Energy Security and Cross-Border Electricity Trade:
Can the Asian Super Grid project pose security risks for Japan? Can the electricity imports be used as an extortion weapon?

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Abstract

Connecting the Japanese electricity grid into the Asian Super Grid may prove useful if increasing the use of renewable energy sources and to overall increase its energy efficiency. This approach, however, has raised questions about a possible impact on the energy security of Japan. Regularly raised argument against Japan joining the cross-border electricity trading project is that it would make Japan dependent on other countries and exposed to political extortion. This paper investigates a scenario, in which Japan imports electricity from Russia. The method to assess the interdependence between importer and exporter countries examines only worst-case scenarios and was adopted from a similar study conducted for the Desertec project. If Japan maintains the current capacity buffers, demand-response mechanism and follows appropriate risk-reducing strategies, it will not be susceptible to any political pressure or extortion by Russia using the ‘energy weapon’. This paper in its essence argues that the Asian Super Grid project would not pose substantial security risks for Japan.

エネルギー安全保障と電力貿易

アジア・スーパーグリッド構想における日本の安全保障への影響

要約

アジア・スーパーグリッド構想（ASG）は、エネルギーミックスにおける自然エネルギー比率の増加と、電力システム全体の効率的な運用を実現するための有力な手段の一つである。実際、欧州においてはノルウェーとオランダを結ぶ Norned を始め既に多くの国家間連系線が存在し、自然エネルギー導入の拡大に貢献している。

一方、日本国内では海外と電力融通を行うことに対する安全保障上の懸念が根強くあり、実現に向けた大きな障害となっている。この安全保障上の懸念とは、海外に電力供給を依存すれば、外交的に緊張関係になった際に電力供給を武器（Energy weapon）として利用されるのではないかとする考えである。

本レポートは、ASG の欧州版とも言える Desertec 構想をケースとして実施された研究を参考に、電力の輸出国と輸入国における相互依存関係性（interdependence）について分析を行うものである。

分析結果より、電力融通を適正な規模に設定し、国内に十分な予備供給力と需要抑制手段を維持することで、万が一、ロシアからの電力供給が途絶するという最悪の事態を想定したとしてもその経済的影響は限定的なものに留まることが分かった。また、一般的な認識では、電力供給の途絶は電力輸入国側に一方的に損失を与えると考えられているが、他の代替輸入国が存在しない場合には輸出国側にも大きな損失を与え、双方にコストを発生させるものであることが分かった。さらに、輸出国側に発電・送電事業への投資参加を促すことによって、事業リスクを双方で共有することになり、より一層、相互依存関係性を高められる可能性がある点も明らかになった。

このような相互依存関係性が成り立つ国家間の電力融通においては、どちらかが一方的にバーゲニングパワーを持つことは無く、適切な事業設計を行うことによって輸入国側への安全保障への影響は限定的にすることが可能であることが示唆される。

1. Introduction

With the closure of many nuclear reactors, Japan has had to replace its lost power. Tokyo has had no immediate choice but to use additional fossil fuels, which has negatively affected Japan's economy because of rising fuel costs. The rise of Japan's fossil fuel consumption has also caused a notable increase in CO_2 emissions, and affected Japan's commitment to lower CO_2 levels.[1] One way out of this situation can be "the German way", i.e. replacing nuclear by renewable sources biomass, wind, solar, hydro, and in Japan Geothermal energies. A possible solution to this problem involves cross-border electricity trading.

The experience with cross-border electricity trading in Europe shows that it can make such a transformation easier. Electricity trading can increase security of supply, efficiency, bring down electricity prices and serve as a catalyst for further deployment of renewable energy technologies.[2] The Asian Super Grid project (ASG), which is the central focus of this paper, is seemingly similar to the Desertec concept for Europe.[3] It proposes linking the enhanced electric power systems of China, Japan, Republic of Korea, Mongolia and Russian Federation (hereinafter Russia) via a super grid. The ASG project is showing to be very challenging and not without major obstacles. There are studies that confirm technical possibility and economical feasibility,[4] but the biggest challenge lies in the sphere of politics and international relations. The security situation in Northeast Asia has been stained with numerous territorial disputes and now the region faces the growing significance of China. A certain degree of political integration seems to be necessary for the project to succeed. Unlike Europe, where the interconnection of national grids and cross-border trade of electricity is becoming more and more common, Northeast Asia is still at the beginning of the process.

Despite its obvious benefits, the ASG has raised a lot of critical questions both in the media and in the academic sphere.[5] In Japan, one of the often raised questions is about energy

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[1] Vivoda, Vlado, *Japan's Energy Security Predicament post-Fukushima*, Griffith Asia Institute, Griffith University, 2012, http://dx.doi.org/10.1016/j.enpol.2012.03.044 (last acces 30/7/2013).

[2] Bahar, Heymi, Jehan Sauvage. *Cross-Border Trade in Electricity and the Development of Renewables-Based Electric Power: Lessons from Europe, O*ECD Trade and Environment Working Papers, OECD Publishing, 2013, http://dx.doi.org/10.1787/5k4869cdwnzr-en (last access 17/7/2013), Teusch, Jonas; Behrens, Arno; Egenhofer, Christian, *The Benefits of Investing in Electricity Transmission: Lessons from Northern Europe,* CEPS Special Reports, No. 59/January 2012, http://www.ceps.eu/book/benefits-investing-electricity-transmission-lessons-northern-europe (last access 15/8/2013).

[3] The Desertec Concept, http://www.desertec.org/ (last access 5/8/2013).

[4] Taggart, Stewart; James, Geoffrey; ZhaoYang Dong; Russell, Christopher; *The Future of Renewables Linked by a Transnational Asian Grid*, Institute of Electrical and Electronics Engineers, Proceedings of the IEEE, 2012, vol.100 issue 2.

[5] Yamamoto, Kozo, 孫正義さん、電力輸入は可能ですか, *WEDGE Infinity*, 18/6/2012, http://wedge.ismedia.jp/articles/-/1992?page=1(last access 19/8/2013).

security, namely the fear of becoming dependent on foreign countries and the possible impact on Japan in case the power supply is suddenly cut.[6] Since Japan is already heavily dependent on energy imports,[7] the main worry would seem to be the risk of being deliberately extorted through electricity imports. Any deliberate one-sided cancelation of energy exports can have profound impacts on a country's economy. Such methods of political extortion can be viewed as a case of "energy weapon". Examples of governments using their energy exports as energy weapon could be seen in the Western dependency on oil from the Middle East and oil shocks in the 70s and more recently in the 2006 Russia-Ukraine gas crisis.[8]

The purpose of this paper is to make a contribution to the discussion about Japan's involvement in the ASG project by investigating the question, whether the Japanese fears of political extortion by the exporter countries are well-founded: "If the ASG project becomes a reality, is Japan susceptible to extortion by the exporters' use of energy as weapon?" In order to answer this question this paper is using a method developed for the Desertec study. The method is more broadly discussed in chapter 2.

The implications of the different characteristics of the electricity trade in contrast to the oil/gas trade are also discussed in this paper and particular attention is drawn to the different bargaining position of exporter. This paper argues, contrary to a common perception, that the risks of energy weapon abuse in the case of electricity trade are not higher than in the case of oil/gas trade.

2. Desertec Study

The Desertec project is an initiative aiming to reduce carbon emissions in Europe by importing renewable energy (namely solar and wind) from deserts in North African countries by the year 2050. Here, it is important to note that although seemingly similar the ASG and the Desertec project represent in fact quite different concepts. While the Desertec project calculates with one-way electricity import to Europe, the ASG proposes more sophisticated larger interconnection between participating countries. In this sense, the Desertec concept can

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[6] Japan's House of Representatives, Committee for Economy, Trade and Industry (衆議院 経産委員会), http://www.shugiintv.go.jp/jp/index.php?ex=VL&deli_id=42855&media_type=fp (last access 5/8/2013).
[7] The Federation of Electric Power Companies Japan, *Dependence on Imported Energy Sources by Major Countries*, http://www.fepc.or.jp/english/energy_electricity/supply_situation/sw_index_01/index.html (last access 17/7/ 2013).
[8] Further analysis of the topic at The Oxford Institute for Energy Studies, http://www.oxfordenergy.org/tag/russia-ukraine-crisis/ (last access 15/88/2013).

be regarded as the worst-case scenario of the ASG. In other words, for the purposes of this paper the Asian Super Grid is heavily reduced to its worst-case scenario form, which is represented by the one-way import/export concept of Desertec.

Therefore, this paper in its essence tries to duplicate a study conducted by Austro-German researchers in 2011: Energy security and renewable electricity trade – Will Desertec make Europe vulnerable to the "energy weapon"?[9] The study investigated the possibility of using electricity export cuts in North Africa as means of political extortion of the EU.

The Desertec study developed a new method of assessing a country's vulnerability and susceptibility to extortion through the use of the energy weapon. It took into account the difference between electricity imports and oil/gas imports, stating two important characteristics of these two energy carriers: Firstly, oil and LNG (to some degree) are traded on a flexible world market. This increases the possibility to replace failed imports by buying supplies from other external sources. In contrast, electricity imports are grid-bound and the suppliers can only be substituted to a degree allowed by the existing grid. Secondly, oil and gas can be stored. Japan, for example has storage large enough to bridge 6 months in the case of oil[10] and 20 days in case of gas import disruption.[11] The ability to be stored also means that an exporter can store failed exports and deliver them at a later point. Electricity, unlike fuels, cannot be stored in any larger amounts over significant times. Therefore, a supply disruption would mean that the non-delivered amount of electricity is immediately missing. The exporter of electricity would suffer a greater loss than the exporter of oil for example, as the undelivered oil would be sold and rerouted to another buyer.

These facts lead to the conclusion that electricity import disruption can indeed cause damage in importing countries; however, exporters would also suffer damages, because the export revenues from exporting the electricity would immediately stop. To address these special characteristics of electricity trade, the Desertec study developed a new method of assessing the actors' vulnerability and susceptibility to the energy weapon. The method is based on the balance in bargaining power that is conceptualised as the costs of a supply disruption to both exporter and importer. The concept is explained in detail in chapter 3.

While the Desertec study worked with data assumptions for the year 2050 (e.g. electricity prices, countries' GDP, etc.) this paper uses current (2013) data. The main reasons

[9] Lilliestam, Johan; Ellenbeck, Saskia, "Energy Security and Renewable Electricity Trade - Will Desertec Make Europe Vulnerable to the "energy weapon"?" *Energy Policy 39*, 2011: 3380–3391.

[10] 185 days (approximately 6 months) including both private companies and state owned facilities, JOGMEG, *Stockpiling oil*, http://www.jogmec.go.jp/library/stockpiling_oil_003.html (last access 13/8/13).

[11] 80 days (approximately 2,5 months) Agency for Natural Resources and Energy, http://www.nira.or.jp/pdf/taidan69.pdf (last access 14/1/25).

for the slightly different approach is the fact that the ASG project realisation is expected to start much sooner than the Desertec project – around the year 2020. Using current data rather than projections for 2020 allows avoiding rough assumptions and contributes to accuracy of results. The downside is obviously the possibly outdated outcome. It is nevertheless believed that due to the general unavailability of the data a large part of which has to be estimated or assumed, estimating future data creates an even bigger risk of inaccuracy.

In the same way, where the Desertec study calculated with five exporters, this paper assumes only one exporter: Russia. Where the Desertec study had to incorporate transit costs due to geographical positions of exporters, this paper has the benefit of being able to ignore such an issue. In general, this paper tries to keep a simpler approach avoiding as many rough assumptions as possible.

2.1. Interdependence

This chapter briefly outlines the concept of interdependence originally developed by Keohan and Nye[12] and used by the Desertec study.[13] The energy industry is becoming more and more international with large amounts of energy being traded across the globe. Japan, as well as most industrialised countries, has a growing dependency on imports. Japan depends on imports for more than 90% of its primary energy supply.[14] For that reason, it is understandable that the government of Japan sees the security of supply as a priority.

Equally, energy exporting countries perceive the security of demand as vital to their economies. As for Russia, oil and gas accounts for more than half of the export income and represents up to 30% of the country's GDP and half of its GDP growth since 2000.[15] Therefore, the relationship between energy importing countries and energy exporting countries should not be regarded as simple dependence, or even as interconnectedness, but rather as a relationship of interdependence.[16]

Interdependence can become a situation, in which both parties benefit from the reciprocity, or in its negative form interdependence can also be a mutual threat of imposing costs on both parties. The Desertec study gives an example of the gas trade between USSR

[12] Keohane, R.O; Nye, J.S, *Power and interdependence*, 2001. 4th ed. Longman, New York.
[13] Lilliestam and Ellenbeck 2011, p. 3381.
[14] The Federation of Electric Power Companies Japan, *Japan's Energy Supply Situation and Basic Policy*, http://www.fepc.or.jp/english/energy_electricity/supply_situation/ (last access: 31/7/13).
[15] Leon, Aron, *The Political Economy of Russian Oil and Gas*, American Enterprise Institute for Public Research, Spring 2013, http://www.aei.org/files/2013/05/29/-the-political-economy-of-russian-oil-and-gas_083506286519.pdf (last access 31/7/13).
[16] cp. Lilliestam and Ellenbeck 2011, p. 3381.

and Western Europe during the cold war: on one hand, the USSR was highly dependent on the hard currency income from the trade and had large investments locked down in infrastructure, and at the same time Western Europe was dependent on the Soviets as a main supplier of gas. As a result, there were no notable politically motivated disruptions in gas trade between the USSR and Western Europe, in spite of the strong political tensions between the two blocks.[17] Both positive and negative symmetric interdependences are characterised by evenly distributed costs or benefits through non-compliance and compliance, respectively. Such a relationship is likely to be stable, because no party has "bargaining power" over the other. [18]

Contrary to the stable, symmetric interdependence, asymmetric interdependence may be a source of bargaining power. Decisions to use the energy weapon are strongly connected to rational expectations and calculations about the future development and the cost symmetry of breaking the trading relationship. For example, the relationship can be a source of bargaining power for exporter X if a broken deal causes large damages for importer Y, without damaging the deal-breaking exporter X. If importer Y can substitute the shortage or do well completely without the undelivered product, the dependency does not constitute a source of bargaining power for exporter X. The threat of extortion for political reasons is therefore a function of symmetry of the impacts of a one-sided cancellation of the deal on both actors. However, an asymmetric relationship is indeed a source of bargaining power, but it only means that the bargaining power *can* be used, not that it *will* be used.[19]

Lastly, it is important to note, that an interdependent trading relationship is highly dynamic. A mere threat of a disruption may be reason enough for one or both parties to prepare for future conflicts. The effects of a disruption event are also not static: both parties will try to minimise their damages (importers will try to find other suppliers; exporter may try to export to other markets). In this sense, the development of the interdependence must also be taken in to account when assessing the possibility of an energy weapon scenario induced by bargaining power.

[17] Adamson, D.M, Soviet gas and European security, *Energy policy*, 1985, 13-26, http://dx.doi.org/10.1016/0301-4215(85)90077-1 (last access 2/8/2013).
[18] Keohane and Nye. 2001.
[19] Ibid.

3. Interdependence and the ASG

In this chapter, concrete scenarios in which the exporter country, Russia, uses the energy weapon and cuts the electricity exports are considered. Japan, as the importer country, is very unlikely to suddenly stop importing electricity – such a scenario is therefore not considered. Analogically to the position of Europe in the Desertec study, there are two reasons for that: Firstly, Japan would not start importing electricity from renewables if it could produce it cheaper and better domestically. The main reason why Japan would import electricity in the first place is because it would be cheaper. Secondly, by cutting its own electricity imports, Japan might risk costly shortages.

Governments of exporter countries can have different reasons to use the energy weapon. The Desertec study gives various examples: Economical reasons (higher prices), political reasons (achieving a certain foreign policy goal) or personal (the arrest of a leader's son). It is impossible to quantify these reasons in a meaningful way, other than assessing that the reason can be understood as expected benefits for the exporter and expected costs of accepting the demands for the importer. The stronger the reason, the larger is the willingness of the exporter to risk a conflict and accept damages. However, rather than the reason, the bargaining power balance is the most important determinant, as it is the threat and leverage that forces the importer to accept the demands.[20]

For the purpose of this paper, it is assumed that a strong reason to deliberately break a trading deal is present. Although the ASG project calculates using the interconnections of Mongolia, China, South Korea, Russia and Japan, this paper focuses only on the scenario of a simple bilateral interconnection between Japan-Russia. The interconnection is based on a real concept: There is a potential seen in the Hokkaido-Sakhalin renewable energy trade,[21] which could resemble the proposed Sakhalin 1 and 2 projects.[22] Furthermore, this paper introduces an approach that can be applied to other cases of Japan's electricity trade with its neighbours (Japan-Republic of Korea), if the necessary data are made available.

3.1. Damage functions

[20] This logic was adopted from the Desertec study: Lilliestam and Ellenbeck 2011, p. 3382.

[21] Ivanova, Yu; Tuguzova, T.F; Khalgayeva, N.A; Tikhonkikh, V.N, Renewable energy resources of the Sakhalin region: assessment and priorities of utilization, http://dx.doi.org/10.1016/j.gnr.2010.03.009 (last access 31/7/2013).

[22] *Sakhalin 1 project*, http://www.sakhalin-1.com/Sakhalin/Russia-English/Upstream/about.aspx (last access 31/7/2013).

As was suggested above, the bargaining power symmetry is determined by the difference between exporter (c_{exp}) and importer (c_{imp}) costs. The party with the higher costs is the more dependent one. If both costs are equal, the relationship is stable and no party has bargaining power over the other. The following damage functions are almost identical to the ones in the Desertec study.[23]

The costs of the exporter for a broken electricity delivery deal are predominantly determined by the amount of non-delivered electricity (m_{exp}) and the price for this electricity at the target market (p_{exp}). Following the Desertec study, it is assumed that no grid infrastructure to other significant export markets exists due to the relative geographical isolation of Sakhalin Island.

The long-term reputational costs are not considered in this function. The party breaking the deal is very likely to suffer a long term-loss of its reputation as a trading partner. For example, after the first oil crisis in 1973, the West started to invest in diversification and reduction of its dependence on oil (a process that is still ongoing). Although at that time OPEC was initially successful, the reputational loss of OPEC as an exporter led to its loss in income in the long run. A more recent example would be Europe's reaction to the 2006 Ukrainian gas crisis. Since then, Europe has been trying to avoid dependence on Russian gas.

Penalty payments and damages claimed, which would apply if the contract is breached, are not considered. Such compensation clauses may be included in electricity trade contracts, but their impact or the quickness of their enforceability is very hard to predict. Because such penalty payments will be ≥ 0, this may lead to an underestimation of the exporter cost.

The damage function for the exporter is written as:

$$c_{exp}(t) = m_{exp}(t) \; p_{exp}(t)$$

The importer's costs are predominantly determined by the size of the blackout and the blackout costs per non-delivered kWh (p_{bl}), minus the value of the non-delivered electricity ($m_{exp}\, p_{exp}$). The importer is prepared for technical difficulties and other disturbances and has access to different emergency response mechanisms to replace failed capacities. The reserve and control capacities are denoted by m_r and can be produced at the price p_r.

[23] Lilliestam and Ellenbeck 2011, p. 3383.

The importer can also reduce its demand, both promptly through emergency measures and in a longer-term through consumer oriented incentives. This load reduction is assumed to imply only negligible direct costs. Building new capacities is also not considered as it takes a long time before they are operable. The possibility of electricity imports from other countries is not considered.

The damage function for the importer is written as:

$$c_{imp}(t) = [m_{exp}(t) – m_r(t) – m_{red}(t)]\,[p_{bl}(t) – p_{exp}(t)] + m_r(t)\,[p_r(t) – p_{exp}(t)]$$

The equation is constrained by $m_{exp}(t) \geq m_r(t) – m_{red}(t)$

3.2. Economic Assumptions

The costs of a blackout (p_{bl}), both direct and indirect, are generally hard to quantify precisely. In the Desertec study, European blackout costs were estimated using a concept of Value of Lost Load (VOLL). The VOLL depends on many factors such as what time of the day/year the blackout occurs, how long it lasts, the degree of the country's readiness, etc. These factors are extremely difficult to determine as far as the data availability is concerned. Therefore, a rough assumption of a fixed VOLL was made.[24] A very similar approach will be used in the case of Japan. According to a recent study conducted by the Central Research Institute of Electric Power Industry (CRIEPI) an approximate cost of a blackout in Japan is likely to be 500～750 yen/kWh. The study used statistical data from input-output tables of Japan (2005) and the following equation: p_{bl} = GDP/ (intermediate input of electricity) (electricity price per unit). The study itself concedes that the estimate is very rough.[25] This paper takes the higher estimate of 750 yen/kWh.

The price of the exported (imported) electricity, p_{exp}, represents the avoided costs for the importer (Japan) and the lost income for the exporter (Russia). This paper, unlike the Desertec study, which worked with assumptions of the prices in 2050, sticks to the current (2013) prices of electricity in the exporter's market. However, the character of the cross-border electricity trade poses one important limitation. The price of the exported (imported) electricity has to be lower than the price of electricity within Japan. Otherwise the whole project would lose its rationale. Similarly, an economically rational exporter would not (in

[24] Lilliestam and Ellenbeck 2011, p. 3383.
[25] Imanaka, Takeo, *An Overview of Supply and Demand Costs Curve.* Central Research Institute of Electric Power Industry, p. 2. http://criepi.denken.or.jp/jp/serc/discussion/index.html (last access 31/7/2013).

some cases requiring larger investments *could not*) sell electricity internationally cheaper than it sells it domestically, let alone the political implications of such decision.[26]

In the case of Russia the exported electricity price will be set between Russia's domestic electricity price of 8 US cents/kWh (approximately 8 yen/kWh)[27] and Japan's average domestic price in the wholesale market of 15.73 yen/kWh.[28] Although it would be more appropriate to use the likely lower average wholesale price, some approximation was necessary due to the unavailability of the average wholesale price data.[29] The price of operating the reserve capacities (p_r) is assumed to be the same as the present price for electricity generation predominantly from burning fossil fuels as they are highly flexible: 15.73 yen/kWh. This number is likely to be higher, but due to the unavailability of more specific data, the estimation above is used. This assessment may lead to an underestimation of the importer's costs.[30]

The relative impact of these costs on the national economies is a relevant measure as the economical strength of Russia and Japan differ. The results are presented in relation to GDP per time unit. The GDP figures are based on the data for 2012.[31] Russia: $2.015 trillion (201.31trillion yen), Japan: $5.960 trillion (595.44 trillion yen).[32]

Lastly, disruption magnitudes will be estimated individually for different scenarios. It is however important to note, that in order to cause blackout on the importer's side, the disruption magnitude (the amount of the non-delivered electricity) would have to be higher than the sum of the importer's reserved capacities (m_r) and reduction of demand capacity (m_{red}). Detailed explanations of these estimations are explained in the next subchapter.

3.3. Importer Response Mechanisms

Since the Japanese national grid is still relatively divided, the data of Japanese 2013 summer peakload are different for each area: The east area amounts for 74 GW and the west

[26] Sokolov, Dmitry, *Russia's involvement in the ASG project*, Asia Pacific Energy Research Centre, meeting minutes, 18/7/2013.
[27] 7,9 yen according to the monthly average of July 2013.
[28] The average of the system price in JEPX from April 1 to July 29 in 2013, Japan Power Electric Exchange, http://www.jepx.org/ (last access 30/7/2013).
[29] Despite the fact that the wholesale market in Japan is small and most of the electricity traded is contract-based, its price was used as an alternative to the unavailable average wholesale price.
[30] Note this is the only underestimation of the importer's costs in this paper.
[31] The World Bank, http://data.worldbank.org/country (last access 30/7/2013).
[32] Exchange rate according to the monthly average of July 2013.

area for 93 GW.[33] Since the examined case is an interconnection Hokkaido-Sakhalin, only the east area's peakload is considered. All calculations assume that the disruption incident happens at peak times, which is when Japan would be most vulnerable. This is an overestimation of the importer costs.[34]

Furthermore, Japan's response mechanisms are not distributed equally across the entire system, hence the different peakloads for the east area and the west area. This could be regarded as an underestimation of Japan's capability to react to sudden disturbances (and therefore another overestimation of the importer costs), because the current system's transmission bottlenecks are expected to be unblocked to a certain degree. There are plans to expand the capacity of Japanese grid systems in the near future.[35]

As is the case in the Desertec study, the importer's spare capacities (m_r) are split into primary, secondary, tertiary and other spare capacity. According to Electric Power Counsel of Japan (ESCJ), the country's current primary spare capacity in the east area that can be immediately used amounts for 2.2 GW (3% of the peakload for the east area).[36] It is assumed that the primary control capacity remains constant and that it can reach full capacity instantly and is able to operate indefinitely.[37]

There are no data available for the secondary and tertiary control capacities; however as for the secondary capacity, this paper works with the assumption of 4% of the peakload for the east area (3.14 GW). This assumption is based on the previously cited Japanese Cabinet's Committee for Electricity data that estimate the short term spare capacity to be 7% for the east area.[38] The secondary control capacity is then calculated as the difference between the Committee's data and Japan's primary capacity.[39] The secondary control capacity can be activated in 10minutes[40] and is assumed to remain operational indefinitely. As for the tertiary control capacity, it is not considered in this paper due to the lack of reliable data. The other spare capacities are those which can be used during extreme peaks or to replace a capacity that is being repaired. These are also not assumed by this paper.

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[33] Committee for Electricity Supply and Demand under the Cabinet Secretariat, http://www.kantei.go.jp/jp/singi/electricity_supply/20130426/taisaku.pdf (last access 30/7/2013).
[34] Same assumption as in Lilliestam and Ellenbeck 2011.
[35] Kanekizo, Kensuke, *Japan Energy Brief*, Institute of Energy Economics, 2010. http://eneken.ieej.or.jp/en/jeb/1005.pdf (last access 15/8/2013).
[36] Electric Power System Counsel of Japan. *The Rules of EPCJ*. p. 106. http://www.escj.or.jp/making_rule/guideline/data/rule_english20120619.pdf (last access 15/8/2013).
[37] cp. Lilliestam and Ellenbeck 2011, p. 3384.
[38] Committee for Electricity Supply and Demand under the Cabinet Secretariat, http://www.kantei.go.jp/jp/singi/electricity_supply/20130426/taisaku.pdf (last access 30/7/2013).
[39] This estimate is also consistent with the ESCJ guidelines, p. 95, http://www.escj.or.jp/making_rule/guideline/data/rule_gaiyou20130227.pdf (last access 28/8/2013).
[40] Ibid.

The numbers for Japan's control spare capacities given above are likely to be an underestimation of these capacities, because the ASG project plans the use of renewables, of which some parts are intermittent. Therefore, the Japanese grid system will be required to have larger spare capacities in comparison with the current ones. The reaction speed of the importer response mechanisms described above represents the start-up times of the different control capacities and are estimated based on the Electric Power System Council of Japan's review of wind energy potential in Japan.[41]

In case of an emergency, demand can be reduced through demand-response programs and through additional measures. According to a 2012 experiment conducted by Japan's Ministry of Economy, Trade and Industry (METI), the reduction amounts for 6 – 8% of the peakload.[42] Here, this paper takes a conservative estimate and will assume a 6% demand reduction potential. As for Japan's east area peakload, the reduction potential (m_{red}) is assumed to be 4.5 GW.

In the case of energy extortion events, the precise timing is not known and for the purpose of this paper it is assumed that the demand reduction can take effect as fast as the primary control (0min) and can be maintained for as long as necessary. It is also assumed, that the demand reduction mechanism has no immediate cost. The response mechanism end its timing is summarized in Table 1.

Table 1

	Current East area capacity (% of peakload)	Model input time interval
Primary control	2.2 GW (3%)	0 – ∞
Secondary control	3.14 GW (4%)	10 min – ∞
Reduction of demand	4.5 GW (6%)	0 min – ∞

41 Electric Power System Counsel of Japan. 風力発電連携可能量確認ワーキンググループとりまとめ報告書, 2012.

42 Committee for Electricity Supply and Demand under the Cabinet Secretariat 2013.

3.4. Scenario Variations

The data above are built largely on assumptions which are justifiable and reasonable, but are still assumptions. The results should therefore be interpreted rather as indicative results which show a pattern in the balance of bargaining power. However, the main point of interest is how the balance changes when modifying key input data. Therefore, based on the data and assumptions above, the following variations are investigated (table 2):

Table 2 (scenario variations)

scenario	input data
A)	Russian imports (m_{exp}) are lower than 6.7 GW.
B)	Russian imports (m_{exp}) are 7 GW and the disruption lasts 10 hours.
C)	Russian imports (m_{exp}) are 7 GW and price of operating reserved capacities in Japan is doubled at 30 yen/kWh.
D)	Imports (m_{exp}) are 7 GW, but the power stations in Russia are owned and operated by non-Russians, and the electricity payments do not go to the exporter country's government. Russia receives royalties of 1 yen/kWh and the price paid by Japan is thus 8+1 yen/kWh (cost + royalty). Therefore, importer's p_{exp}= 9 yen/kWh, exporter's p_{exp}= 1 yen/kWh.

4. Results

In Scenario A), no blackout occurs, because Japan's spare capacities (2.2 GW) and instant demand reduction mechanism (4.5 GW) are able to absorb the sudden electricity cut as Russian imports do not exceed 6.7 GW. Japan's costs are therefore minimal and amount only for the slightly increased costs from the operation of the more expensive back-up capacity. The cost implications of demand reduction are not included, but are assumed to be negligible since the secondary control would able to cover the lost load in 10 minutes. Russia's costs are higher, as the exporter experiences lost profit from the undelivered electricity over time (loss of opportunity). The importer's sudden disruption is unable to compromise the importer's grid.

In this scenario, Russia is not able to sustain bargaining power over Japan and for that reason Scenario A) is not graphically displayed.

Scenario B) on the other hand allows the exporter to cause a blackout on the importer's part. Nevertheless, after initial blackout costs, Japan is very quickly (in 10 min) able to eliminate the blackout using its spare capacities. The subsequent costs are significantly lower and remain constant over time – as in Scenario A). Russia, the exporter, faces constant costs of the undelivered electricity. Japan's accumulated costs (in absolute numbers) 10 minutes after the disruption are significantly higher than Russia's (table 3). However, the Russian costs are growing faster and after 10 hours overtake the Japanese. As for the cost/GDP ratio, Russia's costs overtake the Japanese even faster and after 10 hours, Russian costs relative to GDP are nearly 3.7 times higher than Japanese (table 4). Neither this scenario offers the exporter any bargaining power. As Japan withstands the initial shock, it can easily wait the exporter out.

Table 3 (Scenario B)

Accumulated costs (¥millions) over time after disruption	10 minutes	1 hour	10 hours
Japan	39.9	74.3	445.8
Russia	18.7	56.0	560.0

Table 4 (Scenario B)

Accumulated costs (10^{-5} % of GDP) over time after disruption	10 minutes	1 hour	10 hours
Japan	0.67	1.24	7.49
Russia	0.93	2.78	27.81
Japan/Russia Ratio	0.72	0.44	0.27

In Scenario C), the situation is similar to the previous scenario. The first 10 minutes after the blackout are identical. Japan is able to deal with the blackout and continues to run its reserved capacities, but because the price of running the reserves is doubled, Japan faces slightly higher costs relative to GDP than in the previous scenario. After 10 minutes, Japan's costs relative to GDP are approximately 3/4 of the Russian costs, however, from that point on, the costs of both importer and exporter are comparable. Japan's cost/GDP remain only slightly lower (table 5).

This scenario demonstrates that the price for operating the reserve and spare capacities has a significant impact on the importer's costs. Russia, nevertheless, would not be in a position of power, since the countries' costs are nearly equal. Therefore, neither this scenario puts the energy weapon into Russia's hands.

Table 5 (Scenario C)

Accumulated costs (10^{-5} % of GDP) over time after disruption	10 minutes	1 hour	10 hours
Japan	0.67	2.64	26.67
Russia	0.92	2.78	27.81
Japan/Russia Ratio	0.72	0.95	0.96

Scenario D) hypothesises that Russia is not the main receiver of profit from electricity trade. Russia receives only a royalty and is in a very similar position to a transit country.[43] As a consequence, Russia's costs are significantly lower as its loss of opportunity is also lower compared with the previous scenarios. A disruption of the electricity flow would burden third party companies rather than the exporter. This scenario assumes that the power stations are neither owned, nor operated exclusively by Japanese companies, or that Russia's (exporter's) cost would probably include loss in tax revenues. Moreover, in this scenario the exporter's liability would be greater as it would be facing international arbitrations claiming damages from multiple third party subjects.[44] For these reasons, Scenario D) is very likely an underestimation of exporter costs.

In the first 10 minutes of the disruption event Japanese costs, although very low (0.00001% of GDP), are higher in comparison with Russian costs by a factor of 6.73. After one hour the ratio climbs down to 3.4 times Russia's costs relative to GDP. After 10 hours however, the ratio settles on 1.9 (table 6). This rather large discrepancy is due to the difference between the countries' costs during the Japanese blackout. The costs of the Japanese blackout alone however, are in absolute numbers lower than in Scenario B). Therefore, the large difference is solely caused by the very low costs on the Russian side. The subsequent costs/GDP of both exporter and importer are slowly drawing closer to each other and the ratio after 48 hours stops at 1.8 (Japan's costs/GDP are 1.8 times higher than that of Russia's).

In Scenario D) Russia is able to cause damage to Japan over a short period of time that is significantly higher than its own. However, whether this scenario constitutes Russia's bargaining power over Japan is not clear. Firstly, and most importantly, the possibility of putting pressure on Japan after the import cut is very limited, because of the small window in which it can be effectively realised. After 10 hours, Russia's costs are 1.9 times lower, which does not serve as powerful leverage. One way Russia could use the short term advantage would be to try to cause repeated disruptions within a certain span of time, but this approach counts with Japan's willingness to trust its trading partner right after it has been cheated on.

Secondly, it is important to bear in mind that all these scenarios work with relatively small interconnection capacity. The capacity considered in this scenario cannot seriously

[43] If this study included South Korea and other countries as proposed by the ASG, it would follow a slightly different formula, which includes transit costs, cp. Lilliestam and Ellenbeck 2011, p. 3383.

[44] As mentioned in subchapter 3.1., penalty payments for breaching a contract and other legal consequences are difficult to estimated, but since Russia is a member of WTO and is a party to several bilateral investment treaties. United Nations Conference on Trade and Development, *Full list of Bilateral Investment Agreements*, http://unctad.org/Sections/dite_pcbb/docs/bits_russia.pdf (last access 22/8/2013).

harm Japan economically. If the amount of electricity being traded were higher, the damage done to Japan in absolute numbers would be greater and the chances of Russia using the energy weapon would be very real. Although very unlikely under current conditions, this scenario provides a valuable example of potential risks, which will have to be hedged against in future energy security strategies. In connection with the previous ones, Scenario D) shows, that the more involved the exporter is in the trade, either by investments or direct profit shares, the lower is the rationale and general likelihood of her wilfully braking the deal.

Table 6 (Scenario D)

Accumulated costs (10^{-5} % of GDP) over time after disruption	10 minutes	1 hour	10 hours	24 hours	48 hours
Japan	0.66	1.17	6.60	15.04	29.53
Russia	0.12	0.35	3.48	8.35	16.69
Japan/Russia Ratio	5.73	3.36	1.90	1.80	1.77

5. Conclusion

Before proceeding with the paper's conclusion, the core assumptions of this study paper will be recapitulated.

<u>Basic assumptions</u>

As was established in chapter 2, trading electricity is not the same thing as trading oil and gas. Failed imports of oil and gas can be replaced more easily than failed electricity imports by buying supplies from other exporters. Electricity cannot be stored in large amounts over significant timescales. Moreover, any non-delivered amounts of electricity will be noticed missing immediately. The exporter suffers a greater loss, as the undelivered electricity cannot be effectively sold and rerouted to another importer. Both, the exporter and the importer face high costs. However, higher costs of a deliberate electricity disruption should be differentiated from the mere risk of such event. The risk depends on the bargaining power between countries. If the exporter country is able to sustain bargaining power over the importer, then the exporter is more likely to use (or threaten to use) the energy weapon to its advantage.

It can be concluded, that although the effects of the import disruption of electricity are greater, the risk itself is not higher than in the case of oil or gas import. In fact, it is possible that the risk may even be lower, as the loss of both exporter and importer would be high and instantaneous and both parties would try to avoid such loss.

For example it is often argued,[45] that Japan as an importer of electricity would be in a difficult position, because if Russia cut the electricity export, there would be no corresponding way of replacing the lost power, unlike the case whereby Russia cuts gas, because gas can be simply imported from other countries. While this argument's statements are essentially correct, they do not look at the big picture. As demonstrated in this paper, the questions of Russia's "energy weapon" have to be analysed both from the importer's and from the exporter's point of view. By using the energy weapon, Russia would suffer a loss equally high and in some cases even higher than Japan precisely because electricity cannot be stored and sold to other buyers.

Throughout this paper, the assumptions have always been conservative and have in effect overestimated importer costs. The numbers for Japan's control spare capacities given above are likely to be an underestimation of these capacities, because the ASG project plans the use of renewable energy of which some parts are intermittent. Therefore, the Japanese grid system would be required to have larger spare capacities in comparison with the current ones. Moreover, all scenarios assume that the disruption happens at peak times, which is when Japan is most vulnerable.

Also, this paper does not include the long-term costs of the exporter's reputation of an irresponsible state. Russia's long term costs of the Ukrainian gas crisis are clearly visible today as Europe lowers its energy imports from Russia. For these reasons Russia is likely to avoid any politically motivated disruptions in the future.[46] The costs of legal disputes and breach of contract penalties were also not included, which means another underestimation of exporter costs. Fundamentally, only worst-case scenarios were examined, let alone the fact that the Desertec-based model is the worst-case scenario itself.

[45] Yamamoto, Kozo 2012.
[46] Sokolov, Dmitry 2013.

Conclusion

The analysed scenarios suggest that even if the ASG were to have similar parameters as the Desertec project Japan is not in danger of being extorted through the use of energy as a weapon. Scenario A) is probably the closest one to reality, because it is unlikely, that Japan would import more than 2 or 3 GW from Sakhalin in the short run. And if Russian imports do not exceed 6.7 GW, there is very little room for political extortion, because of the lack of a blackout.

However, this paper took into account scenarios with larger imports to investigate situations that appear to pose more risks. No scenario above provides Russia with the ability to cause serious harm to Japan, for example in the form of uncontrolled rolling blackouts. The capacity assumed in this paper is not big enough and Japan's ability to quickly recover from blackouts prevents Russia from harming Japan economically (without harming itself economically).

The security risks posed by the ASG project's cross-border electricity trading between Japan and Russia therefore seem to be small. Japan is likely to be able to restore system operations following all hypothetical disruptions, as the amount of the imports from Russia is too low to exceed Japan's response capacities (mainly control and spare capacities, as well as demand reductions). The impacts on the Japanese economy are not significant and temporally highly limited.[47]

Minimising risks

There are important lessons that can be learned in order to minimise Japan's security risks in the ASG future. The obvious key to this lies in good relations with Japan's neighbours (exporters) and international institutions as well as in emergency strategies for both the impact of an energy weapon event and reduction of the likelihood that exporters use their exports for political extortion. Similarly to the case of Europe and the Desertec project there are three main priorities:

Firstly, there is a general rule that cannot be stressed enough – to diversify. By diversifying the exporter countries, Japan would reduce the potential bargaining power of each single country. This means that it would be beneficial for Japan to close cross-border

[47] cp. Lilliestham, Johan. Patt, Anthony, Energy security in scenarios for Europe's future electricity supply, SEFEP working paper, 2012, p. 6, http://www.sefep.eu/activities/publications-1/Lilliestam-%20Patt_SoS%20paper_SEFEP.pdf (last access 15/8/2013).

electricity trade deals both with Russia and Korea as well as with other countries that are included in the ASG project.

Secondly, strengthening the emergency response capability further reduces the leverage of the exporter, as the impacts of a potential disruption are reduced. But rather than increasing the often expensive control and spare capacities, or increasing demand response capabilities, the focus should be mainly on improving the buffer capacity of the Japanese national grid, to minimise the fluctuations in the whole system in order to spread the risks.

Lastly, as already mentioned in Scenario D), by increasing the exporter's dependence on the trade, the attractiveness of a politically motivated electricity cut significantly diminishes. Japan should encourage exporters (Russia) to invest in the renewable energy power stations and in the import/export transmission lines. Such capacities have very high capital costs and therefore they require constant trade to be economical.[48]

[48] cp. Lilliestham, and Patt 2012. p.12.

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