

Review of existing indicators of energy security

2nd Meeting CEPS Task Force
Securing European Energy Supplies: Making the Right Choices
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OUR MISSION: A SUSTAINABLE ENERGY SUPPLY FOR EVERYONE

Structure of presentation

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

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Background

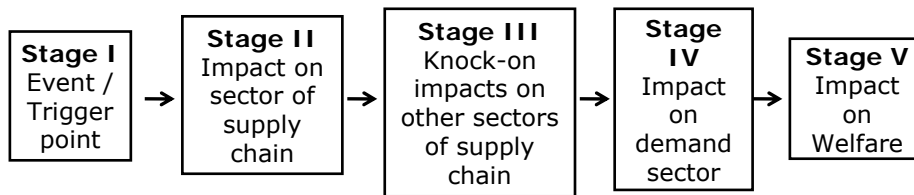
- Project for DG Environment (6 months to ~July 2009)
 - “Analysis of Impacts of Climate Change Policies on Energy Security”
 - Consortium led by Ecofys with ERAS, Redpoint Energy and 2 associates responsible for earlier IEA work in this area
- Main aims
 - Develop a base methodology to analyse impacts 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

ES Framework (v.short version - 2)

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



- 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

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

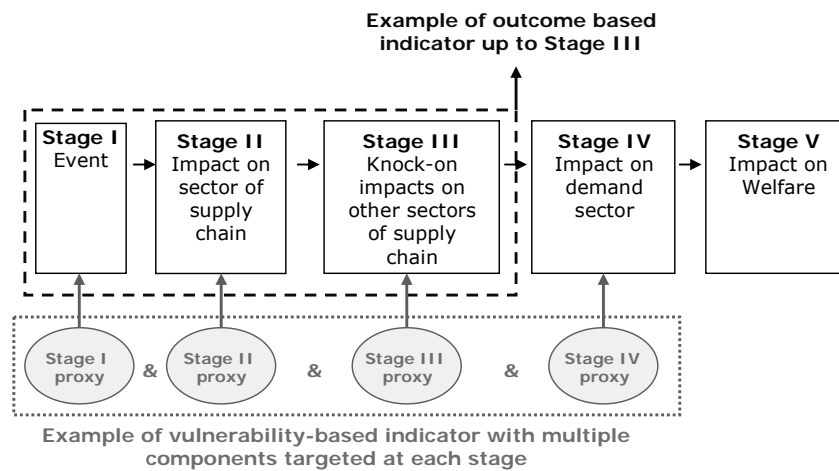
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Two main types of indicator

- **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.

Link between type and causal mechanism



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)

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

| 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) and | 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) and | 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

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

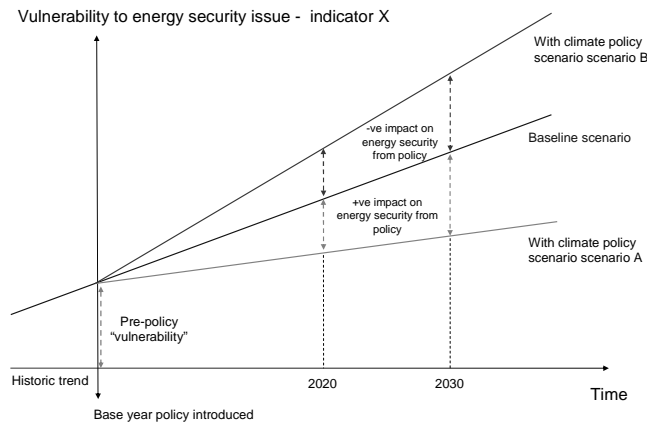
Examples – Load balancing failure

- 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

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

Basic use of indicators



- 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)

Thank you for your attention