The Cost of Improving Gas Supply Security in the Baltic States

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January 2012

CWPE 1204 & EPRG 1203

EPRG WORKING PAPER

UNIVERSITY OF CAMBRIDGE

Electricity Policy Research Group

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EPRG Working Paper 1203

Cambridge Working Paper in Economics 1204

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Abstract

The Baltic States (Estonia, Latvia and Lithuania) are three amongst the smallest gas markets in Europe. They import all the gas they consume from Russia, with whom they have difficult political relationships. A disruption of their supply from Russia, whatever the cause, would have severe consequences as a large share of their peak winter consumption could not be replaced by alternative gas or other fuels. The three governments want to invest in improving gas supply security and the European Commission pushes in the same direction. But what should they do? We present an assessment of the cost of various national and regional options – dual-fuel for heat plants and CHPs; strategic gas storage; strategic LNG terminals – to increase gas supply security. The cost is calculated over thirty years for different scenarios of supply disruptions. Uncertainty in commodity prices and interest rates is taken into account through Monte Carlo simulations. We draw the policy conclusions, taking into account the regional political context.

Keywords natural gas; energy security; Baltic States; European Union

JEL Classification O13; P28; Q48

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Publication January, 2012

Financial Support Economic & Social Research Council, Towards a Sustainable Energy Economy (TSEC) programme.

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1. Context and background

The Baltic States (Estonia, Latvia and Lithuania) are small energy economies and gas markets with annual gas consumption for 2008 of 1 billion cubic meter (bcm) for Estonia, 1.7bcm for Latvia and 3.7bcm for Lithuania.[2] Altogether the Baltic States account for less than 1.5% of EU gas consumption. The three countries import all the gas they consume from a single source, Russia. Having difficult political relationships with that country[3] the Baltic States live with an acute sense of energy insecurity. Recently developed numerical indicators

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Most of the work was financed through a grant by the Economic and Social Research Council to EPRG, under the Towards a Sustainable Energy Economy (TSEC) programme. Additional financial help was received from the European Council on Foreign Relation for fieldwork performed in the spring of 2009. We benefited from comments and suggestions by an anonymous referee.

[2] Source: Eurostat (www.ec.europa.eu/eurostat). More recent figures show a significant decline in gas consumption in 2009 due to the economic crisis, which severely hit the Baltic States.

[3] In an analysis of the 27 EU member states' foreign policy attitude towards Russia (LEONARD & POPESCU, 2007) Estonia and Latvia were amongst the "Frosty Pragmatists" while Lithuania was one of the "New Cold Warriors". A similar ranking done by a Russian newspaper (IZVESTIA, 2008) characterised all three Baltic States as "Russophobes". According to a survey published in June 2011 (TRACEVSKIS, 2011), the Russian population perceives the Baltic States as three of the five most "unfriendly countries" in the world.

of gas supply security show the Baltic States to be amongst the least secure of EU member states (RAMBOLL, 2010; NOËL & FINDLATER, 2010).[4]

The purpose of this paper is to estimate the cost of policy measures to improve the Baltic States' gas supply security. We use the framework proposed by NOËL & FINDLATER (2010) where improving gas supply security means reducing the share of final contracted energy demand that could not be met if gas supply were disrupted during a peak consumption period. In other words, improving gas supply security means increasing the system's ability to either substitute alternative gas – imported or withdrawn from storage – for disrupted supplies, or switch the gas load to alternative primary or final energy sources, or a combination of both (NOËL & FINDLATER, 2010, p. 12).[5]

1.1. Plan of the paper

Section 2 presents the existing gas supply security policies in the Baltic States. Section 3 describes our scenarios of gas supply disruptions. Our methodology to calculate the cost of various policies is presented in section 4. The results of our cost calculations are presented in section 5. Policy implications are discussed in section 6, taking into account the regional political context and the European Union's policy initiatives.

[4] The Ramboll index of security of gas supply is obtained by weighting several parameters such as "capacity diversification"; "volume diversification"; "ratio of storage on household consumption"; "geopolitical risk" (Ramboll 2010, p. 7). It shows very low levels of security for Estonia and Lithuania and a much higher level for Latvia. Noël and Findlater's index is based on direct empirical evaluation, for the 13 most Russia-dependent countries in the EU, of the ability of the national energy system (including energy security policies and contractual arrangements) to meet final contracted energy demand when the flow of Russian gas is disrupted. It shows the three Baltic States as the most insecure countries of the panel (NOËL & FINDLATER, 2010, p. 26).

[5] For an extensive discussion of concepts of energy security see WINZER (2011).

2. Existing gas security policies

On average in 2008, 15% of electricity generation and 74% of district heating in the Baltic States was reliant on natural gas, with these two usages accounting for an average of 56% of all gas consumed.[6] All three countries have policies in place to mitigate the effects of a gas supply disruption on the supply of centrally generated heat; furthermore Lithuania secures part of its household gas consumption through a storage requirement.

Estonia mandates that all suppliers of gas-fired heat producing more than 500GWh per heating network per annum maintain oil stocks equivalent to three days worth of peak production (REPUBLIC OF ESTONIA, 2003). Only the plants serving the district heating networks of Tallinn are above the threshold, leaving thousands of households and businesses in smaller cities at risk of losing their supply of network distributed heat in case of gas supply disruption. Moreover, a gas supply disruption would also leave un-served the energy contracted by gas consumers in the industrial, commercial and residential sectors – more than 40% of total gas consumption.

Latvia's energy law states that in a crisis, energy (i.e. heat and electricity) suppliers may use fuel reserves as determined in their licence agreements (REPUBLIC OF LATVIA, 2005). However, it is uncertain that the licences actually include any dual-fuel obligation, though the CHP plants serving Riga do maintain storages of back-up petroleum products worth a few days' peak heat supply, apparently on a voluntary basis.[7] As in Estonia, about 40% of total

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[6] In Estonia, 61.7% of gas consumption produces 5% of electricity and 53% of heat. In Latvia, 65.2% of gas consumption produces 90% of heat and up to 20% of electricity. In Lithuania, 41.4% of gas consumption was producing 80% of heat and up to 19% of electricity before the closure of the Ignalina nuclear power plant; however, with a new 450MW gas-fired combined cycle gas turbine (CCGT) being built (see EBRD, 2010), the share of gas in electricity production will rise.

[7] Source: series of interviews with Latvian energy industry executives, April 2009 (in person) and November 2009 (by phone).

gas consumption is accounted for by the industrial, commercial and residential sectors; this energy would be left mostly or entirely un-served in case of total gas supply disruption.

Lithuania mandates that all suppliers of heat and electricity store one month's worth of alternative fuels (REPUBLIC OF LITHUANIA, 2007).[8] In addition, Lithuania also secures household gas consumption by mandating that gas suppliers keep volumes in the Latvian underground storage facility at Inčukalns. Suppliers must store at least 10 days worth of household consumption beginning 1st September 2008, rising by 10 days each year until a 60 day level is reached (REPUBLIC OF LITHUANIA, 2008). The capacity of the pipeline connection between Lithuania and Latvia is just sufficient to supply the peak daily household natural gas consumption. However, more than 60% of total gas consumption seems to be left uninsured and the corresponding contracted energy could not be served in case of total gas supply disruption.

3. Gas supply disruption scenarios

3.1. Four disruption scenarios

The cost of various gas supply security measures will be calculated under four scenarios of total gas supply disruption:

- One peak consumption period of 15 days over 30 years;
- One peak consumption period of 1 month over 30 years;
- One peak consumption period of 3 months over 30 years;
- One peak consumption period of 6 months over 30 years.

[8] The obligation is stated in Article 24 paragraph 5 of the Law. The English version of the text wrongly mentions a "one year" stock instead of one month.

A peak period of 15 days is calculated as 15 days of average January gas consumption. None of the three Baltic States publish daily or weekly gas consumption figures and only Estonia publishes monthly consumption data. The January gas consumption in Latvia and Lithuania was estimated by applying the Estonian monthly distribution to their annual gas consumption. A one-month peak period is considered to be the January gas consumption. Three-month and six-month peak periods represent the gas consumption of the three and six months of highest demand, respectively.

These scenarios reflect the risk of infrastructure breakdown – technical failure of a pipeline or storage facility – as well as *relationship breakdown* – a political or contractual dispute with Gazprom or the Russian government leading to a disruption of gas supplies.

3.2. Infrastructure breakdown

The technical risks have been analysed in detail by S. Findlater and P. Noël (FINDLATER & NOËL, 2010) and the following is based on their work.

Latvia and Estonia receive gas directly from Russia from April to September and rely entirely on gas withdrawn from the Latvian storage facility at Inčukalns, from October until March. Accordingly, the technical risks for both Estonia and Latvia are a pipeline failure during the summer months and a failure of the Latvian storage facility during the winter months.[9] Such a winter disruption is likely be total or near-total, as the gas situation is very tight in North-West Russia in peak winter months (MÄE, 2007[10]), and there is little possibility

[9] Although storage facility failures are uncommon, they are not unknown. The Rough storage facility in the UK failed in 2006 and was out of operation for several months. On storage facility failure rates, see UK HEALTH AND SAFETY EXECUTIVE (2008).
[10] This was confirmed to the authors by interviews with Estonian energy company executives and energy policy officials.

to re-route volumes through Lithuania due to limited pipeline capacity between Lithuania and Latvia (only 5mcm/day).[11]

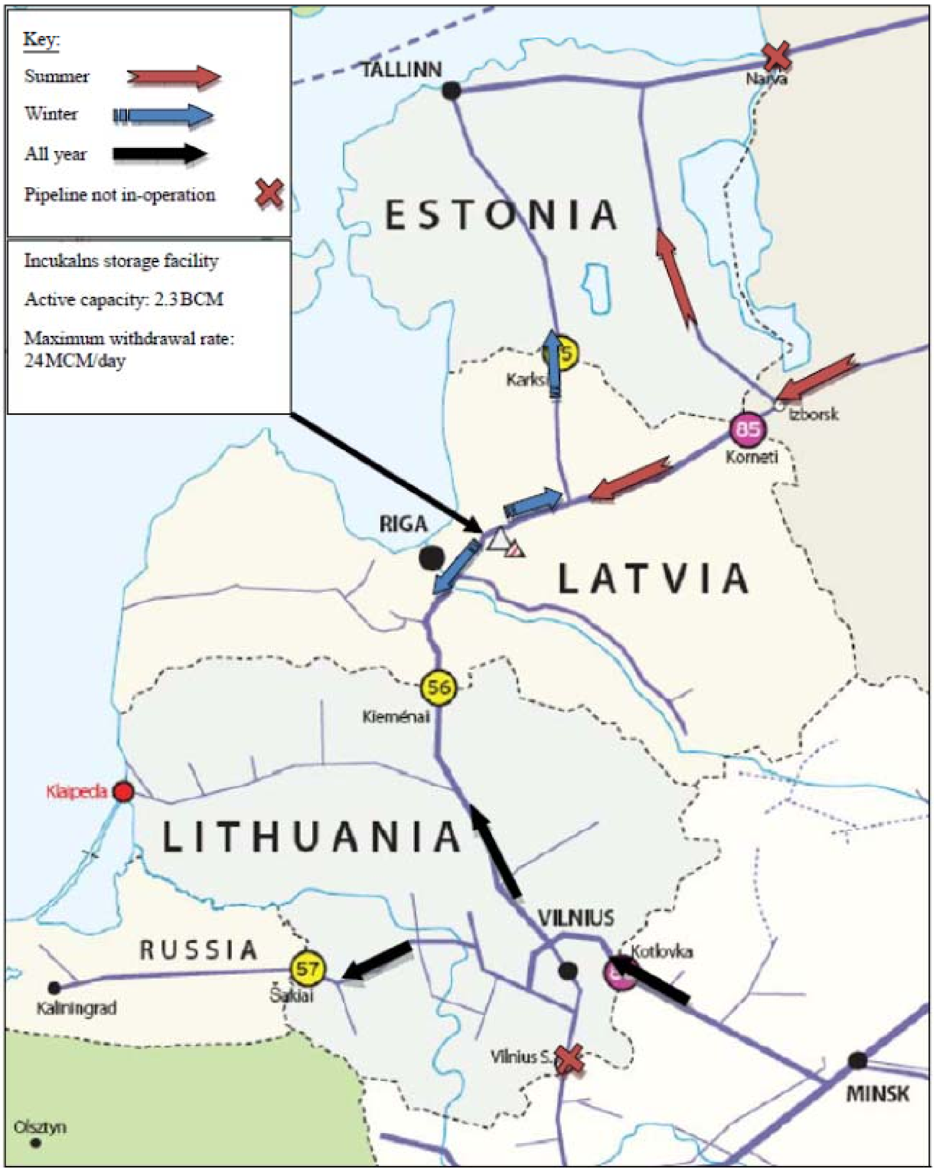

Figure 1 Baltic gas pipeline network

Source: Reproduced from FINDLATER & NOEL (2010, p. 240), based on Gas Transmission Europe and authors' fieldwork.

[11] This could change in the next few years as the Lithuanian and Latvian vertically integrated gas companies, who own and operate the transmission networks, have announced a plan to reinforce the pipeline with financial support from the EU (see DELFI.lt, 2010).

Two weeks is considered the maximum time needed to replace a failed compressor station on a transmission pipeline;[12] most disruptions caused by pipeline failures could be repaired in a week or less. A failure of the Latvian underground storage could potentially disrupt supply to Estonia and Latvia for the entire six months during which they rely on the Inčukalns facility. Although we consider as very unlikely that Gazprom would remain technically incapable of supplying the two Baltic States with alternative gas for more than three winter months, especially after the completion of the Gryazovets-Vyborg pipeline,[13] the worst-case scenario is a six month disruption.

Lithuania receives gas from Russia via Belarus throughout the year and has no storage facility. The country is supplied through one single pipeline.[14] The failure of this pipeline would result in a disruption that may not be total as up to 5mcm/d (out of a peak consumption of about 18mcm/d) could be sourced from gas stored in Latvia by Lithuanian suppliers according to the law.[15] If one discounts the availability of gas stored in Latvia at peak consumption times, the worst case technical risk for Lithuania is for a total gas supply disruption of about 15 days in peak winter conditions.

In summary, the disruption scenarios justified by the risk of infrastructure breakdown are:

- For Estonia and Latvia: peak period total disruptions of up to 6 months;
- For Lithuania: peak period total disruption of up to 15 days.

[12] Source: authors' conversations with pipeline operators in Western Europe.

[13] Gryazovets-Vyborg is the onshore section of the Nord Stream project, scheduled to be operational late in 2011 and which should alleviate the capacity constraints in north-west Russia. Until December 2009 Gazprom's website (Gazprom.ru) quoted 3bcm per year of additional capacity to north-west Russia but this information is no longer available.

[14] Although there is another pipeline to the south, it has not been used or maintained for many years and cannot be relied upon to compensate for a disruption of the main line.

[15] Cf *supra*.

3.3. Relationship breakdown

Infrastructure breakdowns lead to *unintentional* supply disruptions, while disruptions rooted in contractual or political disputes – relationship breakdowns – are *intentional*.[16] Edward Christie (CHRISTIE, 2010, p. 3), using language from the French national security strategy, describes intentional disruptions as "threats" and non-intentional ones as "risks". This is an important distinction. Intentional disruptions, even if based on contractual disputes as opposed to directly political ones, amount to foreign policy crises. Unlike infrastructure breakdowns, they are politically charged. They evoke realities of war – aggression, resistance, submission or survival. The Baltic States, in a situation of asymmetric gas dependence[17] with a less than friendly neighbour, might want to insure against "threats" as well as "risks".

However it is important to note that both types of disruptions have the same practical consequences. For example in the Baltic States, an accidental pipeline explosion or compressor failure would interrupt gas supply to district heating plants, just as a voluntary interruption of exports by Gazprom would. Therefore policies needed to cope with infrastructure breakdowns would also address the risk (real or perceived) of Russia using its 'energy weapon'. Ensuring that the country can cope with long-lived gas supply disruptions does address the 'threat' of intentional disruptions without compromising foreign policy.[18] A national energy system that can cope with unintentional disruptions can also cope with intentional ones – the threat of supply disruptions, implicit or explicit, is no longer credible.

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[16] The case of the disrupted Druzhba oil pipeline into Lithuania, which looks like a refusal to mend a technical failure, shows that it is not always easy to say whether a disruption is intentional or not. Nevertheless, the distinction is valid and important.

[17] The asymmetry is more pronounced for Estonia and Latvia than Lithuania, which is a transit country for gas bound for the Russian Baltic enclave of Kaliningrad (see map).

[18] Looking at it the other way round, one could perceive gas supply dependence as a moderating force on the Baltic States' foreign policy attitude towards Russia. However, because the European Union is not in a position to impose a meaningful cost on Russia in case of misbehaviour in its energy relationship with the Baltic States (BERZINS, 2011) the moderating influence works only one way.

The difference is that, unlike disruptions linked to infrastructure breakdowns, intentional disruptions can in principle be of any length. We have chosen to include scenarios of supply disruptions of up to six months to cover the risk of relationship breakdown. For Estonia and Latvia addressing the risk of infrastructure breakdown also addresses the threat of intentional disruptions, but not for Lithuania, for which scenarios of total disruptions of 1 month, 3 months and 6 months are specifically dedicated to addressing the risk of a relationship breakdown – that is, of intentional supply disruptions.

Table 1. Supply disruption scenarios and nature of disruption risk covered

	Estonia	**Latvia**	**Lithuania**
15 day peak period	infrastructre or relationship breakdown	infrastructre or relationship breakdown	infrastructre or relationship breakdown
1 month peak period	infrastructre or relationship breakdown	infrastructre or relationship breakdown	*relationship breakdown only*
3 month peak period	infrastructre or relationship breakdown	infrastructre or relationship breakdown	*relationship breakdown only*
6 month peak period	infrastructre or relationship breakdown	infrastructre or relationship breakdown	*relationship breakdown only*

4. Calculating the cost of gas security policy measures

4.1. The three policy options

Meeting contracted final energy demand during a gas supply disruption can be done by switching fuels – for instance power plants with dual-fuel capability and industrial users who have signed interruptible supply contracts – or bringing alternative gas supplies into the system – volumes withdrawn from a storage facility or sourced from alternative pipelines or liquefied natural gas (LNG) regasification terminals.

Amongst the policy options available to increase gas supply security, we concentrate on the following three:

- Back-up fuel for gas-fired district heating plants;
- Strategic gas storage facilities;
- Strategic LNG regasification terminals.

The first is a load-reducing measure while the other two would give the Baltic States access to alternative gas in case of supply disruption. Fuel-switching for centrally generated heat provides *partial* gas supply security – insuring only that part of gas consumption which is made switchable – while measures that give access to alternative gas supplies can provide *full* security – if they are properly dimensioned they can insure 100% of the peak gas consumption.

We assume that infrastructure investments, if carried out, would be dimensioned for full security (ensuring the entire national gas consumption). The economically optimal level of gas supply security, which we do not calculate, is probably below full security – the efficient level of gas supply *insecurity* is almost certainly above zero.[19] However we do not prejudge governments' preferred level of risk and will also analyse policy strategies based on partial security measures only (i.e. back-up fuels for heat generation).

4.2. Financial variables

We look at gas supply security policy in a 'central planning' context, whereby national authorities would decide to increase the level of collective insurance against gas supply disruptions, either voluntarily or because they were forced to do so by EU legislation.[20] Therefore, gas security measures, including those based on new infrastructure build, are treated as 'pure' security investments, not commercial ones. Like armed forces, they provide security to the country but are not supposed to generate any revenue.[21] Accordingly, they would be financed 100% by government-guaranteed debt. Therefore we use the coupon value of ten year government bonds plus a country risk premium[22] as the cost of capital for gas supply security investments. We use this same rate as the opportunity cost of working capital for stored gas or oil products as well as discount rate to calculate the present value of operating expenses. For regional investments (pan-Baltic strategic gas storage or LNG

[19] Calculating the optimal level of gas supply security would imply evaluating the economic agents' willingness to pay for security (see DAMIGOS *et al*, 2009, for an example of that) or estimating a marginal damage function of gas supply disruptions (as illustrated by HIRSCHHAUSEN *et al*, 2008, p. 19). It would also imply attaching probabilities to various types of disruptions. On the economics of gas supply security, see HOUGH (2005); on the economics of energy security in general see TOMAN & BOHI (1996).

[20] It is unclear whether the new EU Regulation on gas supply security (EUROPEAN COMMISSION, 2010) will force any of the Baltic States to invest in additional security of supply measures; there is considerable uncertainty as to the methodologies that will be employed to assess whether a country meets the Regulation's two "standards". On the EU Regulation, see: NOEL & FINDLATER (2009) and NOEL (2010); on its likely implications for the Baltic States, see FINDLATER & NOEL (2010), p. 15-16.

[21] Some of them, especially LNG terminals, may have indirect economic benefits as they improve the negotiating position of the country when it has to re-negotiate its import contract with Gazprom. We do not take these benefits into account.

[22] The bond value data is obtained from Bloomberg. For the country risk premium we use the figures compiled by Aswath Damodaran from the Stern Business School at New York University: http://pages.stern.nyu.edu/~adamodar/ (last visited 28 July 2011).

terminal) we calculate a weighted average of these rates for the three countries as the cost of capital.

In order to account for the fluctuation in oil and gas prices, currency exchange rates and the cost of capital, we have performed Monte Carlo simulations re-sampling historical variables; for each policy measure in each country we will present the cost figures corresponding to the average probability, as well as 10^{th} and 90^{th} percentiles.

We calculate the cost of providing security of gas supply over a period of 30 years. However we depreciate infrastructure investments over 20 years.

4.3. Back-up fuel for district heating plants

This measure consists in mandating that gas-fired generation equipment – usually, in the Baltic States, combined heat and power plants (CHPs) – feeding district heating systems can run on liquid fuels in the event of a gas supply disruption. As already noted, centrally-distributed heat is highly reliant on natural gas in the Baltic States and all three of them have such back-up fuel obligations in place, to different degrees (very modest in Estonia and Latvia, much more ambitious in Lithuania). Based on 2008 figures, backing-up all heat generation plants (including combined heat and power plants, CHPs) could insure as much as 45% of peak daily gas consumption in Estonia and 43% in Latvia and Lithuania. In volume terms, it represents 3.6mcm/day of gas in Estonia, 6.0mcm/day in Latvia and 10.4mcm/day in Lithuania.

Table 2 summarises how we calculated the cost of the back-up fuel policy and shows which input variables were used in the simulations. Two components of the cost deserve particular comment: the fuel cost and the cost of the working capital employed to finance the permanent storage of oil products.

Oil products are generally more expensive than natural gas. However, heavy fuel oil (HFO) is much more polluting and much cheaper – about half the price – than light fuel oil (LFO),[23] creating a trade-off between the cost and environmental impact of the gas supply security policy, especially in a context where many of the larger district heating plants are located within densely populated areas.[24] This trade-off is for each government to arbitrate, within the constraints of existing EU legislation. We have calculated the cost of the policy with both HFO and LFO as back-up fuel.

The cost of the working capital in oil product storage is a key component of the total cost of a back-up fuel policy. Filling a 10,000 tonne tank[25] could cost between 10 and 15 million euros; 10 million euros worth of oil stored for 30 years at an opportunity cost of capital of 8%[26] equates to over 90 million euros. This cost can be contained by limiting the mandatory number of day's storage, which makes sense as there is no reason to assume that access to the oil product market would be hindered during a gas supply emergency. However supplying power plants with liquid fuels raises serious logistical issues. If all of Estonia's gas fired district heating converted to oil at the same time, the average daily volume of fuel to be transported amount to around 220 oil trucks.[27] Very low temperatures and heavy snow fall could complicate the matter further, especially as the three Baltic States have, beyond large plants in big cities, hundreds of small and distributed boiler houses. Therefore there is clearly a trade-off between the number of day's storage mandated (hence the cost of the policy) and

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[23] LFO can replace natural gas in boilers and turbines alike while the latter cannot run on HFO.

[24] For this reason, Estonian law restricts the burning of heavy fuel oil by the main district heating company to 10 days.

[25] A 10,000 tonne storage tank was cited by industry experts as a standard size for a large generator with dual fuel capability.

[26] In Estonia, the regulatory agency allows generators to include in their costs, for regulatory purposes, a remuneration of working capital for back-up fuel storage of 8%. Source: authors' interview with Estonian Competition Authority (Konkurentsamiet).

[27] Based on an energy amount of 123TJ to replace natural gas fired heat in one day, an oil truck capable of carrying 14,300Kg, a calorific value of light fuel oil of 38.68GJ/1.0017m^3 and a density of 980 Kg/m^3:

the exposure to oil logistics risks in case of a gas supply disruption.[28] This is why we calculated the cost of the back-up fuel policy under four cases, with mandated on-site storage of 3 day's worth of peak generation, 7 days, 15 days and 30 days, respectively.

Table 2. Cost calculations – Back-up fuel for district heating plants

HEAT GENERATION AND FUEL INPUT		
Heat demand for one "peak" day (TJ)	[1]	Peak month (January) heat consumption in TJ divided by 31 (see text for details).
Duration of disruption ("peak" days)	[2]	15 days, 1 month, 3 months or 6 months, according to scenarios
Heat demand for length of disruption (TJ)	[3]	= [1] * [2]
Back-up fuel storage obligation (in day's worth of peak heat generation)	[4]	3, 7, 15 or 30 days, according to cases
Efficiency of the system	[5]	Calculated as [heat energy out]/[energy value of gas in]. Raw data obtained from Estonian National Statistics and applied to all three countries. Note that for boilers and turbines there is a 1% difference in efficiency betweeen running on gas or oil, which we have chosen to ignore
Fuel input required for heat generation in a "peak" day (TJ)	[6]	= [1] / [5]
Fuel input required for heat generation over disruption length (TJ)	[7]	= [3] / [5]
DURATION OF POLICY		
No. of years measure is in place (years)	[8]	30 years
PRICES AND COST		
Cost of capital	[9]	**Simulation variable** - resampling of historic government bond rates and country risk premiums (see text for details)
Capital costs - turbine retrofitting and storage tank (€)	[10]	Quoted by a leading original equipment manufacturer. (Depreciation to zero over 20 years)
Turbine maintenance costs (€ / EOH)	[11]	Quoted by a CCGT operator with dual fuel capability. For maintenance purposes every hour running on oil is 1.5 equivalent operating hours (EOH).
Price of oil products (light fuel oil or heavy fuel oil, depending on cases) in €/TJ	[12]	**Simulation variable** - resampling of historic industrial light fuel oil prices. Data obtained from national energy regulatory agencies and Enerdata
Price of natural gas (€/TJ)	[13]	**Simulation variable** - resampling of historic industrial natural gas prices. Data obtained from national energy regulatory agencies and Enerdata
Net cost of oil products (LFO or HFO) for duration of disruption (€)	[14]	= [7] * [12] - [7] * [13]
Cost of working capital for oil storage over 30 years (€)	[15]	= ([4] * [6] * [12]) * (1+ [9] ^ [8]) - ([4] * [12])
Additional maintenance costs from running on oil for the duration of the disruption (assuming a 100% load factor during the entire disruption period)	[16]	= 24 hours * [2] * 0.5 * [11]
TOTAL COST OF POLICY		
Total cost of back-up fuel obligation with one disruption over 30 year period (€)	[17]	= [10] + [14] + [15] + [16]

[28] In Finland, where heat generators have a back-up fuel obligation, biennial gas supply emergency drills are organised that include exercises in oil product logistics. In Singapore, where all CCGTs have back-up fuel obligations, generators typically have a dedicated oil product pipeline to an oil refinery or depot, which is made easy by the geographical concentration of the oil processing and electricity generation industry. Source: authors' phone interviews with energy industry and energy regulatory agency representatives in Finland and Singapore.

4.4. Strategic gas storage

A strategic underground natural gas storage facility (UGS) is meant to be used only in the event of a gas supply emergency – it is a security-only storage, as opposed to a commercial one.[29] The only strategic gas storage in Europe is in Hungary (REUTERS, 2009), though several facilities in other countries are partly operated as security-only storage.

There are three distinct types of UGS facility; salt caverns, aquifers and depleted gas fields. Salt caverns have much higher withdrawal and injection rates than aquifers or depleted fields but tend to have a much lower capacity, making them unfit for strategic storage purposes (EVANS & CHADWICK, 2009). As no depleted fields are available in the Baltic States we only calculate the cost of aquifer based UGS.

Among the three Baltic States only Latvia has suitable geological structures.[30] The existing UGS facility (at Inčukalns) is aquifer based and many other structures are suitable candidates (DAVIS *et al*, 2006). Any strategic storage facilities for Lithuania and Estonia would have to be physically located in Latvia; in the case of Lithuania we include the cost of a pipeline to Latvia[31] (see Table 4). We will also calculate the cost of a single facility for the three countries (pan-Baltic strategic gas storage), located in Latvia.

The working volume has to be sufficient to meet total demand for the duration of the relevant disruption scenario. The withdrawal rate has to cover total peak gas consumption. To determine the size of a regional Baltic strategic UGS facility (or strategic LNG terminal, see

[29] Commercial storage facilities provide supply security benefits only if the rate of withdrawal can be increased when other supply is disrupted. A seasonal storage facility operating at or near maximum withdrawal rates in peak demand conditions has little security value. It is possible to operate the same facility as part-commercial and part-strategic, unless the risk one wants to insure against is the failure of that facility itself.

[30] For an aquifer storage facility, proving containment is a key issue and a sufficiently impermeable and dome-shaped cap rock is needed (EVANS, 2009). Lithuania has already explored one site only to find that it is unsuitable and is now carrying out a second feasibility study into another site which will not be completed until 2012.

[31] It has proved impossible to evaluate the possibility and cost of upgrading the small existing one to the capacity required to transport the country's entire peak gas consumption. In the case of Estonia the existing pipeline to Latvia would be empty (by definition) in case of a winter gas supply disruption as all the gas flows from Latvia anyway.

infra) it is necessary to make a judgement on the correlation of risks faced by the three countries. Estonia and Latvia face highly correlated risks as they both rely on the Inčukalns storage for six months of the year. However, the risks to Lithuania's gas supply linked to infrastructure breakdowns are not correlated to Estonia's and Latvia's. On the other hand, a relationship breakdown (see the section on gas supply disruption above) could have a regional dimension, especially if directly linked to a political issue with Russia. If one discounts the latter possibility, the Baltic strategic UGS (or LNG terminal) only needs to be able to cover the combined peak consumption of Estonia and Latvia, which is higher than the peal consumption for Lithuania. If one does not discount the possibility of a regional disruption then a regional Baltic strategic UGS (or LNG terminal) must be able to meet the combined peak consumption of all three countries.

We assigned a probability with uniform distribution (between 0 and 1) of having simultaneous disruptions. In other words, the expected peak gas consumption that the strategic UGS (or LNG terminal) should be able to meet is an average of the peak consumption of all three Baltic countries and the peak consumption of only Estonia and Latvia.

The summary cost calculations are shown in Table 3. The main costs components are[32]: capital cost (working volume times typical unit construction cost); the cost of financing the investment; and the opportunity cost of storing the gas over the facility lifetime. Uncertainty is taken into account by treating the cost of capital (see the section on financial variables above) and the price of gas as simulation variables.

[32] We do not include any exploration costs which could reach anywhere between 10% and 20% of the total final costs of the facility (WALLNER, 2003).

Table 3. Cost calculations: strategic gas storage

Active working volume required [cm]	[1]	The volume of gas consumed during the peak period of the year, based on average Baltic gas consumption patterns. Raw data obtained from Eurostat.
Facility construction cost [€/CM of working volume]	[2]	The cost of facility construction was given as 0.7€ / mc of working volume by a European UGS facility company. This value is a heuristic for the cost of constructing the facility as well as the cost of the gas within it.
Operational costs [% of capital investment]	[3]	This figure was given as 3% and was obtained from a European UGS facility company.
Facility lifetime [years]	[4]	The lifetime of infrastructure projects has been taken as 30 years.
Cost of capital [%]	[5]	Simulation variable - resampling of historic government bond rates plus a resampling of historical country risk premiums where the country risk premium is calculated using the methodology developed by Aswath Damodaran at the Stern Business School and Moody's long term ratings.
Loan repayment period [years]	[6]	Twenty years was cited by the European Bank for Reconstruction and Development as a typical loan repayment period for large infrastructure investments such as UGS facilities.
Price of gas [€/CM]	[7]	Simulation variable - resampling of historic industrial gas prices.
Duration of disruption [days]	[8]	15 days, 1 month, 3 months or 6 months, according to scenarios
Facility investment [i.e. Capital cost] [€]	[9]	= [1] * [2]
Financing costs [€]	[10]	= (([9] - (2 * [1] * [7]) * [6] * 0.5 * [5]) + (([9] - (2 * [1] * [7]) * 0.5 * [5])
Operational costs over 30 year lifetime [€]	[11]	= [4] * [3] * [9]
Opportunity cost of storing the gas [€]	[12]	= (2 * [1] * [7]) * (1 + [5]) ^ [4] - (2 * [1] * [7])
Total cost [€]	[13]	= [9] + [10] + [11] + [12]

Table 4. Cost calculations: pipelines

Pipeline cost [€/km]	[1]	**Simualtion variable** - resampling of historical price data obtained from a major European transmission system operator. Pipeline costs vary significantly depending on land topography whether or not the pipeline passes through an urban area.
Compressor capital cost [€]	[2]	Information obtained from a major Transmission System Operator.
Annual compressor running costs [€]	[3]	Information obtained from a major Transmission System Operator.
Distance between compressors [km]	[4]	A major Transmission System Operator estimate that approximately 1 compressor should be placed in a line every 80 km.
Annual pipeline maintenance costs [€/km]	[5]	Information obtained from a major Transmission System Operator
Pipeline length [km]	[6]	Approximate distance between the Latvian and Lithuanian transmission networks
Cost of capital	[7]	**Simulation variable** - resampling of historic government bond rates plus a resampling of historical country risk premiums where the country risk premium is calculated using the methodology developed by Aswath Damodaran at the Stern Business School and Moody's long term ratings.
Operational lifetime of pipeline [compressors]	[8]	30 [25] years
Loan repayment period	[9]	Twenty years was cited by the European Bank for Reconstruction and Development as a typical loan repayment period for large infrastructure investments.
Cost of pipeline [€]	[10]	= [1] * [6]
Number of compressors needed	[11]	= Round ([6] / [4])
Cost of compressors [€]	[12]	= [11] * [2]
Running costs [€]	[13]	= [8] * [6] * [5] Note that the running costs of the compressor stations have been excluded as these will only run when the pipeline is in use.
Financing costs [€]	[14]	= ([10] + [12]) * [9] * [7] * 0.5 + ([10] + [12]) * [7] * 0.5
Total cost [€]	[15]	= [14] + [13] + [12] + [10]

4.5. Liquefied natural gas (LNG) regasification terminals

There are no examples (known to us) of security-only LNG terminals[33] in the world. The key differences with a commercial terminal is that the facility generates no revenue and must have gas permanently stored in order to provide, with certainty, security from the very first moments of a (total) supply disruption. For disruptions beyond a few days, an LNG terminal would give the Baltic States access to the global market for spot LNG cargoes. We estimated the cost of LNG terminals based on numerous interviews with industry experts in LNG technology companies, engineering and economic consultancies, and terminal operators across Europe as well as the technical and trade literature. We only considered standard regasification terminals as the ship-based regasification technology cannot be relied upon as an insurance against unplanned supply disruptions.[34]

We derive the total capital expenditures from the terminal's storage volume, using the industry rule of thumb that storage tanks represent a third of total cost.[35] A large LNG storage tank costs about €450/m^3 but there are economies of scale – larger tanks are cheaper to build, per unit volume, than smaller ones – and economies of scope – building several tanks is cheaper, per unit volume, than building one. For economies of scale we derived the equation

[33] An LNG regasification terminal receives and regasifies liquefied natural gas brought to the facility by ship, loading it either into storage for later use or sending it straight to the gas transportation network for immediate use.

[34] In discussions of Baltic (and even European) gas security policy, ship-based LNG regasification – a technology, commercialised by Excelarate Energy, whereby LNG is regasified as it leaves the carrier and injected directly into the transmission system, either offshore or onshore – is often mentioned. As the capital expenditures are much lower than for a conventional LNG terminal, the ship-based technology is said to be especially attractive to small gas markets such as the Baltic countries or Finland. However, we found that this was not the case. Because it implies immediate injection into the transmission system, ship-based regasification is suited to large and liquid gas markets such as the United States or Great Britain where the facility offers a low-cost option to bring volumes when the spot price is attractive. Two of the five existing facilities worldwide are in the US and one is the UK (see www.excelerateenergy.com/marketaccess.html, last accessed 19 August 2011). Moreover, as the fleet of regasification vessels is very limited, the technology allows delivering volumes on a seasonal baseload mode in chronically short markets such as Argentina and Kuwait – in those cases, the regasification ship is docked for the entire period of injection and is refilled by the transfer of LNG from normal carriers using another Excelerate proprietary technology – but is no solution to unplanned losses of contracted volumes.

[35] Some industry sources mentioned up to 50% but we retained a third as more consistent with the cost of various LNG projects we could access.

from a graph published by Tokyo Gas;[36] economies of scope were calculated from figures provided by European utilities on actual terminal projects.

It takes about two and a half days to bring a cargo from Zeebrugge or Rotterdam to the East Baltic coast[37] and 2 to 3 days to structure the transaction on the spot market. Accordingly, a terminal built for security of supply purposes in the Baltic States must have at least 5 days worth of peak gas consumption permanently stored in its tanks; we choose 7 days to account for the uncertainties in transacting and shipping.[38] For Estonia, Latvia and Lithuania it amounts to 56mcm, 94mcm and 168mcm of gas respectively,[39] which corresponds to LNG volumes of 93,000, 163,000, and 280,000 cubic meters.[40] We include in our calculations the opportunity cost of the working capital tied up in LNG storage tanks.

The annual operational expenditures are calculated as 4% of capital expenditures over the lifetime of the infrastructure, using an industry rule of thumb. We discount operational expenditures at the rate described in the previous paragraphs.

The cost at which LNG would be brought to the Baltic States during a crisis is considered to be the spot LNG price in north-western Europe plus a premium of $1 per million BTU to redirect the cargo.[41] Given the small share of residential consumption in all three countries we use the industrial gas prices as final prices.[42]

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[36] See http://www.tokyo-gas.co.jp/lngtech/ug-tank/index.html (last accessed 19 August 2011).

[37] http://distances.com – calculates the time for LNG ships to travel between ports using a speed of 19 knots which was cited by industry experts as the speed at which LNG ships travel.

[38] To reduce the uncertainty regarding access to the spot market it is possible to sign optional contracts with LNG suppliers or traders, which would carry a cost to be weighed against the additional security and, possibly, marginally reduced volumes stored permanently at the terminal. It is also possible to reduce the amount of gas stored during the summer months when peak consumption is a fraction of what it is in winter, significantly reducing the financial cost of storage over the lifetime of the terminal but increasing the logistical and transaction costs.

[39] The peak gas consumption in 2008 was 8mcm/day in Estonia, 14mcm/day in Latvia and 24mcm/day in Lithuania.

[40] 1m^3 of LNG expands into 600m^3 of natural gas.

[41] Premium obtained from interviews with LNG traders in London.

[42] To simplify calculations we consider that final gas prices would not increase during a crisis, the gas company being compensated *ex post* for the difference between the usual contract import price and the spot import price during the crisis. Spot LNG prices are considered to be uncorrelated with the price of Russian gas in the Baltic States.

Simulations are performed using three variables: the cost of capital; the spot price of LNG; and the import price for Russian gas.

We calculate the cost of a regional, pan-Baltic strategic LNG terminal for the three Baltic States. It is sized according to the same rule used for the regional strategic gas storage. We include the cost of a pipeline between the regional terminal, which we assume would be located in Latvia, and the Lithuanian transmission system, using the calculations summarised in Table 4.

Table 5 summarises the cost calculations for security-only LNG terminals. Once a terminal is built it may have benefits beyond security of supply: it would increase the importer's bargaining power with the Russian gas monopoly; it would also allow the Baltic States to arbitrage between Russian gas and LNG to some extent – when prices are low on the global LNG spot market, gas could be purchased there and the volume taken on contracted gas flows from Russia reduced to a minimum.[43] Our calculations do not take these potential benefits into account. Finally, we have not tried to estimate the cost associated to siting the terminal, including the legal and other transaction costs linked to dealing with local interests.

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[43] On the arbitrage between spot purchases and long-term contract nominations by continental European gas importers, see STERN & ROGERS (2011).

Table 5. Cost calculations: security-only LNG terminals

Duration of disruption	[1]	15 days, 1 month, 3 months or 6 months, according to scenarios
Volume of gas required during disruption [mcm]	[2]	The volume of gas consumed during the peak period of the year, based on average Baltic gas consumption patterns. Raw data obtained from Eurostat.
Cost of capital	[3]	**Simulation variable** - resampling of historical government bond yields plus risk premiums. Risk premiums are calculated using the methodology developed by Aswath Damodaran at the Stern Business School and Moody's long term ratings.
Operational costs [% of capital investment]	[4]	This figure was obtained from multiple experts in the LNG industry.
LNG ship day charter rate [€/day]	[5]	We use the figure for a 138TCM ship during the gas crisis of January 2009.
Journey time [days]	[6]	It is assumed that while the first cargo in an emergency situation could be attracted away from Zeebrugge, subsequent cargos may be arranged from source. The journey time given here is for Arzew port in Algeria to the Baltic Coast.
Daily transit volume boil off [%]	[7]	Information obtained from LNG industry experts.
mcm per 125tcm vessel [once regasified]	[8]	The volume of LNG is approximately 600 times less than that of gaseous natural gas. Source: http://www.ch-iv.com/links/lng_information.html
Regasification losses [%]	[9]	Information obtained from LNG industry experts.
Price of LNG [€/mcm]	[10]	**Simulation variable** - resampling of historic LNG prices in France plus $1 per MBTU to account for diversion of cargos from their original destination [$1 was the figure given by experts within the LNG trading industry].
Price of Russian gas [€/mcm]	[11]	**Simulation variable** - resampling of historic industrial gas prices.
Period over which the loan must be repaid [years]	[12]	Twenty years was cited by the European Bank for Reconstruction and Development as a typical loan repayment period for large infrastructure investments such as UGS facilities.
Facility lifetime [years]	[13]	The lifetime of infrastructure projects has been taken as 30 years.
Cost of LNG storage [€/mcm]	[14]	On average, storage tanks cost $900/m3. Figure obtained from LNG design engineers.
Volume of gas equal to 7 peak days [mcm]	[15]	Seven times the peak daily consumption, which is calculated as 1/31 of January consumption, using Estonian profile and data from national statistical agencies.
Facility investment [i.e. Capital cost] [€]	[16]	= [14] * [15] * 2 Costing LNG facilities is difficult, but as a general rule, storage tanks account for 50% of total capital cost.
Operational costs over lifetime [€]	[17]	= [16] * [13] * [4]
Number of cargos needed to bring LNG	[18]	= Round up (([2]/ ([8] - ([8] * [6] * [7]) - ([2]/ ([8] - ([8] * [6] * [7]) * [9]))
Cost of chartering cargos [€]	[19]	= [18] * [5] * [6]
Cost of LNG [€]	[20]	= [18] * [10] * [8]
Savings made in not purchasing Russian gas [€]	[21]	= [2] * [11]
Financing costs [€]	[22]	= [16] * [12] * 0.5 * [3] + [16] * 0.5 * [3]
Opportunity cost of storing 7 days worth of gas over 30 years [€]	[23]	= [15] * [10] * (1 + [3]) ^ [13] - [15] * [10] * (1 + [3])
Total cost [€]	[24]	= [16] + [17] + [19] + [20] + [21] + [22] + [23]

5. Results: the cost of gas supply security measures

5.1. Estonia

The cost of backing-up all gas-fired district heating in Estonia is shown in Figure 2. The dots – for heavy fuel oil (HFO) – and diamond shapes – for more expensive and less polluting light fuel oil (LFO) – show the average probability cost of each measure while the vertical bars stretch between the 10th and 90th percentile. Because of the relative movements in commodity prices, as well as the volatility in the cost of capital, the longer the mandated oil product storage period the more uncertain is the cost.

The cost of 'full security' measures – strategic LNG terminal and strategic gas storage – is shown in Figure 3. A national strategic storage (which we assume would be located physically in Latvia as no suitable location has been identified in Estonia) is cheaper than an LNG terminal for shorter peak disruption periods (15 and 30 days), but becomes much more expensive for longer disruptions (3 and 6 months). There is also more uncertainty in the cost of strategic storage because of the large volume of gas stored at an uncertain rate of return on working capital.

The average probability cost for all the measures and scenarios considered is presented in Figure 4. For long-lived gas supply disruptions (3 and 6 month peak periods) the cost of backing-up district heating with LFO is as or more expensive than a strategic LNG terminal that would insure 100% of national peak consumption. On the other hand, a back-up fuel policy using HFO can provide partial security to the country at a fraction of the cost of a 'full security' LNG terminal. Among 'full security' measures a strategic storage facility only makes sense if Estonia chooses not to insure against long-lived disruption, while the cost of the LNG option is not sensitive to the length of gas supply disruptions.

In Figure 5 we show the same costs expressed in terms of 'gas security levies', i.e. percentage increase in the industrial gas price[44] required to cover the cost of the policy measures. A strategic LNG terminal insuring 100% of peak consumption requires a levy of about 10% while all gas-fired districting heating can be insured with back-up HFO, including 15 day's onsite storage, for a tax on gas of little more than 1%.

An important consideration to calculate the gas supply security levy is the denominator, i.e. the total value of the national gas market (sum of each sector's consumption times the relevant price). We used an average for the period 2006-2008. A higher value, denoting increased consumption and/or higher prices, would produce a lower security levy, and reciprocally.

[44] We use an average of the period 2006-2008.

Figure 2. Estonia: cost of back-up fuel for district heating & power

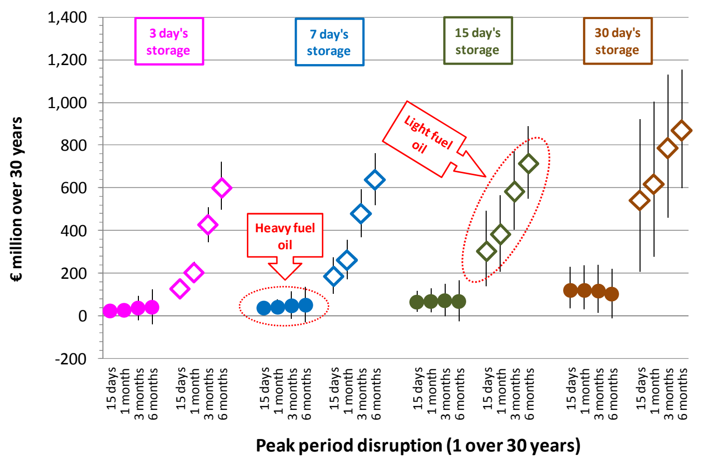


Figure 3. Estonia: cost of strategic LNG and storage facilities

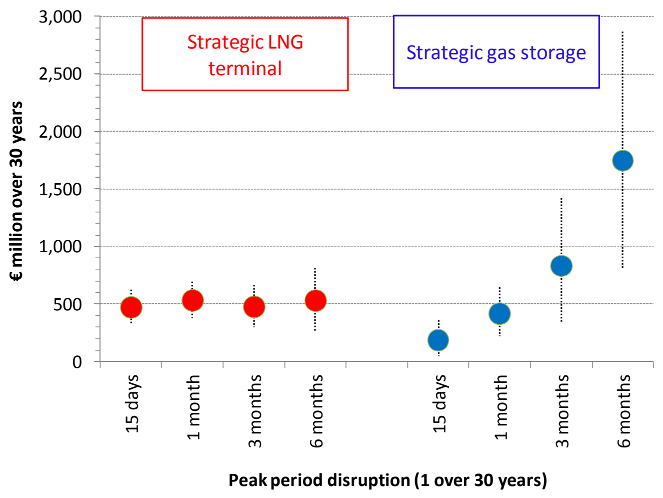


Figure 4. Estonia: all measures, all scenarios (average probability cost)

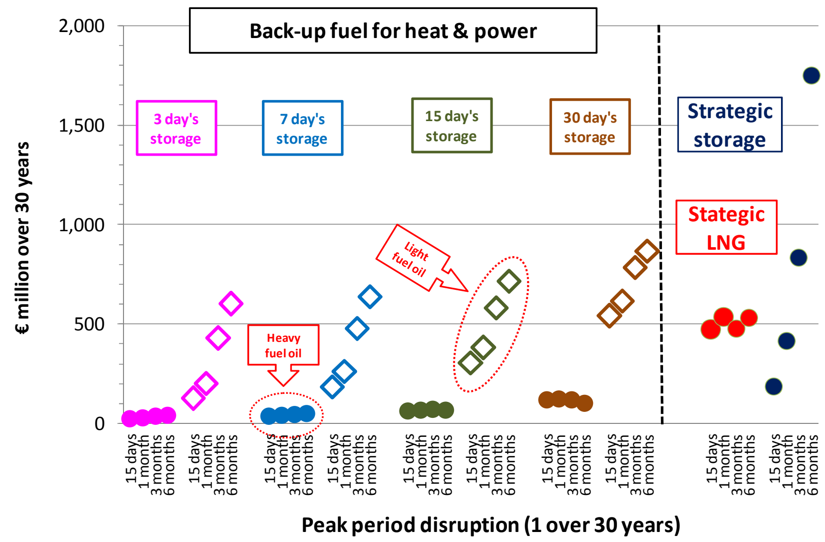
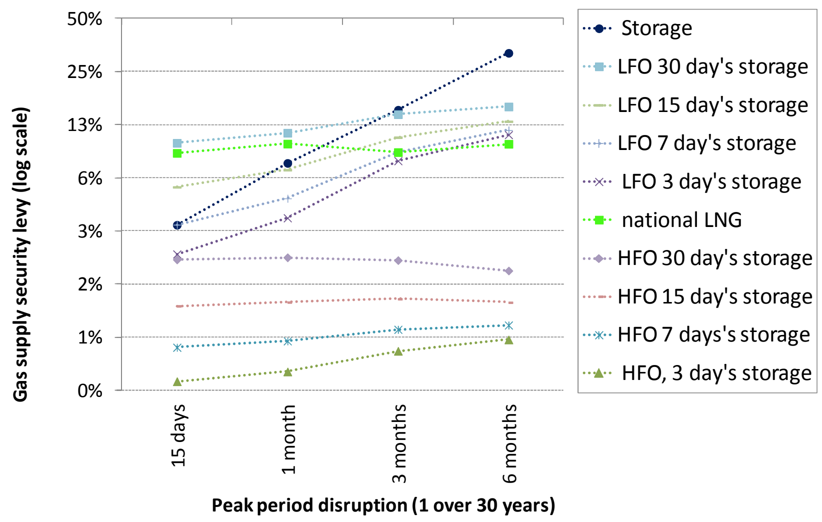


Figure 5. Estonia: all measures, all scenarios (gas supply security levies)



5.1. Latvia

The same graphs are presented for Latvia (Figure 6, Figure 7, Figure 8 and Figure 9). It appears that strategic storage is always more expensive than a strategic LNG terminal, by a very significant margin. The gas security levy required to finance the LNG policy is roughly the same as in Estonia, around 10%. All back-up fuel options except LFO with 30 day’s storage could be paid for by a levy of 6% or less.

Figure 6. Latvia: cost of back-up fuel for district heating & power

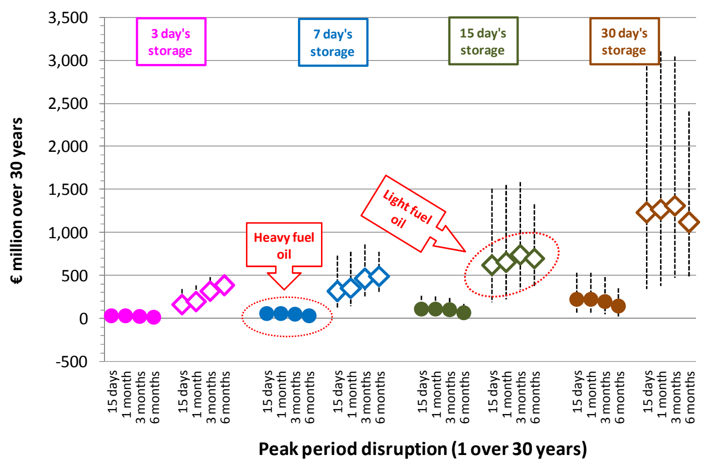


Figure 7. Latvia: cost of strategic LNG and storage facilities

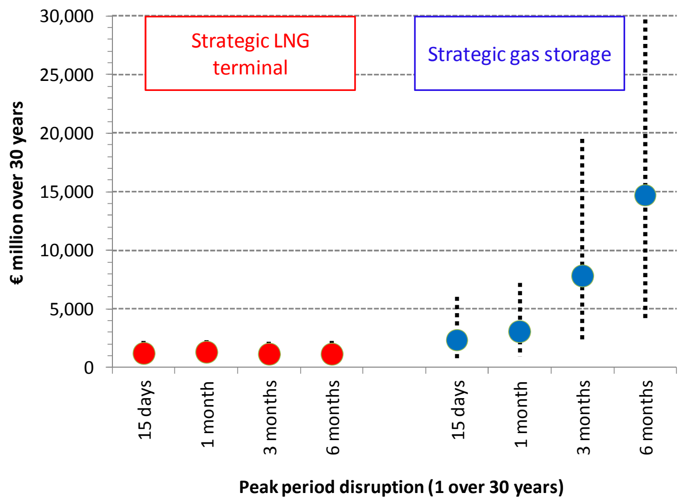


Figure 8. Latvia: all measures, all scenarios (average probability cost)

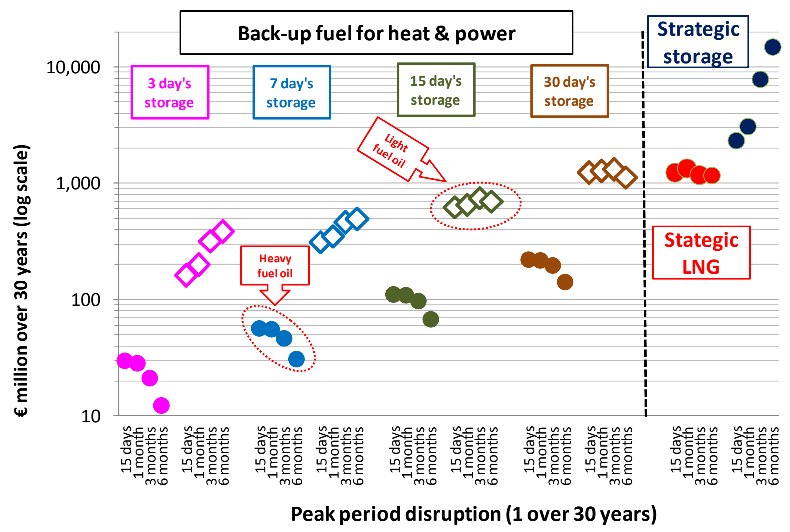
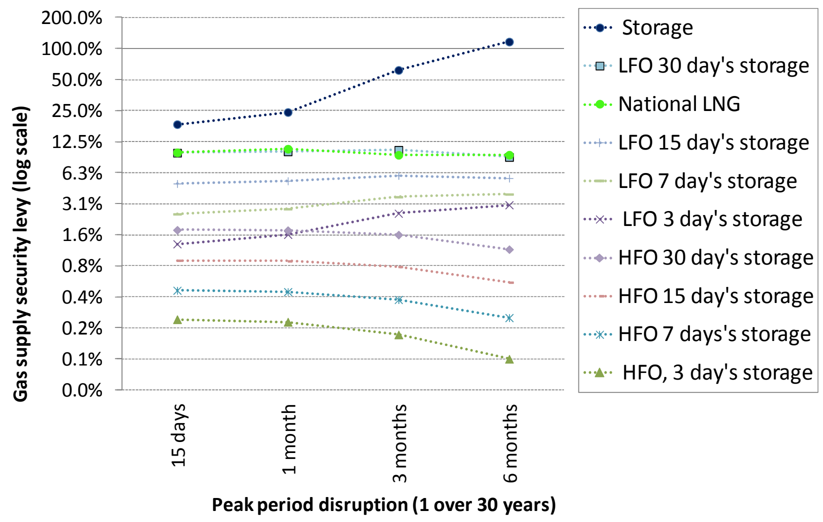


Figure 9. Latvia: all measures, all scenarios (gas supply security levies)



5.1. Lithuania

Our results for Lithuania (Figure 10, Figure 11, Figure 12 Figure 13) show that strategic storage in this country is much more expensive than a strategic LNG terminal, for all disruption scenarios. Three back-up fuel options (LFO 15 and 30 day's storage and HFO 30 day's storage) are always more expensive than an LNG terminal insuring 100% of peak gas consumption. Backing up gas-fired heat and electricity with HFO is cheaper than an LNG terminal if storage obligations are kept at 3, 7 or 15 days. Although the absolute costs are much higher than in Latvia and especially Estonia, the gas supply security levies are comparable, especially for LNG. A Lithuanian strategic LNG terminal would need a tax of 10% or less on gas prices, while a less than 3% levy would cover the back-up of all gas-fired heat and power with heavy fuel oil, with 7 day's worth of onsite storage.

The cost of some gas supply security policies in Lithuania goes down with longer disruption periods. This is because gas prices in Lithuania tend to be higher than HFO and international spot LNG prices; therefore replacing imported Russian gas by other fuels tends to save money.

Figure 10. Lithuania: cost of back-up fuel for district heating & power

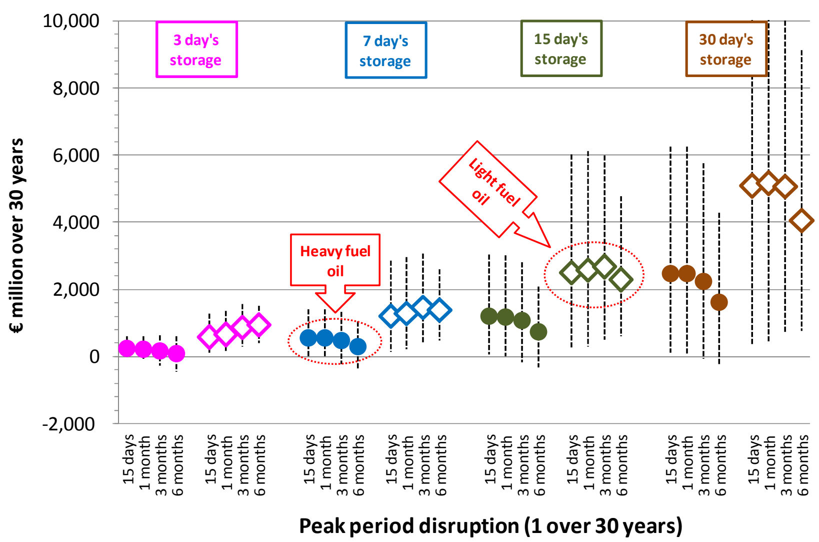


Figure 11. Lithuania: cost of strategic LNG and storage facilities

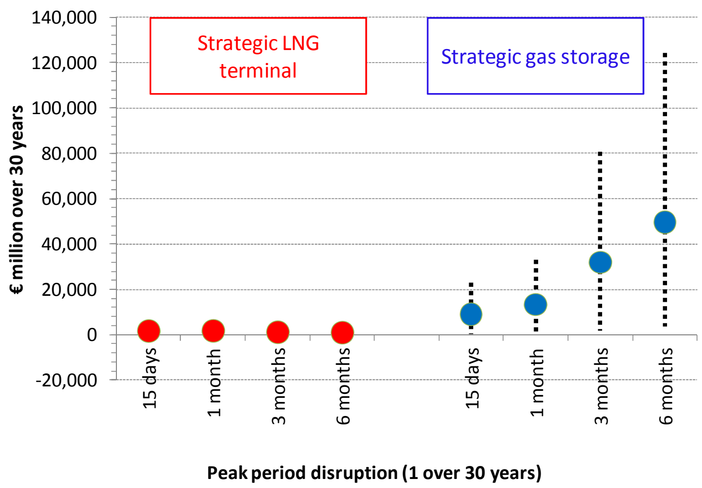


Figure 12. Lithuania: all measures, all scenarios (average probability cost)

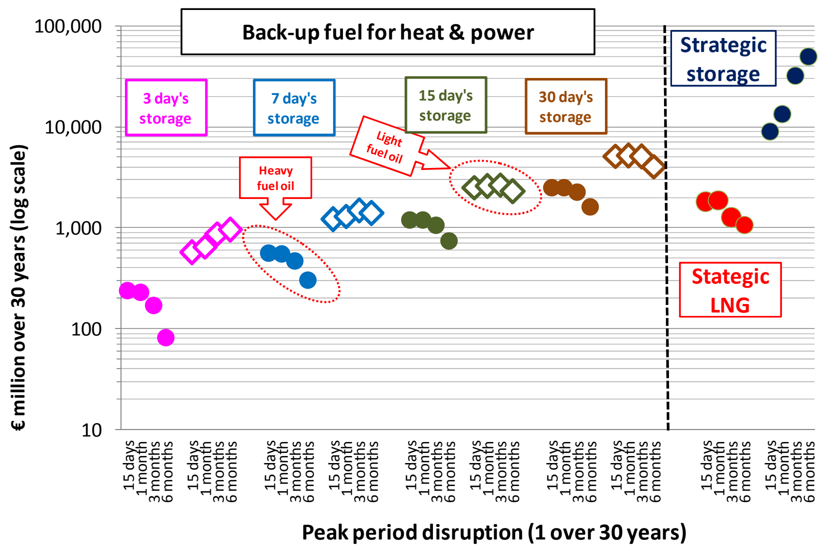
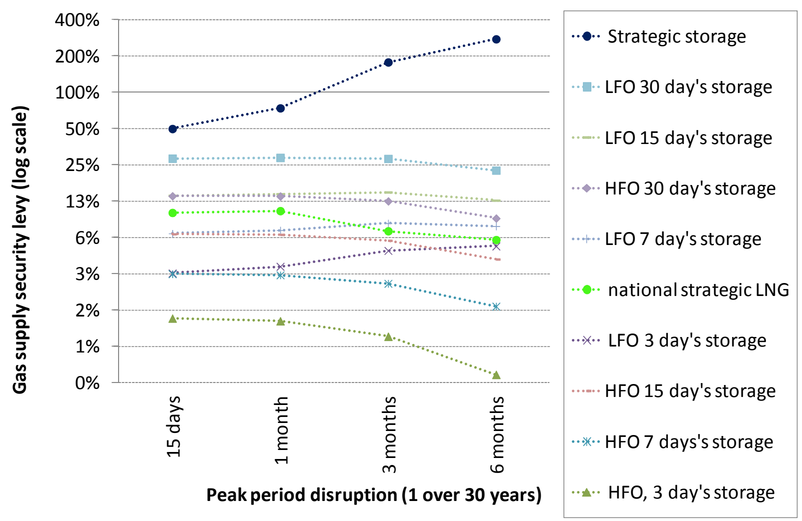


Figure 13. Lithuania: all measures, all scenarios (gas supply security levies)



5.1. Joint Baltic infrastructure for gas supply security

A joint Baltic strategic LNG terminal is much cheaper than a regional strategic gas storage and the difference grows exponentially with the length of gas supply disruptions (Figure 14). Our calculations also show that, if a joint Baltic gas supply security terminal were to be financed by a gas security levy on all gas consumers in the three Baltic States, this tax would be about 7% (based on the annual value of the Baltic gas markets in 2006-8). This compares favourably – although only marginally so – to levies necessary to cover the cost of national strategic LNG terminals, except in the 6 month disruption scenario in Lithuania (Figure 15).

Figure 14. Joint Baltic infrastructure (strategic LNG and gas storage)

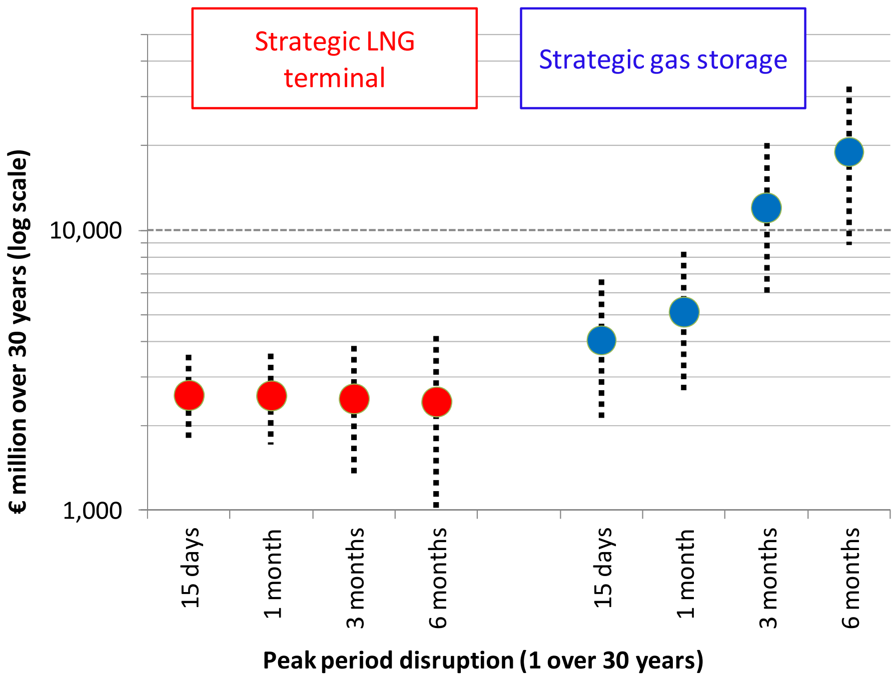
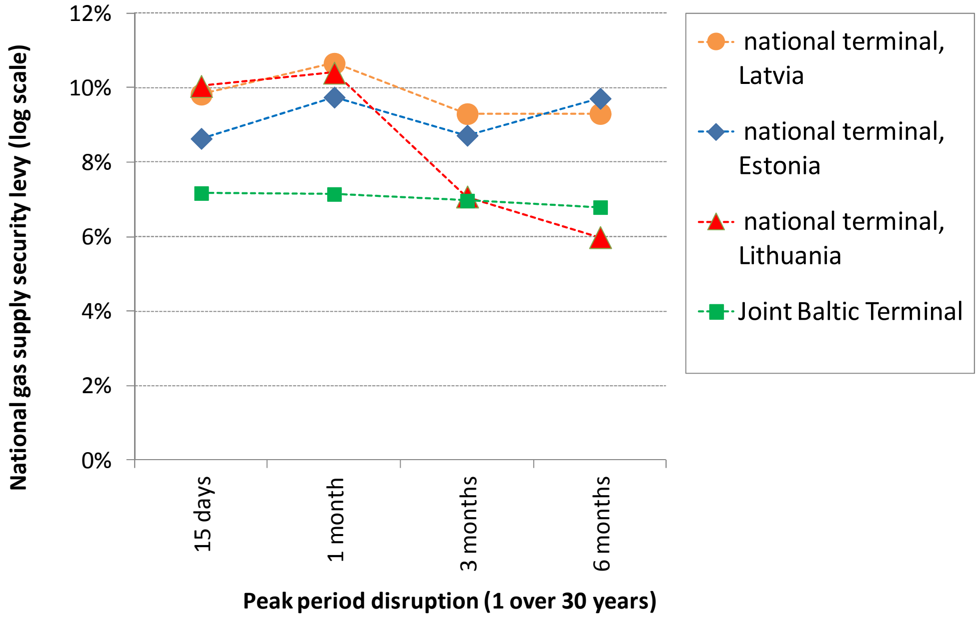


Figure 15. Joint Baltic vs national LNG: comparison of national gas supply security levy



6. Policy Discussion

6.1. Can the Baltic States make rational choices about gas security?

The economically optimal level of gas supply security is the point where the willingness to pay for security (the 'demand curve') meets the 'supply curve' for security (HOUGH, 2005). To make rational choices national governments in the Baltic States would have to perform three tasks: (1) evaluate the probability of events leading to gas supply disruptions; (2) assess the value of protecting the economy from unintentional interruptions in final energy supply; (3) rank various gas security policy options by order of rising unit cost. Tasks (1) and (2) would inform the decision about *how much* security to buy, while (3) would guide the decision about *how* to meet the preferred level of security. The analysis presented in this paper only relates to the third task. It provides information about the relative cost of various gas security policy measures.[45]

Recent research has tried to evaluate the willingness to pay for security of supply from various categories of gas consumers in Greece (DAMIGOS *et al.*, 2009) or Great Britain (LONDON ECONOMICS, 2011). However, in the Baltic region but not only, the political decision about how much insurance to buy – the 'demand for security' – is likely to be driven by *representations* of the risks, themselves shaped by perceptions of the geopolitical environment. As a consequence, governments may choose to over-provide security. It makes it even more important that they know about the relative cost of various policy options; the chosen level of security might not be economically efficient but it could still be achieved in a cost-effective manner. This is where the research presented in this paper can be helpful to public authorities in the Baltic States.

6.2. The Baltic States can make informed national choices

The analysis presented in this paper shows that the Baltic States have a variety of options to improve their ability to cope with gas supply disruptions at a cost that need not be prohibitive. Moreover, most policies can be implemented directly by national governments.

Estonia can back-up its district heating networks with heavy fuel oil, with 15 days worth of onsite storage, for a security levy of less than 2%. This cost is certainly overestimated because the heat plants in Tallinn, which represent the majority of gas-fired district heat in the country, already have dual-fuel capability and maintain stocks of HFO worth three days of peak production (see the paper's section on existing policies in the Baltic States). Moreover, Estonia can also insure its entire gas consumption by building a security-

[45] Although unlike SILVE and NOEL (2010) for the case of Bulgaria, we have not computed a proper supply curve for gas security for the Baltic States. On the concept of supply curve for security of gas supply, see LAPUERTA (2007).

only LNG terminal for a levy of less than 10%, this cost not being sensitive to the length of Russian gas supply disruptions it could face.

For Latvia the security premium for an LNG terminal is also around 10%. Backing up all heat generation with heavy fuel oil is probably not an option for Latvia as the CHPs in Riga are turbine based (as opposed to boilers in Tallinn and Vilnius) and therefore could only be backed up with light fuel oil. Nevertheless, a back-up policy based on LFO with 3 days worth of onsite storage would imply a security levy of between 1% (if the country faces one 15 day disruption of Russian gas over 30 years) and 3% (in case of one 6 month disruption). This cost is also overestimated as the CHPs in Riga already have dual-fuel capability and store a few peak days worth of LFO.

In Lithuania, the policy that the country currently enforces – back-up HFO with 30 day's storage – seems to cost *more* than a full-security LNG terminal (see Figure 12 and Figure 13). This finding would be reinforced had we taken into account the cost of the storage mandate imposed on gas suppliers to cover 60 days (eventually) of residential gas consumption. Therefore the ongoing debate in Lithuania about how to pay for an LNG terminal[46] seems to have a simple solution as the terminal would be more than paid for by scrapping the existing gas supply security policies. Lithuania would get more security for a lower cost: it should be an easy decision.

6.3. The EU approach to Baltic gas security policy: help or hindrance?

One of the reasons why national LNG terminals are not being built in the region is that the European Commission has been pushing for a single, regional terminal as opposed to national solutions (RAMBOLL, 2009; BEMIP HIGH LEVEL GROUP, 2009). European subsidies have been conditioned on the Baltic States agreeing on a regional project (BALTIC NEWS

[46] See for example BALTIC NEWS SERVICE (2010c).

SERVICE, 2009). This approach seriously underestimates the political barriers to Baltic gas security co-operation and may have contributed to perpetuating the status quo. Baltic countries tend not to trust each other and, more specifically, Latvia has been perceived by Estonian and Lithuanian political elites as deeply corrupted by Russian interests. Moreover, Latvia awarded its national gas company, of which Gazprom owns 33%, a legal monopoly over gas transmission, trading and storage from 1997 until 2017. Given the centrality of Latvia in any regional gas supply security scheme, whether it is based on strategic storage or LNG, it is difficult to see how the necessary political and legal conditions could be met.

Since the European Commission started to actively push for regional gas policy co-ordination in 2009, the political hurdles have become significantly higher. In Latvia, elections held in 2011 have seen the ethic Russian party come first with 29% of the vote, and then kept out of the coalition government. In Lithuania, regulatory change imposed by European legislation[47] has triggered a bitter political dispute with Russia over the ownership of the country's gas transmission network (BLOOMBERG NEWS, 2011). It comes at a time when Russia re-launches its campaign against EU gas market regulation, an issue that occupied most of Prime Minister Vladimir Putin's visit to Brussels in February 2011 (EU INSIDE, 2011). It certainly makes Baltic political cooperation on gas security policy even more difficult, while making a gas crisis between Russia and Lithuania less unlikely.

Since 2009, the three Baltic States have tried to convince each other and the European Commission that the regional terminal should be based on their territory. Projects in Latvia involving Russian interests have raised deep suspicions in Estonia (BBN.EE, 2011). Estonia has consistently but, unsuccessfully tried to convince Finland to build an EU-subsidised gas pipeline between the two countries and a joint LNG terminal. Despite being entirely reliant on Russian imports, Finland already enjoys a high level of gas supply security thanks to fuel-

[47] Since it joined the EU in 2004 Lithuania has been exempted from implementation of the EU gas directive but this exemption has now expired.

switching obligations and has no interest in spending more money in this area.[48] Lithuania seems to be committed to building an LNG terminal and has announced several plans since 2009, but has failed to convince its Baltic partners.

In November 2011 the three countries acknowledged the impasse and asked the EU to 'find a compromise' or abandon the LNG plan in favour of a pipeline from Poland (EURACTIV, 2011).[49]

The analysis presented in this paper shows that a single, regional LNG terminal is indeed cheaper than national ones in most cases, but only marginally so.[50] The national gas supply security levy needed to cover the cost of a security-only, regional terminal is 7%, against 9-10% for national terminals (Figure 15). The practical question is whether this small difference in cost in favour of a regional terminal justifies the difficult and lengthy process of overcoming the political and legal barriers to the building and operation of a regional security infrastructure. The past three years suggest that it might be better to let the Baltic States address gas supply security effectively through national measures, than spend time and energy trying to overcome serious political hurdles while gas insecurity is left unaddressed.

[48] Authors' interviews with Finnish energy policy and industry officials, April 2009 and September 2009.

[49] The pipeline link to Poland as an gas supply security option for the Baltic States raises even more serious political and operational issues than a joint LNG terminal. See NOEL, FINDLATER AND CHYONG (2010).

[50] Only in Lithuania in the 6-month disruption case is the national terminal cheaper than a regional one.

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