capacity required (in GW or €M) – scale of investment
  - Capital intensity of new capacity (ratio of capital to total costs) - indication of difficulty to finance
  - Load factor - high penetration of intermittent renewables may impact load factor of dispatchable plant, increasing uncertainty over returns

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Basic use of indicators

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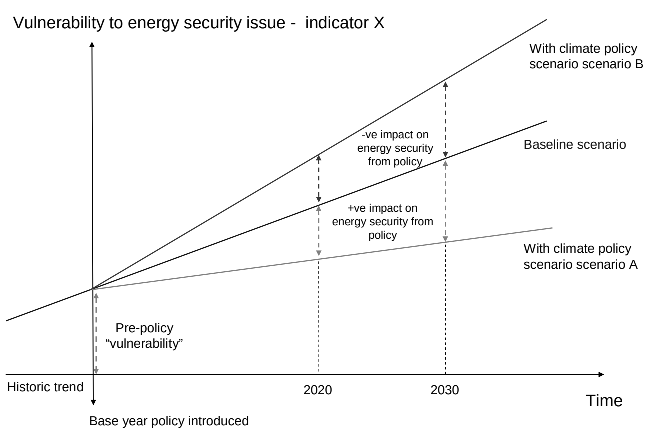

- Focus on vulnerability indicators
- Input data from impact of CC policy on energy system (e.g. PRIMES modelling) + other data not provided explicitly by model (e.g. energy infrastructure)
- Leads to Δ vulnerability to ES (risk / magnitude of impact)

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Thank you for your attention

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