Conceptualising Energy Security in the European Context

A policy-perspective bottom-up approach to the cases of the EU, UK and Sweden

SEFEP working paper 2012-4

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Juni 2012

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Abstract

Energy security is a term that is widely used, and one that is highly ambiguous. A recent series of articles has risen to the challenge of conceptualising it, and suggests that energy security may have up to 20 dimensions, which are to be assessed by arrays of up to 372 indicators. However, such extremely broad conceptualisations threaten to divert focus from what is at the core of such an important concept, thus making it devoid in all its richness. In this paper, energy security, which in all respects is a policy matter, is conceptualised from the bottom up in a European policy perspective, by identifying the aims and concerns underlying actual energy security policy in the European Union, the UK and Sweden. In addition, possible indicators for a quantitative holistic assessment are proposed. Based on these measures and aims, the orthogonal dimensions of energy security as perceived by policy in the three cases are induced. The paper concludes that, from a European policy perspective, energy security is a multi-faceted but not multi-dimensional issue: two orthogonal dimensions could be identified, with a limited number of possible indicators needed for a holistic assessment of energy security.

Keywords: Energy security, energy security definition, energy policy

1 Introduction

The European energy systems will be dramatically reshaped over the coming decades, driven by diverse factors like climate concerns, increasing worries about competition for energy resources from emerging economies, and increasing prices. Consensus among energy policy-makers and researchers alike is that this transformation must aim at achieving a secure energy supply at prices that support economic and social activity without damaging the environment and the climate.

Whereas it is clear that a climate protection discourse is about greenhouse gas emission reductions and that an economically beneficial energy supply is about prices and market organisation, it is less clear exactly what the subject in the energy security discourse is. The academic literature is of little help in this: as "*few works have made a serious attempt to clarify the concept*" (von Hippel et al., 2011:6720), the "*slippery*", or "*polysemic*", nature of the energy security concept remains largely undiscovered (Chester, 2010:887). Consequently, "*the concept of energy security is widely used, yet there is no consensus on its precise interpretation*" (Kruyt et al., 2009:2166), and energy security definitions range from very narrow ones – e.g. the "*likelihood that energy will be supplied without disruptions*" (Ocaña and Hariton, 2002:9) – to extremely broad ones – e.g. "*the challenge of equitably providing affordable, reliable, efficient, environmentally benign, properly governed and socially acceptable energy services*" (Sovacool and Rafey, 2011:93). Overall, *"the concept of* […] *'energy security' seems to be rather blurred*" (Löschel et al., 2010:1665).

A recent series of articles has set out to conceptualise energy security in a "*new Comprehensive Energy Security Concept*" and propose arrays of indicators for holistically evaluating the security of an energy system (von Hippel et al., 2011:6723). This series started with the six-dimensional energy security definition by von Hippel et al., which is complemented with the "*broad, but by no means complete*" list of 29 energy security policy issues, to be assessed by 25 unique indicators. Building on this work are Vivoda's 11 dimensions and 44 indicators, and responding to Vivoda is Sovacool, who proposes that a holistic energy security assessment should use 200 unique indicators in 20 different dimensions (von Hippel et al., 2011; Vivoda, 2010; Sovacool, 2011). In a subsequent paper, Sovacool and Mukherjee present largely the same 20 dimensions, which are renamed to "components" and are to be assessed using 372 indicators. These indicators can however be "*boil*[ed] *down* […] *to 20 indicators* [one per dimension] *depending on the country and data availability*" (Sovacool and Mukherjee, 2011:5353, these four articles are here referred to as "HV&S"). In all four HV&S articles, the aim was to provide a conceptualisation addressing all issues that could potentially threaten a country's energy security. von Hippel and Vivoda derive their dimensions in a top-down approach through deductive reasoning based on concerns in the broader security and energy security literature. Sovacool and Sovacool & Mukherjee, on contrast, base their conclusions on expert interviews. The three first articles focus on the Asia-Pacific – although the conceptualisations do not appear to be limited to this area – whereas Sovacool & Mukherjee have a global focus.

The ambiguousness originating in such broad definitions is not a problem in itself; one could even argue that the vagueness of the energy security concept is what makes it attractive. However, a number of articles *have* started to look for better, more holistic definitions, so the

issue is on the table and has to be dealt with. Broadening the view from the narrowest energy security conceptualisations is a good idea. Nonetheless, it seems that the definition business may have gotten out of bounds – is unlikely that all 20 dimensions and 372 indicators are equally important and really crucial to energy security. This could be a problem: assigning that many issues to a concept may divert attention from what is really important, making the concept so rich that it becomes hollow. For example, it is not obvious that "number of oil spills" "installed capacity of fuel cells" and "induced employment" are important indicators for the energy security of a country, en par with "import dependency" and "diversification of suppliers". One might also ask what is left for the broader energy policy if energy security policy is about pollution control, access to resources, land use, technology development and 16 other policy issues: is energy security policy really *everything*? Are contemporary academic notions of energy security "*so broad that they lack precision and coherence*" (Sovacool and Brown, 2010:79)? In a way, it seems that security – as in energy security – has evolved into a term that represents all that is good, making it similar to other terms like justice or sustainability, which are also positively laden but largely devoid of concrete meaning.

This raises questions about how this deeply political concept is used by policy-makers and whether they really address this many things simultaneously. This paper follows a different approach to defining energy security. Instead of normatively prescribing what policy makers *should* worry about, it seeks to analyse what they actually *do* worry about while discussing energy security. In pursuing such an approach this paper follows Cherp and Jewell's view that "*the starting point for defining energy security should be empirically observed policy concerns*" (Cherp and Jewell, 2011:210). By choosing a bottom-up approach, we avoid many of the traps of the currently overly normative abstract-to-concrete studies which risk arriving at too esoteric and non-policy-relevant concepts. Here, we look at three European cases – the European Commission, the UK and Sweden – with the objective to see whether a limited number of orthogonal dimensions, each of which is less ambiguous than the term energy security, can be identified to be repeatedly and consistently appearing in actual energy security policy. If this is so, then any statements about these dimensions or any or indicators measuring them refer to energy security, whereas statements referring to other dimensions or issues do not. This way we aim to bound the meaning of the energy security concept while still catching policy makers' concerns and to find a more practical set of indicators to assess it.

2 Methods

In this article, we use a novel approach to identify the dimensions and underlying issues of energy security in a European policy context. In contrast to the majority of energy security studies which follow an abstract-to-concrete deductive approach to defining energy security, this paper pursues an inductive approach which identifies key dimensions of energy security by analysing actual policy priorities. This is done in three steps.

First, the proposed policy measures explicitly linked to energy security and, more importantly, the stated aims of these measures are identified. The underlying assumption is that these aims reflect the perceived threats, and hence of what energy security means in a certain policy setting. We present and discuss the measures in groups, which are formed based on their context in the policy documents, so that related measures are described together. In the following, the term "measure" refers to a concrete policy proposal, e.g. a tax reform, which is proposed to achieve a certain objective, e.g. triggering investments; such objectives are referred to as "aims". Due to the expected overlaps between energy policy areas (such as competitiveness, climate protection and security), we only consider measures and aims which are explicitly mentioned to be immediately stated to be issues of energy security[1]. The measure and aim identification is presented in sections 3.1-3.3 and summarised in section 3.4.

Second, we abstract the aims and measures – the empirical data and the foundation of the work – through inductive reasoning into the dimensions of energy security. We use term dimension in its mathematical sense: dimensions of a space (here: energy security space) are the minimum number of coordinates needed to specify a point (here: an aim) within it. This abstraction is thus different than the grouping in the first step: the first abstraction refers to the measures, whereas the second abstraction refers to the aims.

Third, we propose a range of possible indicators to assess progress towards the aims. The wording "possible indicators" shows that these are merely suggestions and that the list is not conclusive: other indicators may be equally possible or better. It is beyond the scope of this paper to justify and discuss the choice of and how to use each indicator[2]: Most of them are self-explanatory, or easily understandable in combination with the aim they assess. The objective of the proposing indicator is to show ways to assess energy security policy progress as directly as possible, without resorting to remote proxies, and to show the relationships between different aims. The conceptualisation and the possible indicators are presented and discussed in section 0.

As the objective of the article is to induce an energy security conceptualisation in a European context, the primary base for the exploration of measures and aims is the energy security

[1] The terms "energy security" and "security of supply" are used interchangeably in the policy documents; the UK documents also use "reliability" interchangeably with "energy security". The Swedish documents primarily mention "trygghet", which is similar to the English "safety". Here, we only use the term "energy security". All quotations in the section about Sweden are translated from Swedish by the authors.

[2] An overview of many of the metrics proposed here can be found in Kruyt et al., 2009.

policy process as described in the stream of policy documents of the EU. In order to get a more robust base and to filter out the policy effects of singular events, also older policy documents building up the currently dominant energy security discourse are reviewed. The ongoing European-level energy and energy security policy debate has its roots in the 1990s and has largely been following one intellectual tradition, without disruptive course changes, although it has been intensified and broadened. As we aim to conceptualise energy security, we use the conceptual energy and energy security policy papers and surveys from this period as base, and not the more one-dimensional issues such as single Directives or Regulations[3]. Hence, the base for the measures and aims extraction are the Green papers of 1995, 2000, 2006 and 2008 as well as the 2008 Second strategic energy review and the 2010 Communication Energy 2020 (EC, 1995; 2000; 2006; 2008a; b; 2010).

However, the perceived threats and the very concept of energy security, may differ between countries/regions, depending on their energy situation and history. For a more comprehensive view of the energy security concept, the exploration of the European level documents is accompanied by similar explorations of the energy security policies of the UK and Sweden. These two countries were chosen as they have very different energy systems and very different energy policies: the British energy supply is fossil-fuel-based, Britain used to be an energy exporter, and its energy policy takes place in a strong liberalisation paradigm. Sweden, on contrast, has an energy supply based on renewables and nuclear power but is completely dependent on fossil fuel imports for transport, its energy policy is characterised by a nuclear phase-out decision and it operates in a powerful sustainability paradigm. Thus, these two countries will likely reflect a wide span of different energy backgrounds and policy paradigms in Europe, adding depth to the investigation of European-level energy security policy. For the extraction of measures and aims, the same principle applies as in the European case: the conceptual documents underlying energy and energy security policy within the current policy paradigm are analysed. Hence, the extraction of measures and aims in the UK is based on the documents underlying the current British energy policy (which can be traced back to at least 2003) especially the White papers of 2003 and 2007, the Energy review of 2006, the 2009 Low carbon transition plan and its accompanying energy security discussion, the 2009 Wicks report (DECC, 2009; DTI, 2003; 2006; 2007; Wicks, 2009). For the Swedish case, the base is the energy policy framework reforms, and the accompanying policy surveys, within the current energy paradigm (i.e. after the deregulation in 1996) of 1997, 2002 and 2009 (MD, 2009; ND, 1997; 2002; 2009).

[3] The measures, and the reasons for these, of Directives and Regulations are in most cases discussed in the conceptual policy papers assessed here: the issues addressed by the various legislative documents are thus included indirectly.

3 Results

3.1 The European Commission

Energy has always been a central part of the European idea: two of the three European Communities – the Coal and Steel (1952) and the Euratom (1957) Treaties – are based on energy concerns. Nonetheless, the European level had no competence for energy policy until 2009, but it designed much of the current energy policy through areas where it had competence, primarily internal market and environmental policy. Today, following the Lisbon treaty, energy is a shared competence between the Member States and the Union. Some issues, most prominently the energy mix, are still handled mainly on the national level. In most cases, the Commission has framework competence, for example by designing targets to be reached, but leaves the precise measure formulation to the Member States: hence, the distinction between measures and aims is not always unambiguous. The central target of the EU energy policy is to make the European energy supply *sustainable*, *competitive* and *secure* (e.g. EC, 1995; 2006; 2010).

The 1995 and 2000 Green papers give explicit definitions of energy security. The 1995 Green paper defines security of energy supply as "*ensuring that future essential energy needs are satisfied by means of a sharing of internal energy resources and strategic reserves under acceptable economic conditions and by making use of diversified and stable externally accessible sources*". As such, the concept of security of supply includes "*physical security, economic security and continuity of supply*" (EC, 1995:22). The 2000 Green paper defines energy supply security as a policy strategy that is "*geared to ensuring, for the well-being of its citizens and the proper functioning of the economy, the uninterrupted physical availability of energy products on the market, at a price which is affordable for all consumers (private and industrial), while respecting environmental concerns and looking towards sustainable development*" (EC, 2000:2). The risks come in four dimensions: physical, economic, social and environmental risks; the environmental risks to energy security are stated to originate in environmental policy, which ultimately constrain energy supply decisions (EC, 2000:64f, 81). Interestingly, these definitions are only partially reflected by the energy security-enhancing measures suggested (see below).

Eighteen separate policy measures with 42 stated aims (of which some are repeated) are identified in the European energy security policy documents, see Table 1. Here, we discuss them in five thematically defined groups of energy security policy measures.

The focus in the first group – which only consists of one measure – is the internal market, especially for gas and electricity, as a panacea to ensure energy security, by efficiently re-allocating resources during emergencies, by ensuring adequate investments and setting price signals for energy savings: "*a functioning internal market on the basis of sufficient transmission and storage infrastructure*" is "*in itself an instrument of security of supply*" (EC, 2010:13; 1995:22). It is even "*the best guarantee for security of supply, as energy will follow market mechanisms and flow to where it is needed*" while still fulfilling the price objective of "*affordable, but cost-reflective*" energy (EC, 2010:13). Further, the Commission argues that a competitive market is necessary for energy security to unfold, by "*sending the right investment signals*", thus ensuring the timely replacement of ageing assets (EC, 2006:8). A

functioning internal market thus leads to diversification and individual (single-country) reduction of risks (EC, 2000). In addition, a functioning market leads to unbiased prices which, in turn, is expected to reduced the overall energy demand.

The second group consists of measures to increase energy efficiency and to reduce energy demand and import dependency. Energy efficiency is "*the most cost-effective way to* […] *improve energy security*" (EC, 2010:6), and has beneficial effects also for the Union's climate targets. The main measures for increased energy efficiency are sharpened standards and energy labelling of products within Europe, but also in the international context. Furthermore, the Commission discusses increased CO_2 and energy consumption taxes "*to promote energy efficiency*" by setting incentives to "*encourage behavioural changes or to fund investments*" (EC, 2008b; 2010:6). Adding to these cross-sectoral measures are sector-specific measures, such as the coordinated use of the cohesion funds to improve energy efficiency in eastern European buildings and increased work towards the development of pan-European railways. Throughout the work to increase energy efficiency, "*the public sector needs to lead by example*" (EC, 2010:7).

The third group addresses infrastructure and crisis mechanisms, both capacity expansions and hardening of assets, and internal responses to ensure the efficient allocation of resources during emergencies. These measures are based on "*recent experience*", e.g. the 2003/2006 blackouts and the repeated disputes affecting the oil/gas imports from Russia (EC, 2006:8). An increase of such risks has been long anticipated, and response measures like improved internal re-routing capacity and larger storages are expected to "*become more important as overall energy dependence increases, as domestic reserves dwindle, and as supplies are increasingly sourced from politically unstable regions*" (EC, 1995:23). Solidarity between Member States, which means mutual assistance and cross-border reallocation of energy as well as europeanised dispatch of storages and buffer capacities, is seen as the primary response mechanism to ensure the continuous energy supply to all customers during a crisis. Bottleneck-free internal infrastructure and europeanised response mechanisms enable the internal market to efficiently re-route energy to where it is needed and are thus "*essential to spread and reduce individual risk*" (EC, 2008b:4; 2006). Equally, "*the obligation of solidarity among Member States will be null and void without a sufficient internal infrastructure and interconnectors*" as this fragments the internal gas and electricity markets, which in turn "*undermine*[s] *security of supply*" (EC, 2010:10, 4).

The measures in the fourth group addresses access to domestic resources to ensure long-term energy availability, minimise the import dependency and increase the fuel diversity. As the Commission does not have competence over the energy mix, it approaches the domestic resources through the environment competence and proposes European medium-term targets for low-carbon energy, especially domestic renewables. In the longer term, various measures to support the development and market introduction of new technologies to access Europe's domestic "*secure and low-carbon energy sources*" and to diversify the fuel mix are proposed (EC, 2006:9; 1995; 2000). In particular, these technologies are renewable energies – "*the most promising* [sources] *in terms of diversification of supplies*" (EC, 2000:46) – but also into technology development support for coal power coupled with Carbon Capture and Storage (CCS) and new generations of nuclear power (EC, 2000; 2008b).

The fifth group addresses access to foreign resources and the risks of energy imports through foreign policy and cooperation. Of particular importance is a common European foreign energy policy, giving Europe "*a single voice*" on the international markets (EC, 2006:20). This measure would allow Europe to "*throw its combined market weight effectively in relationships with key third-country energy partners*" and "*use its political and economic influence to ensure flexible and reliable external supply conditions*", thus securing long-term access to foreign resources (EC, 2010:17; 2000:73). In addition, new and diversified import capacities are required to ensure European access to non-European resources. This competitive view is complemented with a cooperative view, aiming at increasing the stability of imports through a dialogue with suppliers and transiters to build "*trust and deeper and legally binding ties between the EU and producer and transit countries*" (EC, 2008b:7). This is beneficial for European energy security, as it leads to "*good governance, respect for the rule of law and protection of EU and foreign investments*" in the producer and transit countries (EC, 2010:18; 2000).

Table 1: Proposed energy security policy measures and stated aims of the measures as described in the reviewed European Commission documents. Sources: EC, 1995; 2000; 2006; 2008a; b; 2010.

Measure	Stated energy security aims
Market	
Improve functioning and competitiveness, complete internal market	• Efficient allocation of energy resources, also during crises • Trigger investment in production and infrastructure • Reduce consumption (energy), through "true" prices
Energy efficiency	
Improve efficiency/emission standards and energy labelling	• Reduce consumption (energy) • Reduce consumption (fossil fuels) • Reduce import dependency • Decouple economic growth and energy consumption
Work for global energy efficiency standards	• Reduce consumption (energy) • Reduce consumption (fossil fuels)
Improved energy and CO_2 taxes	• Trigger investment in low-carbon energy and energy-efficient technologies • Reduce consumption (energy)
Use of cohesion funds for efficiency in buildings in new Member States	• Reduce consumption (energy)
Increase energy efficiency in the public sector	• Provide energy-efficient example for rest of society, create demand for efficient products/technologies • Reduce consumption (energy)
Increase use of CHP	• Reduce consumption (primary energy)
Reform transport policy, towards multimodal transport and pan-European railways	• Reduce consumption (oil)

Infrastructure and crisis response capacity	
Improve internal infrastructure and intra-European interconnection	• Enable solidarity among MS, enable energy flow to adapt to new situations and crises • Supplier & transit route diversification • Fuel diversification
Increase storages	• Improve emergency response capability, maintain supply during crises • Reduce price swings during emergencies, threat situations and short-term shortages
Improve solidarity between Member States	• Improve emergency response capability, maintain supply during crises
Improve physical infrastructure protection	• Increase/maintain reliability in existing assets
Access to domestic resources, manage import dependency	
Increase use/targets of domestic (low-carbon) resources	• Reduce import dependency • Access domestic resources • Fuel diversification
Support for development, introduction of new energy technologies	• Access domestic resources • Fuel diversification
Support for introduction of non-oil fuels for vehicles	• Reduce consumption (oil)
Access to foreign resources, manage import risks	
New oil and gas import infrastructure and new LNG capacities	• Access foreign resources • Supplier & transit route diversification • Fuel diversification
Improve dialogue/cooperation with suppliers & transiters	• Access foreign resources • Trigger investment in upstream/transit capacities through competitive external market • Stabilise imports • Predictable prices, minimise price volatility on global markets • Good governance and rule of law throughout the energy chain • Supplier & transit route diversification
Create single European external energy policy	• Access foreign resources • Add weight in negotiations with supplier & transit countries • Supplier & transit route diversification • Early warning and contingency preparation

3.2 The United Kingdom

British energy policy is shaped by the transformation of the national energy system from being self-sufficient to becoming reliant on imports for most of its energy needs. The central target of UK energy policy is to provide *carbon-reduced, reliable*[4] energy, which is *affordable* to all citizens and supplied via *competitive* markets both within the UK and beyond its borders (DTI, 2003:12ff; DTI, 2006:10; DTI, 2007:6). The dominant paradigm is one of liberalised markets, in which the government does not intervene "*except in extreme circumstances, such as to avert, as a last resort, a potentially serious risk to safety*" (DTI, 2003:77). Despite this, the UK energy and energy security policy is much more detailed than the European, which is both due to the needs for new solutions as the North Sea oil and gas fields are depleted and due the competence issue: the national government has much more far-reaching competence than the EU to go into detail.

The 2007 White paper offers a direct definition of energy security: "*Security of supply requires that sufficient fuel and infrastructure capacity is available to avoid socially unacceptable levels of interruption to physical supply and excessive costs to the economy from unexpectedly high or volatile prices*" (DTI, 2007:106). The Wicks report defines the aims of energy security policy as achieving physical security ("*avoiding involuntary interruptions of supply*"), price security ("*providing energy at reasonable price to consumers*") and geopolitical security ("*ensuring the UK retains independence in its foreign policy through avoiding dependence on particular nations*") (Wicks, 2009:8). These definitions are largely reflected in the proposed policies, although price is rarely discussed as a security issue. The overall objective of the British energy security policy is to create a resilient energy system, "*without significant weaknesses, which* […] *recovers quickly if problems occur* […] *based on a mix of fuel types, a variety of supply routes, efficient international markets* […] *storage, and a robust infrastructure*" (DTI, 2003:76).

The measures – 31 measures with 67 aims (of which many appear more than once) were identified (see Table 2) – are here discussed in five broad thematic groups.

The first group of measures concerns market issues, both within and outside the UK. The primary objective of this is to trigger investments in order to ensure that sufficient and reliable fuels and infrastructure capacity are available, essentially through "*a market framework with the right regulatory framework*", which "*incentivise*[s] *suppliers to achieve reliability".* In addition, the UK will work to promote liberalisation in other countries, with particular emphasis on "*the completion of the EU energy market liberalisation*" (DTI, 2007:108), which must operate "*under similar rules*" as the British markets (Wicks, 2009:5). This is beneficial for the UK as it triggers upstream investments and create fair, more stable prices, and as it allows "*us to purchase what we need at any time*" (DTI, 2003:79). Properly functioning markets "*deliver energy reliability most cost-effectively*" because they, in addition to triggering sufficient investment, "*can help us achieve diversity, as companies themselves seek diversity in order to manage risks*" (DTI, 2003:88; 2006:19). Other, non-power-market issues are viewed as crucial to support continued investments, especially improved planning and

[4] The UK White papers use reliability and security interchangeably

permitting processes and the improvement of the European Emissions Trading Scheme (ETS) (DECC, 2009; DTI, 2003; 2006; 2007; Wicks, 2009).

The second group consists of energy efficiency measures, primarily with the objective of reducing the UK's energy and import dependencies, but also in order to reduce the pressure on the global energy markets by reducing energy consumption internationally. For this, "*action to improve energy efficiency should be the greatest priority both domestically and in the Government's relations with other states*" (Wicks, 2009:82), with the aim to "*decouple economic growth from energy use and pollution*" (DTI, 2003:12). Many measures must be done on the European level, such as the improvement of efficiency standards for appliances and transport. Purely domestic measures include information campaigns, home insulation, new building standards and energy savings in the public sector (DECC, 2009; DTI, 2007). Supporting developing and transition countries – explicitly China, India, Ukraine and Russia – to increase their energy efficiency would "*do a great deal to support EU energy security*", as it would help to reduce strain on the global fuel markets (Wicks, 2009:100; DTI, 2003; 2007).

The third group focuses on infrastructure reinforcements and updates to make it fit the future needs, originating both in an expansion of renewables and the shift from domestic to imported energies, as well as crisis response mechanisms. Domestically, these measures include regulatory provisions for projects increasing stability, to trigger both new investments and sufficient maintenance of existing assets. New demand-response mechanisms to make demand more flexible through the use of price signals are also proposed to support the market. In addition, efforts to trigger investments in import capacities, especially Liquefied Natural Gas (LNG) capacities, are an increasingly strong focus. Particular emphasis lies on the improvement and regulation of the European infrastructure, including the EU's import infrastructure, in order to ensure the functioning of the European markets and networks, and – especially – "*to bring diverse supplies on-stream and into the EU market*" (DTI, 2003:80; Wicks, 2009). Such diversification of the European energy supply will, especially if it is coupled with an intensified exporter country dialogue, "*minimise the risk of disruption to supplies from regional disputes or local instability*" in the entire European energy system (DTI, 2003:80). This is important for the UK, as the increasing interconnectivity between the UK and the continent leads to increasing interdependence: "*many* […] *risks are outside our immediate control*" and energy security problems on the continent are likely to impact the UK as well (DTI, 2007:108). This group also contains measures concerning oil and gas storages in the UK (to satisfy demand during import disturbances) and encouragement for other countries, especially EU countries, China and India, to increase the emergency stocks in order to dampen price swings on the global markets during turbulent times. The 2003-2007 papers see the responsibility for increasing the storage capacity in the industry and conclude that the existing market mechanisms are likely to trigger sufficient investments in commercial storage: the need for government intervention is limited to planning and permitting reforms. They thus explicitly reject strategic gas storages, whereas the less market-orthodox Wicks report sees a need for these, possibly in a global scheme similar to the IEA oil stocks (DTI, 2003; 2006; 2007; Wicks, 2009).

The fourth measure group aims at securing access to domestic, diverse energy resources and managing the British import dependency. In the short term, the most important measure

is the maximisation of the recovery of domestic fossil fuels, a "*crucial element in mitigating the risks involved in our continuing use of oil and gas*" (Wicks, 2009:112). Apart from this, the overall objective is to create a diverse low-carbon energy supply: "*the best way of maintaining energy reliability will be through energy diversity*" (DTI, 2003:9). For this, an expansion of nuclear power – Wicks recommends 35-40% of the electricity by 2030 (Wicks, 2009:105) – and renewables are important measures, as is the development of CCS in a European context (DTI, 2003; 2006; 2007; Wicks, 2009). However, high shares of variable renewable electricity are also seen as a potential reliability threat (DTI, 2007:143). Consequently, "*the action that the Government is taking to cut emissions from the energy sector is good for the security of our energy supplies too*" (DECC, 2009:28). The Wicks report deviates from the market-orthodox view in the other documents and proposes that the Government takes a more strategic role in "*determining the fuel mix"*, a step that would be an intervention in the market, but nonetheless one that "*might be justified on energy security grounds*" (Wicks, 2009:111f).

The fifth group addresses relations with foreign suppliers to ensure access to foreign resources and reducing import risks. The UK is becoming an energy importer, and to ensure adequate energy imports the country must "*first of all to be an attractive customer for* […] *suppliers*". This can be achieved through stable market and investment environments and good bilateral relations with supplier countries, especially with Norway, Qatar and Saudi Arabia. This will provide "*a firm basis on which to pursue our energy security goals*" and ensure adequate access to resources in the future (Wicks, 2009:97). To stabilise the necessary imports and minimise the political risks, the UK must enter into a dialogue with producer countries, and "*promote good governance among producer countries*" (DTI, 2007:38) and throughout the energy chain, as well as support "*political and economic stability in source and transit regions*" (DTI, 2006:82). In addition, targeted measures to support developing countries to develop renewables and the appropriate infrastructure would reduce the strain on the global fossil fuel markets, which in turn would reduce the British supply risks (DTI, 2003; 2007).

Table 2: Energy security policy measures and stated aims of the measures as described in the reviewed British documents. Sources: DECC, 2009; DTI, 2003; 2006; 2007; Wicks, 2009.

Measure	Stated energy security aims
Market	
Improve functioning and competitiveness of domestic markets	• Trigger investments in production/generation • Trigger investments in flexible generation to support intermittent renewables • Efficient allocation of energy resources, also during crises • Supplier & transit route diversification • Fuel diversification • Reduce vulnerability to demand peaks, through economic incentives for demand-response
Push for liberalisation of European markets	• Trigger investments by removing anti-competitive behaviour • Enable solidarity, by introducing common market regulations
Encourage development of international liberalised markets	• Access foreign resources • Trigger investment in upstream capacities • Predictable prices, minimise price volatility
Improve the ETS	• Trigger investments in low-carbon energy through increased certainty
Improved market data, transparency and projections, market monitoring	• Trigger investments by reducing investment risks • Early warning and contingency preparation
Energy efficiency	
Improve efficiency/emission standards in EU	• Reduce consumption (energy) in UK and EU • Decouple economic growth and energy consumption
Change transport behaviour (eco-driving, public transport)	• Reduce import dependency (oil)
Home insulation and other efficiency programmes	• Reduce consumption (energy) • Reduce import dependency
Improve energy efficiency in the public sector (esp. buildings, transport)	• Provide energy-efficient example for rest of society, create demand for efficient products/technologies • Reduce consumption (energy)
Support for energy efficiency in other countries (esp. fossil-fuel producing countries)	• Reduce pressure on global energy markets, by reducing fossil energy consumption in exporter and developing countries
Infrastructure and crisis response capacity	
Improve regulatory incentives for energy security in domestic infrastructure	• Trigger investments in infrastructure to increase reliability • Increase/maintain reliability in existing assets • Supplier & transit route diversity through additional incentives
Improve intra-European interconnections	• Enable solidarity among European countries, enable energy flow to adapt to new situations and crises • Supplier & transit route diversification (in both UK and EU energy systems)
Increase import (especially LNG) capacities	• Replace diminishing domestic gas production • Access foreign resources • Supplier & transit route diversification (Flexible access to diverse gas supplies) • Predictable prices (gas), minimise price volatility
Support European diversification of suppliers and import routes	• Access foreign resources • Supplier & transit route diversification (in both UK and EU energy systems)
Increase gas storage capacity	• Improve emergency response capability, maintain supply during crises • Smooth fluctuations in domestic supply

Introduce strategic storage	• Improve emergency response capability, maintain supply during crises (if commercial storage growth is insufficient)
Encourage storages in non-IEA countries	• Reduce price swings during emergencies, threat situations and short-term shortages
Improve demand-response capability	• Reduce vulnerability to demand peaks, by shifting demand away from peak times
Access to domestic resources, manage import dependency	
Improve planning and permitting systems	• Enable investments that are economically feasible
Strategic approach to determining the power mix	• Fuel diversification (avoid market-induced dash for gas)
Maximise recovery of domestic oil/gas in the North Sea	• Reduce import dependency • Access domestic resources
Improve support schemes to increase share of renewable energy	• Access domestic resources • Reduce consumption (fossil fuels) • Reduce import dependency • Fuel diversification
Support the development of CCS for electricity	• Access domestic resources • Reduce import dependency • Fuel diversification
Maintain access to domestic coal mines	• Access domestic resources
Nuclear power expansion	• Reduce consumption (fossil fuels) • Reduce import dependency (fossil fuels) • Fuel diversification in power mix
Introduction of alternative fuels in transport sector	• Reduce import dependency (oil)
Access to foreign resources, manage import risks	
Bilateral relations and treaties with energy producing countries	• Access foreign resources • Supplier & transit route diversification (gas) • Predictable prices, minimise price volatility on global markets
Improve dialogue/cooperation with producer/consumer countries	• Stabilise imports • Predictable prices, minimise price volatility on global markets
Support development of renewables and infrastructure in developing countries	• Reduce pressure on global energy markets, by improving energy access in developing world without increasing fossil energy consumption
Development of better investment and transit regimes with potential suppliers/transiters	• Access foreign resources • Trigger investment in upstream capacities by improving investment climate • Stabilise imports • Predictable prices, minimise price volatility on global markets • Enable investments that are economically feasible by removal of bureaucratic barriers (upstream)
Promote regional stability and economic reform in producing countries	• Stabilise imports • Good governance throughout the energy chain

3.3 Sweden

The current Swedish energy policy is anchored both in a belief in liberalisation as the best way to organise the energy supply and in sustainability as general leitmotif. The overarching energy policy objective is "*to secure the access to electricity and other energy under competitive conditions*" and to "*create the conditions for an efficient and sustainable energy consumption*" as "*a step in Sweden's ambition to be a role model in sustainable development*" (ND, 2002:15; 1997:5). Sweden has a very high per-capita energy and electricity consumption, much due to a large energy-intensive industry and the prevalence of electricity heating: throughout the last decade, more than 40% of the energy supply came from hydro and nuclear power (ND, 2009; ND, 2002). As the energy system is based on fuels that have been reliable in the past and which the government seem to perceive as secure, like nuclear power, Norwegian/Danish oil and domestic renewables, Sweden has no explicit energy security policy like the EU or the UK. Nonetheless, many energy security policy measures have been proposed – especially measures linked to filling the capacity gap from the nuclear phase-out, an issue that has dominated the Swedish energy policy since the 1980 referendum[5] – although the traditional European energy security vocabulary is not always used.

The 2002 energy bill defines energy security as "*a broad concept that, besides from the purely physical aspects of access to energy, comprises secure functioning of markets and secure transformation of primary energy to refined energy carriers and the supply of customer-specific energy services to the final consumers*" (ND, 2002:25). This definition is largely reflected in the proposed policy measures.

A total of 19 measures with 45 stated aims (of which many appear more than once) could be identified; the measures discussed using 4 thematically defined measure groups, see Table 3. This is one group less than for the UK and EU: no foreign energy security policy in the traditional sense could be identified, although there are international components of technology development and Nordic power system cooperation.

The first measure group aims at improving the functioning of markets, especially the Nordic electricity market (as the gas consumption is almost zero). The government states that "*the proper functioning of the energy markets is of fundamental importance for a secure energy supply*" (ND, 1997:17) as it provides certainty for new investment and an efficient resource allocation. In this, a "*prerequisite*" for a secure energy supply is "*long-term rules and stable conditions*" for energy companies, or the consequences are "*insecurity and failed investments* [and] *high electricity prices*" (MD, 2009:11). In particular, the competition on the Nordic market must be improved, for which infrastructure expansions (see below), effectively fusing the Nordic price areas together and diluting market power, are a main measure (ND, 1997; 2002; 2009).

[5] The result of the referendum was a decision to phase out nuclear power by 2010. As a result of the unsuccessful phase-out – only 2 of 12 reactors were shut down – the final date was scrapped in 1997. In 2009, the conservative government reversed the phase-out decision and opened up for replacing existing reactors with new ones.

The second group are efficiency measures, especially for electricity end-use, in order to decouple economic growth and energy demand and reduce the consumption. The underlying energy security rationale is mainly to maintain the power system balance during the nuclear phase-out (before 2009), besides the important rationale of climate protection. Increased efficiency is to be achieved through general economic instruments, especially energy and CO_2 taxes, which "*support the spontaneous increase in energy efficiency that happens in the society*" (ND, 2009:39). The tax reforms are also targeted at supporting renewables (see next group). Information campaigns and education of public servants are other measures to increase efficiency, as "*lack of information is one of many reasons why market actors sometimes make energy inefficient investments*" (ND, 2002:108). In addition, various investment programmes aim to reduce the electricity demand, like support for house-owners who change their electric heating for district heating, or for district heating system operators who replace their electric boilers with fuel-burners. Throughout the process, "*the public sector must provide a positive example in the energy efficiency work*" (ND, 2009:84). Another, more long-term, area is measures supporting technology development and market introduction programmes for energy efficient technologies (ND, 1997; 2002; 2009).

The third group concerns measures to ensure access to energy sources, especially through an increase of the electricity generation capacity by increasing the economic attractiveness of renewables through tax reforms and support schemes. In addition, institutional barriers, especially grid access issues and over-complicated permission processes for renewable electricity, are to be removed and replaced by simpler and more efficient regulations (ND, 2002; 2009). Sweden has no fossil fuels but large renewable energy resources, even when hydro power is excluded, and it is the aim of the government to increase the use of these, both on climate and energy security grounds in order to continue being "*essentially self-sufficient in electricity*" and "*continuously guarantee the long-term security of supply*" through "*an ambitious* […] *supply of renewable electricity generation*" as "*a third leg for the power supply in order to reduce the dependence on nuclear and hydro power*" (ND, 2002:18; 2009:11f). A special focus lies on investments in biomass-fuelled combined heat and power (CHP) stations and district heating, which are to be incentivised through support schemes and tax reforms (MD, 2009; ND, 1997; 2002; 2009). In addition, the government proposes to "*adopt the rules of the IPCC and the EU*" to account for the supposed climate-friendliness of peat and remove peat from the ETS, thereby detaching peat-fuelled power/CHP from the obligation to buy emission allowances and increasing the economic attractiveness of this "*domestic energy source contributing to the energy security*" (ND, 2009:36; 2002). The government lifted the ban on construction of nuclear reactors in 2009 to allow for "*a gradual replacement of the existing reactors when these reach the end of their economic life*", both on grounds of climate protection and security of supply (ND, 2009:34). This decision changed the focus on renewables from being compensation power for lost nuclear capacity (and hence an energy security measure) to becoming an immediate climate protection measure. For the longer-term perspective, measures supporting the development of new energy technologies in an international context are proposed. This connects to similar programmes in the EU and is to be carried out in cooperation with the Baltic rim countries. The development of large-scale renewable electricity generation, biofuels and biomass CHP are particular foci of the Swedish technology development programmes, with the objective to harness untapped domestic resources (ND, 1997; 2009).

The fourth group aims at improving the infrastructure, especially the electricity grid and interconnections to the other Nordic countries, and updating the crisis response mechanisms. The domestic infrastructure reinforcements are mainly targeted at the north-south transmission capacity, in order to maintain power system balance in southern Sweden after the shut-down of 2 reactors there, but also in order to enable the continued integration of the Nordic power grids. This is a prerequisite for the functioning of the Nordic market as it dilutes the market power of the dominant actors (ND, 2002). The importance of the integration of the Nordic power systems for Swedish energy security "*cannot be overstated*" (ND, 1997:12), as "*imports from abroad can contribute to smoothing fluctuations in the domestic production*". Sweden's energy security increases, as the Nordic grid "*enables exchange of power* […] *both during normal and strained operations*" (ND, 2009:27). Other energy security gains from improved interconnection are less volatile prices, shared reserve capacities, improved efficiency and reduced investment needs (ND, 1997; 2002; 2009). In addition, new regulations for strategic oil storage and war-time storages for coal are proposed in order to make these economically more efficient. At the same time, the energy rationing laws for extreme disturbances or war are updated. For the power sector, the main energy security problems are connected with the nuclear phase-out and possible capacity shortages in winter. To solve this, the government at various times proposes new tenders for winter-time back-up power, increased demand-response capacities especially in industries and heating, as well as international harmonisation of emergency measures in the Nordic power system (ND, 1997; 2002; 2009).

It should be noted that the government's declaration to completely phase out fossil-fuels in heating by 2020 and in transport by 2030 is not mentioned here. These objectives are not motivated by energy security concerns[6], but are exclusively a climate and industry policy issue[7].

Table 3: Energy security policy measures and stated aims of the measures as described in the reviewed Swedish documents. Sources: MD, 2009; ND, 1997; 2002; 2009.

Measure	Stated energy security aims
Market	
Improve functioning and competitiveness of domestic markets	• Trigger investments • Fuel diversification • Efficient allocation of energy resources, also during crises
Energy efficiency	
Market introduction support	• Decouple economic growth and energy consumption

[6] This is, from a European perspective, remarkable. Fact is, however, that the word "import" appears three times in the 2009 energy and climate package in connection with energy. Imports are at no instance discussed as a problem or a source of insecurity, despite the complete Swedish dependency on import oil and gas – thus, the "Access to foreign resources" measure group, which is prominent in the two other cases, is missing.

[7] "*the policy is focused on* […] *breaking the dependence on fossil fuels, thereby reducing the climate impact.* […] *Swedish industry can become the world leader in this transformation* […] *through the development of hybrid vehicles, electric cars and biofuels*" (ND, 2009:79).

for energy efficient products	• Reduce consumption (energy) • Maintain power system balance
Energy efficiency education/info campaigns	• Decouple economic growth and energy consumption • Reduce consumption (energy) • Maintain power system balance • Reduce import dependency
Improve energy efficiency in the public sector	• Provide energy-efficient example for rest of society, create demand for efficient products/technologies • Reduce consumption (energy)
Reduce electricity use in district heating systems	• Reduce consumption (electricity) • Maintain power system balance
Access to domestic resources	
Energy and CO_2 tax reforms	• Trigger investments in renewables/low-carbon energy • Reduce consumption (energy), through "true" prices
Improve support schemes to increase share of renewable electricity	• Maintain power system balance • Access domestic resources • Reduce import dependency • Fuel diversification
Maintain number of nuclear reactors	• Maintain power system balance, by replacing existing reactors as these reach end of economic life • Fuel diversification
Tax reform for biomass CHP	• Trigger investments in biomass CHP • Increase heat availability for district heating • Maintain power system balance by maintaining economic attractiveness for existing facilities • Fuel diversification
Adopt IPCC/EU accounting regulations regarding peat	• Access domestic resources • Trigger investments in peat-burning generation/heat • Fuel diversification
Improve planning and permitting systems	• Enable investments that are economically feasible
Support for technology development	• Fuel diversification • Access domestic resources • Maintain power system balance
Infrastructure and crisis response capacity	
Improve domestic transmission grid	• Increase/maintain reliability in existing assets • Trigger investments through functioning electricity market • Maintain power system balance in southern Sweden after shutdown of nuclear power
Improve electricity interconnections	• Enable solidarity among Nordic countries, enable energy flow to adapt to new situations and crises • Smooth fluctuations in domestic power supply • Improve emergency response capability, maintain supply during crises • Trigger investments through functioning electricity market
Introduce common Nordic power capacity shortage regulations	• Improve emergency response capability, maintain supply during crises
Expand demand-response capacities	• Reduce vulnerability to demand peaks, by shifting demand away from peak times
Improve oil and other storage regulations	• Improve emergency response capability, maintain supply during crises
Energy rationing	• Ensure vital function remain operational during war or extreme crisis
Tender for back-up power	• Maintain power system balance during cold winters

3.4 Summary

The energy security policy measures of the EU, the UK and Sweden are numerous and multifaceted: the tables 1-3 list 68 measures with 154 entries of stated aims explicitly linked to energy security concerns. The exact measure formulation and the relative importance of each group differ between the cases, but the stated aims can be assigned to the same groups of energy security-enhancing policy measures: markets, energy efficiency, infrastructure and crisis responses, and access to foreign and domestic energy resources. These slight variations were expected, due to the different energy situations, traditions and competencies of the policy authors. The most significant difference between the cases is that the Swedish energy security policy lacks a foreign energy policy (although it has international components, especially concerning the Nordic electricity system), much due to its endowment with renewable energy resources and since it sources most of its fossil fuel imports from trusted neighbours.

Due to these similarities, most of the aims appear numerous times: for example, "Fuel diversification" appears 15 times and the different varieties of "Trigger investments" and "Reduce consumption" appear 17 and 19 times, respectively. The number of unique[8] aims is 27 (see Table 4). Most of the stated aims, and hence the energy security policy concerns, appear to be generally valid: 11 unique aims exist in all three cases, and another 10 unique aims exist in two cases – largely a consequence of Sweden's lack of a traditional foreign energy policy. Only 6 aims appear to be rooted in case-specific (policy) conditions[9], as they exist in only one case. Overall, the aims and hence the concerns and the very concept of energy security are similar across the three cases.

[8] What constitutes a unique aim is partially a subjective issue: For example, the three aims "Improve emergency response capacity", "Efficient allocation of energy resources, also during crises" and "Enable solidarity" are here counted as separate aims, although they have clear overlaps. The exact numbers should therefore be enjoyed with care.

[9] These are linked to the UK's search for replacements for its domestic fossil resources ("Reduce pressure on global energy markets", "replace diminishing domestic resources"); the EU's struggle for a unified European foreign energy policy ("Add weight in negotiations"); and Sweden's tradition of neutrality and war preparation ("Ensure vital functions") its decision to phase out nuclear power ("Maintain system stability") and its wide-spread expansion of district heating ("Increase heat availability").

Table 4: The stated aims and the existence of these as explicitly stated energy security policy aims in the three cases EU, UK and Sweden.

Stated aim / Aim exists in case	EU	UK	Sweden
Markets			
Trigger investments	X	X	X
Fuel diversification	X	X	X
Efficient allocation of energy resources, also during crises, disruptions	X	X	X
Energy efficiency			
Decouple economic growth and energy consumption	X	X	X
Provide energy-efficient example for society	X	X	X
Reduce consumption (primary, electricity, fossil, oil)	X	X	X
Infrastructure and crisis response			
Enable solidarity	X	X	X
Improve emergency response capability, maintain supply during crises	X	X	X
Reduce price swings during emergencies	X	X	
Increase/maintain reliability in existing assets	X	X	X
Smooth fluctuations in domestic supply		X	X
Reduce vulnerability to demand peaks		X	X
Ensure vital functions remain operational during extreme crisis			X
Access to domestic resources, manage import dependency			
Access domestic resources	X	X	X
Enable economically feasible investments by reducing bureaucracy		X	X
Reduce import dependency	X	X	X
Maintain power system balance			X
Increase heat availability for district heating			X
Access to foreign resourses, manage import risks			
Access foreign resources	X	X	
Supplier & transit route diversification	X	X	
Stabilise imports	X	X	
Replace diminishing domestic fossil fuel production		X	
Add weight in negotiations with supplier and transit countries	X		
Predictable prices, minimise price volatility	X	X	
Early warning and contingency preparation	X	X	
Reduce pressure on global energy markets		X	
Good governance and rule of law throughout the energy chain	X	X	

3.5 Dimensions and indicators

As shown above, the energy security policy concerns of the EU, UK and Sweden are similar, with some exceptions mainly rooted in policy competence differences and diverging resource endowment. Viewing the measures in a more abstract sense reveals an even further reaching uniformity between the energy security measures and aims of the three cases. All aims go in at least one of two directions: either ensuring access to sufficient amounts of energy – *availability* – or maintaining the uninterrupted supply to all customers at all places and at all times – *reliability* (see Figure 1). This becomes clear when looking at the rationale behind the measures as stated in the policy documents.

The rationale behind the market measures is primarily to trigger sufficient investment (both domestically and upstream) but also by using price signals to reduce demand. Both perspectives primarily aim at ensuring availability. Market measures also aim at improving reliability, especially by using price signals to efficiently reroute resources during disturbances. Markets and/or other remuneration rules for regulated infrastructures aim to increase reliability by triggering investments in order to adapt the infrastructure to new needs and to reduce the failure rate caused by aging assets. Prices are thus of great importance and emerge as a possible energy security dimension (see below).

The various energy efficiency measures aim at reducing demand, thus positively influencing the availability situation: it is easier to access less energy. For the same reason, they also influence the reliability dimension: it is easier to distribute and handle less energy. Overall, a lower energy demand means a lower exposure to all sources of risk.

The infrastructure and crisis response measures affect the reliability dimension: triggering investment in new infrastructure and maintaining the existing assets is crucial to system reliability. Again, sufficiently high prices are the key. Storages are seen as crucial for reliability to bridge shortages during disturbances. The infrastructure and interconnection measures are in all three cases seen as direct measures to improve the crisis response capabilities, mainly by enabling access to reserves, storages and other crisis mechanisms throughout the domestic system and in neighbouring countries, thus reducing individual risk.

The energy access measures aim at ensuring long-term energy access and are often closely related to the market measures (which aim at triggering investments). Access to domestic and foreign resources differ in their impact on political dependency, which shows the importance of dependency as a possible dimension (see below), but are identical in their core: these measures are about ensuring long-term stable access to energy.

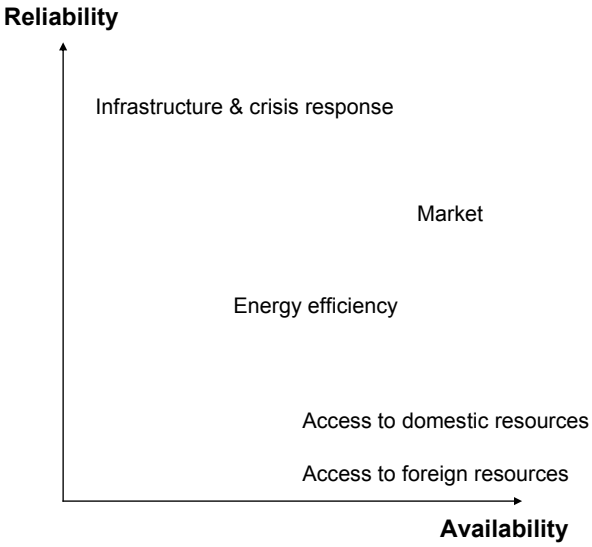

Figure 1: The groups of measures, displayed along their relevance of their main aims for the dimensions availability and reliability.

In addition to these two orthogonal dimensions, the non-orthogonal issues of *price* and *political dependency* emerge as potential dimensions. However, these are – although they are very important for energy security – not true dimensions of energy security, as they are not orthogonal to reliability and/or availability.

Prices need to be high and predictable enough to trigger investments and stimulate efficiency, whereas too low or volatile prices will not achieve any of these. Price signals help to efficiently reroute energy during disturbances. That makes it important to energy security. This, however, means that their impact on energy security is indirect and goes through the dimensions availability (investments) and reliability (rerouting). Hence, the issue of prices is very important but it is not orthogonal to availability and reliability, and it is therefore not a true dimension.

Similarly, the dependency issue is important to energy security, but it is not orthogonal to reliability – a sudden disruption is the main threat in "energy weapon" events (Lilliestam and Ellenbeck, 2011) – nor to availability, as the importer must trust the exporter to allow access to its resources also in the longer term. Hence, dependence is an important issue in both the reliability and availability dimensions, especially as it concerns important issues outside of the domestic policy makers' control, but it is not a true dimension of energy security.

This bottom-up energy security conceptualisation allows for a direct, quantitative assessment of the level of target-compliance. Most aims can be quantitatively assessed simply by measuring the aims themselves (e.g. import dependency, energy consumption, or share of renewables), whereas some few aims may require constructed measures (e.g. diversity indices). A suggestion for possible – with emphasis on possible, as opposed to definitive – indicators for assessing the level of energy security with only readily available data is presented in Table 5. In total, 29 possible indicators are suggested to measure the compliance with the 27 unique aims; this number can probably be reduced, depending on the focus and the setting of the energy security assessment.

Table 5: Stated aims, sorted in the measure groups from Tables 1-3, in the energy security policies of the three cases EU, UK and Sweden, and possible indicators to assess the level of aim compliance. Some aims apply for more than one measure group: the aims are here presented in the group where they have the highest relevance. The symbols in the table mean that a higher ("+") or lower ("-") value indicate higher aim compliance. Symbols in brackets mean that the indicator could apply, depending on what fuels or sectors are assessed[10].

Stated aim / Possible indicator	**Markets**	Trigger investments	Fuel diversification	Efficient allocation of energy resources, also during crises, disruptions	**Energy efficiency**	Decouple economic growth and energy consumption	Provide energy-efficient example for society	Reduce consumption (primary, electricity, fossil, oil)	**Infrastructure and crisis response**	Enable solidarity	Improve emergency response capability, maintain supply during crises	Reduce price swings during emergencies	Increase/maintain reliability in existing assets	Smooth fluctuations in domestic supply	Reduce vulnerability to demand peaks	Ensure vital functions remain operational during extreme crisis	**Access to domestic resources, manage import dependency**	Access domestic resources	Enable economically feasible investments by reducing bureaucracy	Reduce import dependency	Maintain power system balance	Increase heat availability for district heating	**Access to foreign resources, manage import risks**	Access foreign resources	Supplier & transit route diversification	Stabilise imports	Replace diminishing domestic fossil fuel production	Add weight in negotiations with supplier and transit countries	Predictable prices, minimise price volatility	Early warning and contingency preparation	Reduce pressure on global energy markets	Good governance and rule of law throughout the energy chain
Investments (spec. assets)/dem. growth		+											+					+			+				+						+	
Average permission time for new projects		'																													'
Market power (market concentration)		'		'																									'		
Price volatility		'										'																	'		
Fuel diversity (in prim., sec.energy mixes)			+																												
Interconnection cap./peak demand				+						+	+			+	+																
Unutilised interconn. cap. during outage		'		'							'																				
Outage time (due to reason X)													'																		
Available peak cap./peak demand											+										+										
Demand-response capacity/peak dem.											+				+																
Days of peak demand in storages											+			+		+															
Primary energy consumption								'	'																						
Secondary energy, specific fuel cons.								'																							-
Share of non-fossil energy								(+)										(+)													+
Share of renewables								(+)										(+)													+
Share of nuclear power								(+)										(+)													
Energy intensity (in sector X)						'	'	'																							
District heating/total heat demand																						+									
Domestic Reserves-to-production quota																		+													
Exporter Reserves-to-Production quota																									+						
Import capacity/demand																									+		+				
Import dependency (total, fossil fuels)																				-	-										
Imports (absolute)																				-					+						
Global production margin																															+
Supplier & transit route diversity											+														+	+		+	+		

[10] Note that the geographical and/or sectoral scope may differ between assessments: some indicators (esp. investments, share of energy carrier, consumption) allow for such geographical/sectoral specification, whereas other (e.g. price volatility, governance indicators) do not.

4 Discussion

These results show that energy security from a policy perspective is indeed multi-faceted – albeit less multifaceted than suggested by most of the HV&S articles – but not a multi-dimensional concept. Instead, availability and reliability stand out as the two orthogonal dimensions of energy security, with price and dependence as two important subcomponents. This result harmonises well with some studies, for example the three "perspectives" on energy security (sovereignty, robustness, resilience) identified by Cherp and Jewell (2011), but stand in stark contrast to HV&S. The differences in conceptualisation have four important reasons.

First, the different conceptualisation methods here and in HV&S lead to divergence: deducing all issues that *could become* threats, like HV&S do, is different – wider in scope – than inducing what issues *are perceived* as threats. As many things may become threats but only few things are already threats, this narrows down the present study to only the most pressing actual policy concerns.

Second, the deviating results highlight differences in how authors perceive energy security policy and how it differs from general energy policy. A starting point for this study was that energy security policy is a subset of energy policy, which also consists of, among others, market and environmental policy. This distinction was also clearly seen in the policy documents. HV&S do not differentiate in this way, which increases their possible number of dimensions, essentially including all energy policy issues in their energy security conceptualisations.

These two points combined show a main difference between previous research and this article: whereas, say, environmental policy has an important impact on energy security policy (e.g. through influencing investment behaviour) it *is* not energy security policy. Rather, environmental policy is important to energy security because it constrains the choices of energy security policy. The same applies to many other issues, such as affordability (social policy) or job creation (social/industrial policy), identified by HV&S and others. Such issues sometimes appear in the formal energy security definitions in all three investigated cases and may, for example, influence investment decisions or prohibit certain technologies. Thus they have considerable impacts on energy security, but they are not found as energy security policy proposals. This conceptual separation of policies is not very surprising – it appears already in the division of separate but interdependent goals of the European energy objective triad – and in this paper, we have shown that policy makers indeed maintain this policy area separation. Hence, other policies *influence* energy security, yes, but they *are* not energy security.

Third, HV&S are not very strict with what they call dimensions. Formally, dimensions must be orthogonal. As shown here, many "dimensions" such as price and political dependency are important but not orthogonal to availability and reliability, and hence do not qualify as dimensions. Boiling down even Sovacool's 20 "dimensions" to orthogonal, true dimensions would reduce the number significantly: the difference between HV&S and the results of this article may thus not be so large.

Fourth and finally, the results here are only valid for the cases investigated – the European Commission, Sweden and the UK, and only if the assumption that policy-makers really mean what they do is correct. Other EU countries may have somewhat different energy security concerns, but due to the primacy of EU policy, it is unlikely that the perceptions are radically different – differences are likely to be more about the relative importance of single issues than about fundamentals. Non-EU countries, however, could have different views – and HV&S focus mainly on the Asia-Pacific[11]. Finding out whether this is so is outside the scope of this article, and we can only encourage others to do similar analyses for other countries and regions.

Energy security is indeed a multifaceted issue, albeit to a lesser extent than what some recent research suggests. This policy-perspective bottom-up analysis has shown that energy security is, from a policy perspective in a European context, not multi- but two-dimensional, consisting of the two orthogonal dimensions *availability* – having enough energy – and *reliability* – having enough energy at all times and places. Both dimensions are impacted by other, non-orthogonal energy security issues, especially political dependence and price. They are also impacted by other policy areas, like environmental and market policy, which however are separate policies and not dimensions of energy security.

[11] During the research for this paper, an attempt was made to include China and the US as additional cases, but due to the differences, compared to Europe, in policy process and documentation, this was not possible. Still, these would be two interesting cases for further research.

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