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WORLD ENERGY COUNCIL | ESTONIA

Impacts of climate policy on Estonian energy security

Project partner: International Centre for Defence and Security

WORLD ENERGY COUNCIL

ESTONIA, MEMBER COMMITTEE OF THE WORLD ENERGY COUNCIL

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Foreword

Energy security and climate policy are two of the three pillars of Energy Trilemma. Still, most of the time these two categories are not analyzed together, most of the times the discussion is about the costs of implementing stricter climate policies or about the costs of different energy security projects. We at the World Energy Council saw this and decided to try and help to fill the gap in the research.

The first thing this analysis taught us was that implementing climate policy will no doubt bring additional costs, new infrastructure will have to be built and some of the old assets will become stranded. Therefore it is the role of the policymakers to minimize these costs and find optimal ways of moving from one type of energy system to another. The second thing we learned was that climate policy measures don't necessarily have negative impacts on energy security. Negative impacts can be avoided if climate policy takes into account the local circumstances and the actual needs and capabilities of the energy sector.

World Energy Council has always been promoting the sustainable use and production of energy. The same theme echoes from this report as well. Sustainable energy systems can be built if there's stable and clear policy framework with clear targets. The community of experts in the World Energy Council has also voiced the opinion that when it comes to climate policy goals, then it is better to just have on goal - the reduction of CO2 emissions.

Finally, it is clear that the old saying "little by little does the trick". Climate goals are achieved and energy security is preserved by updating the energy system in small increments. That way one can keep the parts of the system that are still useful and change out or tweak those parts that really need replacing.

A sustainable future is one that is mainly fueled by renewable energy, but it is also one that we can afford. It is a future where we will achieve our climate goals, but it is also one where we will have guaranteed our energy security. A sustainable future is one where we have managed to balance Estonia's energy trielmma.

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1. Overview and background info

Estonia's current energy security situation

Estonia's energy sector is unique among EU member states, Estonia has the opportunity to rely largely on one domestic source of primary energy: oil shale. As a pioneer in the large-scale exploitation of the fuel, Estonia has relied on oil shale since 1924 — when the Tallinn Power Plant switched to oil shale firing[1] — and is now one of the world's major producing countries of oil shale and related products. Thanks to oil shale, Estonia is one of the least import-dependent countries in the European Union[2], producing nearly 90% of domestic electricity needs from oil shale, and being capable of producing *ca* 150% of domestic consumption from oil shale. The value added of the energy sector in Estonia is considerably higher than the EU average, at 3.5% as of 2012.[3] The oil shale sector accounts for 4% of the country's GDP, despite accounting for only 1% of the workforce. These benefits, however, come with an environmental cost: the sector is responsible for some 80% of Estonia's greenhouse gas (GHG) emissions.

The value added of the energy sector in Estonia is considerably higher than the EU average, at 3.5% as of 2012.

While the use of oil shale reserves for heat and electricity production provides Estonia with a high level of energy autonomy, oil shale transformation to electricity and heat is by its nature carbon dioxide (CO2) intensive — thereby raising questions of its long-term sustainability. Both in domestic policy statements and in international climate change negotiations, Estonia's government has advocated reducing the carbon intensity of its energy sector.[4] One outcome of the necessary measures to achieve this reduction could be an increased dependency on imported fuels, resulting in potential damage to Estonia's energy security goals. And it is not in the declared interests of the European Union to reach its climate goals by increasing its member states' dependence on imported, foreign-controlled energy supplies.[5]

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[1] Arvo Ots, "Estonian Oil Shale Properties and Utilization in Power Plants", *Energetika* 53:2 (pp. 8-18), p. 12
[2] Magdalena Spooner, et al, "Member States' Energy Dependence: An Indicator-Based Assessment", *European Economy Occasional Papers* No. 196 (Brussels: European Commission, June 2014), p. 15
[3] National factsheets on the State of the Energy Union. State of the Energy Union - Estonia. November 18, 2015. European Commission.: http://ec.europa.eu/priorities/energy-union/state-energy-union/docs/estonia-national-factsheet_en.pdf
[4] Ave Tampere, "Prime Minister Rõivas at the UN Climate Change Conference: smart economy saves environment", Government Communication Unit, November 30, 2015. https://valitsus.ee/en/news/prime-minister-roivas-un-climate-change-conference-smart-economy-saves-environment
[5] European Commission, "Energy Security Strategy". https://ec.europa.eu/energy/en/topics/energy-strategy/energy-security-strategy>

> *It is not in the declared interests of the European Union to reach its climate goals by increasing its member states' dependence on imported, foreign-controlled energy supplies.*

Estonia is at the moment dependent[6] on a single supplier (Russia) for around 80 percent of its gas imports, with winter peak gas demand met primarily by access to the Inčukalns storage facility in Latvia. The lack of a properly functioning gas market and developed gas infrastructure connecting the Baltic region to the EU energy market poses a significant risk in terms of security of supply. However, beginning last year, Estonia was able to buy gas from Lithuania's LNG terminal at Klaipėda, ending the country's previous total dependency on Russian supplies. Estonia has not faced any considerable problems with gas supply. Nevertheless, in some European countries Russia has in the past still been able to use its monopoly in support of its political objectives — resorting to practices including disruptions in gas supplies.

> *Over the coming decades, Estonia must continue to balance the domestic economic and security benefits of oil shale with its increasing international environmental obligations. A key question for Estonia will be how to fulfill its emission reduction commitments while maintaining economic competitiveness and ensuring continued security of supply.*

Objectives of Estonia's climate policy

Estonia has ratified both the United Nations (UN) Framework Convention on Climate Change and the United Nations Framework Convention on Climate Change Kyoto Protocol. Under the Kyoto Protocol, the European Union committed to reducing its emissions of greenhouse gases (GHG) at least 80% by 2050 (using 1990 levels as a baseline), thus ensuring that the average global temperature does not rise more than 2° C [3.8° F]—thereby limiting undesirable climate effects.

In 2014 Estonia agreed with three major goals at the European Union level, as set out in the draft framework – reducing greenhouse gas emissions by 40% compared to 1990, increasing the share of renewable energy in final energy consumption to at least 27%, and increasing energy efficiency by 30%. The framework provided Estonia with the flexibility to use its own energy resources, thereby not undermining its high level of energy supply independence.

National and EU level environmental policies aim to decrease carbon emissions, curb energy demand, and optimize resource consumption. Most relevant for Estonian oil shale utilization are the following: EU Climate and Energy Package and Emissions Trading Scheme (ETS), Estonia 2050 Energy Objectives, Estonian Environmental Charges Act, Electricity Market Act, Earth's Crust Act, and the National Development Plan for the Utilization of Oil Shale.

From all these long-term policies, the European Emissions Trading System (ETS) is the most significant and governs greenhouse gas (GHG) emissions from power plants, heating systems, and energy intensive industries. Estonian oil shale sector is almost completely subject to the ETS.

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[6] J.M. Laats, "Estonian Dependence on Russian Gas Is In the Past, Says Elering Chief," *ERR News*, December

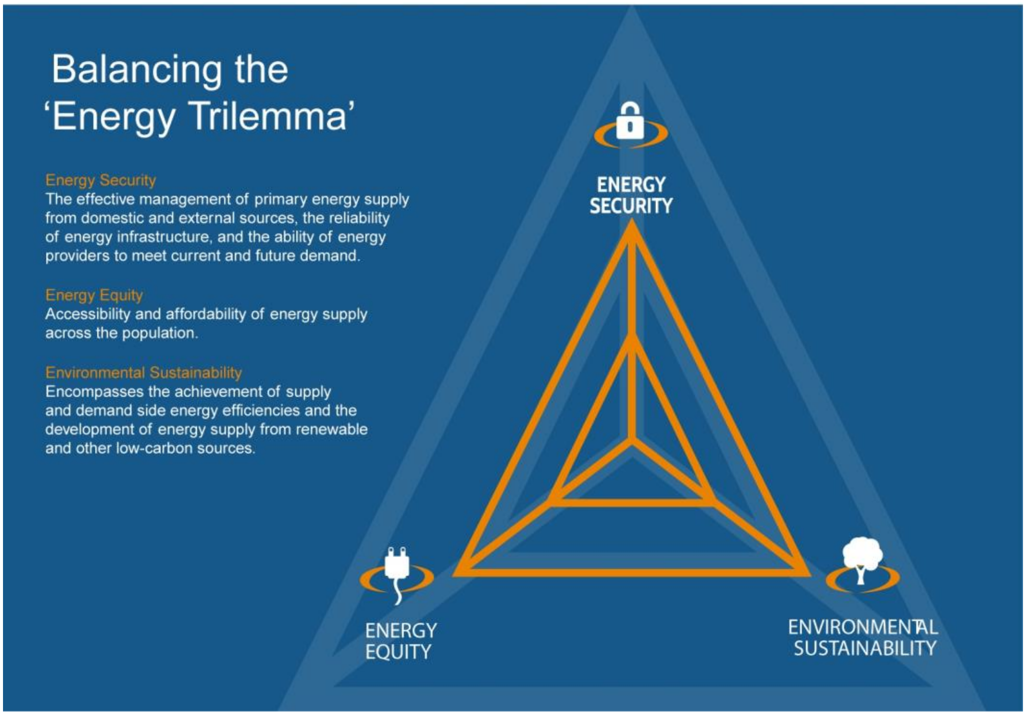
Estonia promotes entry into a legally binding global climate agreement that includes all the countries. Estonian politicians have also wanted to play a constructive role in the European Union and offer solutions, where possible. However, it seems that further promoting very strong climate policies would undermine Estonia's energy independence which is heavily reliant on carbon intensive oil shale.

The general effects of climate policy on Estonia's energy security

An overly ambitious and strong climate policy could weaken the stability of the energy supply—thus potentially leading to energy shortages that would obviously be harmful for the economy and society. Climate policies can also have an important impact on the price of energy and as a result on the competitiveness of countries' economy. Therefore, when planning the implementation of such policies, one has to evaluate the consequences of climate measures on the prices paid by end users. In addition, special consideration on the preservation of an acceptable level of energy security must be paid throughout the development and implementation of climate policy. This is what World Energy Council refers to as the Energy Trilemma.

Balancing the 'Energy Trilemma'

www.worldenergy.org/trilemma



2. Biggest Challenges to Estonian Climate Policy

- 80% CO2 reduction

- Decarbonization of the energy sector

Achieving 80% reductions in greenhouse gas emissions from 1990 levels requires an annual emissions level of roughly 8 Mt of CO2 equivalent. This reduction target is ambitious and unprecedented; accordingly, much uncertainty exists regarding its pathway, price, and associated risks.

Estonia's position is fortunate in that the majority of its CO2 reduction target has already been achieved. As of 2013, Estonian greenhouse gas emissions stood at 21.7 Mt—already a 45.7% reduction from 1990 levels.[7] This reduction was primarily achieved in the early 1990s with the transition from a planned economy to a market economy, and with the separation from the Soviet Union.[8] This reduction in the energy intensity of the economy and population led to a precipitous drop bottoming out in 2002, after which annual emissions have, on average, crept up due to increased energy consumption associated with economic growth. Looking forward to 2050, Estonia's projected moderate decline in population will help enable emissions reduction. Continued economic growth, however, will contribute to increasing emissions. As such, to meet the target emissions reduction without sacrificing economic advancement, Estonian economic growth must be increasingly uncoupled from energy consumption and energy production from carbon emissions.

While reductions in the growth of energy demand are important, they are secondary to the carbon intensity of Estonian energy production. Any scenario approaching the 80% reduction target involves deep decarbonization of the energy sector—the primary source of Estonian emissions. This is particularly true for electricity generation, due to its current emissions-heavy character. Oil shale-based electricity generation currently produces nearly 14 Mt of GHG emissions annually, and thus must face dramatic reductions if Estonia is to meet the 8 Mt economy-wide target.[9] Meeting the emission reduction target will be made easier because all of the old pulverized firing oil shale

[7] Eurostat, "Greenhouse Gas Emissions (source: EEA)," December 2015.

[9] Estimate uses IEA fuel combustion estimate of 1160 g/kWh for oil shale
IEA, "CO2 Emissions From Fuel Combustion," Paris: IEA, 2015, pg. 35.
http://www.iea.org/publications/freepublications/publication/CO2EmissionsFromFuelCombustionHighlights2015.pdf.

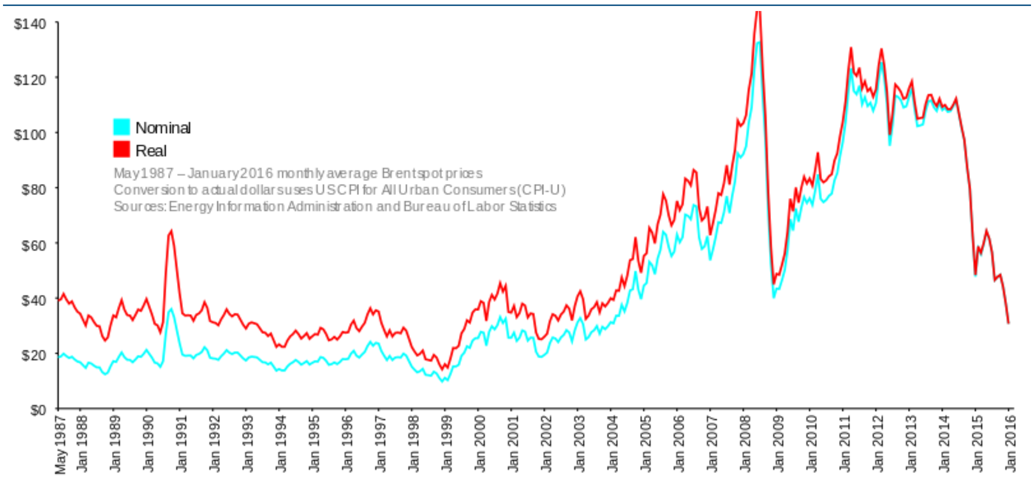
boilers will be shut down before 2050, the remaining circulating fluidized bed combustion (CFB) boiler are more efficient and have lower emissions. Most important of all, the newer CFB boilers can be co-fired with up to 50% biomass, further reducing the emissions from oil shale sector.

The KKM Roadmap calls for increased support for carbon capture research and development, which could have the potential of transforming oil shale combustion into a net low-carbon energy source. Implementation in the Estonian case, however, would be difficult due to lack of sizeable, suitable geologic storage sites near the emission source.[10] Preliminary surveys indicate the closest suitable formations for geologic sequestration are in southwestern Latvia or the southern Baltic Sea, increasing the cost and political difficulty of carbon sequestration.[11]

As carbon capture and sequestration is a difficult route for Estonia, the Roadmap proposes the replacement of most of oil shale electricity generation. As mentioned before, this transition is happening anyway and most likely will not be the most challenging aspect of the climate plan. The proposed reduction pathway envisions heavy reliance on wind and biomass to meet the required reductions and still keep the lights on in Estonia. While coastal eastern Estonia claims strong wind resources, wind production throughout Estonia and its neighboring countries is highly correlated, leading to potential intermittency problems, which cannot be fully mitigated by geographic integration, rather new storage capacity is needed.[12]. To ensure continuous supply, installed wind capacity would require significant backup dispatchable power, most likely in the form of thermal power plants fueled with biomass, natural gas or other fossil fuels. The pumped hydro plant in Lithuania could also be part of the solution. Integrating geographically dispersed wind and biomass plants will also require costly upgrades to the electric grid.

The price of oil

https://commons.wikimedia.org/wiki/File:Brent_Spot_monthly.svg



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[10] Geological Survey of Denmark and Greenland, "Assessing European Capacity for Geological Storage of Carbon Dioxide," 2009, pg. 13. http://www.geology.cz/geocapacity/publications/D16%20WP2%20Report%20storage%20capacity-red.pdf.

[11] Ibid. pg. 18-26.
Alla Shogenova, Kazbulat Shogenov, Rein Vaher, Jüri Ivask, Saulius Sliaupa, Thomas Vangkilde-Pedersen, Mai Uibu, and Rein Kuusik. "CO2 Geological Storage Capacity Analysis in Estonia and Neighbouring Regions." *Energy Procedia* 4 (2011): 2785-92.

[12] Cosseron, Alexandra, C. Adam Schlosser, and U. Bhaskar Gunturu., "Characterization of the Wind Power Resource in Europe and Its Intermittency," Report no. 258, MIT Joint Program on the Science and Policy of Global Change, 2014. http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt258.pdf.

All of the scenarios modelled for the Roadmap predict combustion of oil shale to decline in the early 2020s in favor of oil production due to the EU ETS carbon price and market forces, mainly rising price of oil. This result, however, is highly sensitive to the global price of oil. Oil prices plummeting about 50% last year and the price of wholesale electricity on the Nordic power exchange, Nord Pool Spot, hitting historic lows this year reduces the market incentive for co-production of oil, retort gas, and electricity from oil shale. Any climate roadmap that relies on an exogenous decline in oil shale combustion, the most significant contributor to Estonian emissions, risks severely missing the reduction target if the assumed market conditions do not prevail.

Transport fuels

Transport sector in Estonia makes up a quarter of Estonia's energy consumption.[13] The trend of increasing amount of passenger cars and commitment by ferries increased use of diesel fuels considerably for the last 10 years, this put Estonia in the top fuel consumers in the EU. The increase of fuel consumption on road directly correlates with Estonia's economic growth. An energy intensive economy would require Estonia to ensure availability of alternative fuels from renewable resources, such as biofuels. Estonia has declared to achieve the proportion of 10% of renewables in transport sector's energy consumption to be reached by 2020. This should be reached by a set of measures which consider the promotion of alternative types of fuels like bio methane and electricity.

Estonia imports almost all of the transport fuels used, thus remaining dependent on external supplies. Therefore the situation of energy security of transport fuels can only improve. Using domestically produced electricity and biofuels in the transport sector would improve Estonia's energy security position. At the same time this might not immediately improve the environmental impact of Estonia's transport sector, as the impact is dependent on the type of electricity used. Electricity has a lot of potential in transport sector. Estonia has already installed 167 quick chargers for electric cars and this number will soon increase.[14]

Switching to electric cars would be a good way to simultaneously increase energy security and decrease the GHG emissions from transport sector, unfortunately new electric cars are either very expensive or not as good as their fossil competitors. But switching to electric cars will reduce the emissions from transport sector only if renewable electricity is used to charge the cars. For example, new cars bought in Estonia have average CO_2 emissions of 170g/km, electric cars that use electricity from oil shale emit 250-300 g CO_2/km.[15] This is two times more than the EU 2015 target for CO_2 emissions for cars. A move to electric vehicles as a potential method for mitigation of climate change impacts would therefore only be justified when electricity in Estonia is produced from less CO_2-intensive energy sources. However, supporting the use of electric cars in urban areas is quite possible, and indeed necessary taking in account Estonia's commitment to increase renewables in electricity production, which would make the transition to electric vehicle ecologically efficient.

Another large part of transport sector is the shipping industry. The marine ecosystem in the Baltic Sea has drastically worsened due to the shipping industry - a major

[13] Ministry of Economic Affairs and Communication of Estonia, Objectives and Activities, "Liquid fuels". https://www.mkm.ee/en/objectives-activities/energy-sector/liquid-fuels
[14] ELMO, http://elmo.ee/charging-network/
[15] Stockholm Environment Institute, Policy Brief, "Sustainable Transport Perspectives for Estonia", 2011. http://www.seit.ee/failid/822.pdf

contributor to local pollution, particularly in terms of nitrogen oxides (NOx), sulfur oxides (SOx), and particle emissions. Back in 2010 Baltic countries started gradual implementation of the ECA requirements (which will be in full force in 2016) to improve the environmental situation of the Baltic Sea. If the shippers wanted to continue sailing on the Baltic and North seas – defined as IMO's Emission Control Areas (ECAs) – they had a limited set of options: switch to low sulfur fuel, install an exhaust gas scrubber or switch to LNG as a fuel. After January 2016 the requirements became even more limited, providing only the option to install exhaust gas purification via Selective Catalytic Reduction (SCR) or to start using LNG-fueled ships. At the moment LNG offers the best environmental effect among the two remaining alternatives. Using LNG reduces NOx emissions by 90%, according to an expert calculation, switching a passenger ferry to LNG would have the same emission reduction effect as taking approximately 160 000 cars off the roads. Tallink, one of the biggest ferry operators in the Baltic Sea, is already taking steps in the development of LNG ferries. The construction of a liquefied natural gas (LNG) powered fast ferry—to be named Megastar—began in Turku, Finland in August 2015 and is expected to be delivered in 2017.[16]

LNG as a vessel fuel leads to several benefits and opportunities. According to Det Norske Veritas analysis over a 20-year period – a very conservative lifetime for a vessel -- a switch to LNG could potentially save 22% on total vessel operational costs compared to scrubber option, and 45% compared to MGO.[17]

The LNG market in the Baltic Sea has the potential to become commercially attractive and deliver competitive prices, increased energy security and reduced GHG emissions.

One of the drawbacks of environmentally-friendly solutions is that they come with high costs and high up-front investments. So although LNG is becoming a global commodity and large flexible markets are becoming commonplace, it still needs a lot of investments in this region. First the costs to transition from diesel to LNG and then the costs of building the necessary infrastructure. LNG as a shipping fuel will improve Estonia's energy security and reduce the environmental impact, but only if there are enough funds to carry out the necessary investments. Otherwise there are no benefits.

Overall fuel switching and investment in newer and more efficient vehicles is a no-brainer move. For example, McKinsey estimates that 20% of the total abatement in the transport sector in Poland is due to more fuel-efficient vehicles. They also suggest that, despite high initial costs, energy efficiency measures should be implemented regardless of the outcome of international climate change discussions, due to potential net benefits to society.[18]

[16] "Tallink names its new LNG powered ferry Megastar", ERR News, February 22, 2016 http://news.err.ee/v/economy/210408bd-c365-4895-90e7-8db7698077c0/tallink-names-its-new-lng-powered-ferry-megastar

[17] "Greener Shipping in the Baltic Sea", DNV Managing Risk, June 2010. http://cleantech.cnss.no/wp-content/uploads/2011/05/2010-DNV-Greener-Shipping-in-the-Baltic-Sea.pdf

[18] Ibid., McKinsey, Green House Abatement Potential Poland

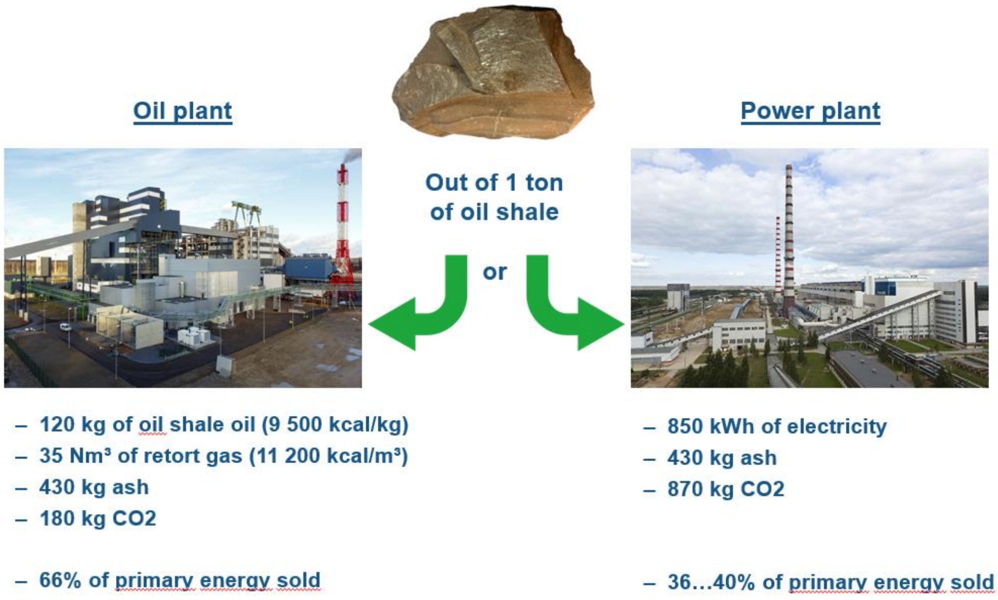
3. Energy Security Challenges in Estonia

Transport fuels, oil shale, electricity

Liquid fuels are available from many suppliers and are easily transportable on a global scale, which is why importing fuels can be considered a secure source of supply. Still, global fuel prices are highly volatile, and it is sometimes thought that domestic production would shield countries form this. Unfortunately this in only partly true, if domestic producers are legally allowed to export their product, then the prices still reflect the global market price. So inland production does not protect against price volatility but it is helpful in the times of supply disruptions.

What can be produced out of 1 ton of Estonian oil shale?

Source: Eesti Energia



Estonia has a potential to increase the domestic production of transport fuels. The cheapest option would be investing into more shale oil production facilities. This would mean that the amount of oil shale available for direct firing for electricity would decrease, meaning reduced emissions from electricity production and also reduced energy security. But this is not the full picture, shale oil production has a number of byproducts, for example heat, electricity and retort gas, which can also be used for producing electricity. The challenge for energy security is the dependence of shale oil production on the global market price of oil. If the oil price is low, we have no shale oil production and also no retort gas for electricity production. Still, this would only be problematic at a system level if the energy supplied by retort gas could not be replaced by alternative domestic generation (like biomass, wind, solar) or imports at an acceptable cost. And it is logical to assume that if the oil price is too low to produce shale oil, then the prices of other energy sources are comparatively low and there are plenty of possibilities to import required energy into Estonia. Should the price of oil rise, then it will become economically feasible to produce shale oil. Should the price of electricity rise, then it will become economically feasible to invest into renewables. Consequently, this risk can be mitigated by investment in diversified capacity at the regional or national level.

It is important to let the market forces decide how oil shale should be used, whether for oil, electricity or some other uses. Using regulatory measures to force the transition of oil shale combustion to shale oil production subjects the sector, a significant source of government revenue and regional economic driver, to the volatile global oil price. While this transition itself would not induce energy security risks, it could entail economic or political risk, while beyond the primary scope of this analysis, this is discussed in more detail in the oil shale section.

Electricity, peak consumption, stability

The most significant obstacle to energy security under the climate roadmap is the ensured stability of the electricity system. Intermittent renewable power, such as wind, is an imperfect substitute for dispatchable power, and, in the absence of utility-scale energy storage, increased consumption of intermittent power decreases its substitutability for dispatchable power.[19] In other words, **the greater the share of intermittent generation the harder it becomes to replace the remaining dispatchable generation**. Current energy systems with high intermittent power penetration demonstrate this challenge. High penetration of wind in Denmark has been attainable only due to the ability to store excess energy through Norwegian pumped hydro storage; selling energy to Norway when wind is abundant and purchasing it back when wind is unavailable or insufficient.[20] The combination of increased intermittent power generation in Germany with the closure of nuclear plants has led to an increase in coal consumption, electricity costs, and carbon emissions.[21]

The climate roadmap suggests heavy reliance on intermittent wind to meet Estonian electricity needs without solar or energy storage resources to smooth wind's variable production profile. Reliance on a single source of intermittent power with a highly correlated regional production profile leads to diminishing returns in usable energy production from additional correlated, intermittent sources, leaving gaps which must be supplied by imports or uncorrelated domestic sources. Reliance on imports could be problematic should neighboring countries also develop wind heavy portfolios due to the correlation of wind patterns at regional scale.

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[19]Erik Delarue and Jennifer Morris, "Renewables Intermittency: Operational Limits and Implications for Long-Term Energy System Models" Report no. 277, MIT Joint Program on the Science and Policy of Global Change, 2015.
http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt277.pdf.
Paul L. Joskow, "Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies," *American Economic Review,* 101, no. 3 (2011): 238-41.
http://web.mit.edu/ceepr/www/publications/reprints/Reprint_231_WC.pdf.

[20] Josh Freed, Matt Bennett, and Matt Goldberg, "The Climate Challenge: Can Renewables Really Do It Alone?" Third Way, December 16, 2015. http://www.thirdway.org/report/the-climate-challenge-can-renewables-really-do-it-alone#.

[21] J.P. Morgan, "A Brave New World; Deep De-carbonization of Electricity Grids. Report," 2015. https://www.jpmorgan.com/cm/BlobServer/Brave_New_World_-_Annual_energy_piece.pdf?blobkey=id&blobwhere=1320687247153&blobheader=application/pdf&blobheadername1=Cache-Control&blobheadervalue1=private&blobcol=urldata&blobtable=MungoBlobs.
James Conca, "Germany's Energy Transition Breaks the Energiewende Paradox," *Forbes*, July 2, 2015. http://www.forbes.com/sites/jamesconca/2015/07/02/germanys-energy-transition-breaks-the-energiewende-paradox/#3471911e2968.

Due to their lower capital costs, higher ramping rates, and the current price of gas, natural gas combined-cycle plants are typically used to balance intermittent sources. This solution, though, carries unique risks to Estonian energy security. The climate roadmap relies partially on biomass to provide power that is both dispatchable and renewable to balance the portfolio, but economic and sustainable biomass consumption is limited and is insufficient to balance wind alone. If some proportion of dispatchable backup generation is required for wind, regulation must decide who will bear the cost of capital-intensive backup projects slated to operate at low capacity.

Natural gas, sources of supply

While natural gas forms a relatively small part of Estonia's energy mix, around 10% of total energy supplies, it plays important part in heating of housing districts, thus any disruptions could lead to negative social impact. Estonia is highly dependent on Russia in supplies of natural gas. **Should natural gas be used to fuel backup generation for wind power, the cost of disruption would be exacerbated.** Until 2015, Estonia was importing 100% of its natural gas needs via direct gas interconnector from Russia. With the commissioning of Lithuania's LNG terminal, Klaipeda, alternate sources of gas are, for the first time, being supplied to the Baltic region. Klaipeda, however, can only supply 3 bcm of gas annually to the Baltic region, compared to a regional consumption of 8 bcm (Latvia, Lithuania, Estonia and Finland). The pace of adding additional infrastructure to facilitate diverse sources of gas supply sources has been slow. Two strategic gas interconnectors, BalticConnector and the Poland-Lithuania Gas Interconnection (GIPL), which would integrate the Baltic and EU gas markets are still not finalized. Diversification of gas supplies is fundamental to develop a resilient energy market in the region, particularly if the role of natural gas as a relatively lower carbon intense resource is to be expanded.

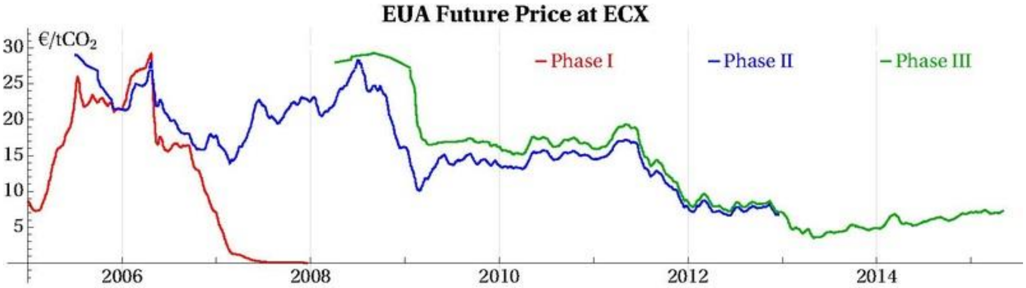
4. Energy Security and Geopolitics

Which risks does Estonia have to take into account?

As mentioned above, Estonia uses oil shale extensively in electricity production. This allows Estonia to be less dependent on external supply of energy resources. Yet in order to respond to global trends in climate policy, Estonia might face the dilemma of decreasing its energy self-sufficiency to meet new CO2 targets. Under the EU's “cap and trade” policy, polluting companies in the EU need to buy carbon credits, effectively making carbon intensive fuels like oil shale more expensive. Lately, prices for those permits have been dropping, lowering the incentive for companies to use cleaner energy and making oil shale more cost effective.[22]

EU ETS Price

Source: commons.wikimedia.org/wiki/File:Co2price.pdf



While natural gas forms a relatively small part of Estonia's energy mix, around 10% of total energy supply, a strategic objective of the government is to reduce the share of oil shale in the energy mix over the medium term. One way of doing so will be to replace carbon-intensive oil shale-fired power plants with more efficient biomass-fired capacity, which will also support the expansion of renewable energy by introducing more flexibility into the electricity system. At present, the Estonian gas market is dependent on one source of gas for supply and is isolated from the EU natural gas market. The small size and monopolistic structure of its gas market makes infrastructure development plans and the decision-making process rather challenging.

Estonia needs to take into account:

- EU ETS price will most probably increase, making carbon-intensive power production less competitive.
- Heavy reliance on Russian gas supplies could be a threat, best way to reduce this threat is by using Latvian gas storage and increasing LNG capacity in the region.

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[22] Isabelle de Pommereau., "Could Estonia's oil shale bolster Europe's energy security?", June 21, 2014. http://www.csmonitor.com/World/Europe/2014/0621/Could-Estonia-s-oil-shale-bolster-Europe-s-energy-security

What are its [potential] risk management measures?

In light of the turbulent events in Ukraine and the escalation of Russo-Ukraine relations in 2014, sustainability of gas deliveries to Europe from Russia has be reconsidered, particularly via Ukraine's territory. The European Commission published a stress test on the outcomes in case of Russia's gas supplies interruption. EU's member states in the Nordic-Baltic region were among the most vulnerable in case of disruption.

> *Although not connected to Ukraine's gas transit, a simple overview of Estonia's preparedness to cope with a short-term shortage of gas demonstrated that in 5 days some of Estonia's residential districts would be left without heating.*

The Commission advised Estonia to review its requirements on alternative fuel stocks. However, as a long-term solution, to ensure sustainable gas supplies Estonia and its neighbors have to focus on further gas market liberalization and improvement of gas infrastructure, to let alternatives to Russian gas enter the market.

Baltic region remains isolated from EU energy market due to missing infrastructure links. In 2015 the first regional LNG terminal was commissioned in Lithuania, this allowed Estonia to be supplied partly with non-Russian gas. The next step should be to complete the gas interconnector between Finland and Estonia (BalticConnector), as well as that between Lithuania and Poland (GIPL). Once completed, these projects will allow Finland and the Baltic states to diversify their gas sources and routes and thus help to effectively deal with possible supply shortages in the future. An integral part of strengthening connections between countries is also the need to build more LNG capacity. All this will also help with integrating the entire region into the EU's internal energy market. Storage, where available, is a key tool to balance the supply-demand situation. Latvia's underground storage is one of the key players in this field, governments need to work together, to ensure that this storage is available for all market participants.

Can Estonia continue to rely on international cooperation?

Estonia has achieved considerable results in liberalizing its electricity and gas markets since joining the European Union. Baltic countries are now completely integrated into Nord Pool Spot trading of electricity covering 20 counties[23], ending the status of "energy islands" in electricity market. A positive progress of cooperation between Estonia and its neighbors in the Nordic-Baltic region resulted in Estonia's electricity market liberalization and market-based prices of electricity for final consumers. Gas market is lagging behind and still can be called an "energy island." Like the electricity market, international cooperation is the key towards success in integrating the gas market of the Baltic States into a single European market. Only by common efforts of Finland, Estonia, Latvia, Lithuania and Poland two strategically important gas interconnectors Balticconnector and GIPL could be realized.

The experience so far with respect to gas security of supply has shown the importance of synergies in further cooperation across borders. Stress test released by the European Comission modelled several scenarios of response to possible disruption of supplies from the East during the fall and winter of 2014/2015. The less

[23] Nord Pool is appointed as a Nominated Electricity Market Operator (NEMO) in Austria, Denmark, Estonia, Finland, France, Germany, Great Britain, Latvia, Lithuania, the Netherlands and Sweden which signifies Nord Pool's ability to meet the new Network Guidelines on Capacity Allocation and Congestion Management (CACM), which came into force on 14 August 2015.

hazardous outcomes were identified in a model where EU's member states relied more on cross-border cooperation. So-called "cooperative" scenario relied on burden sharing by which solidarity between member states guaranteed equal spread of gas across borders. In the absence of cooperation between Member States and of additional national measures, serious supply shortfalls of 40% or significantly more could materialize, at least towards the end of the 6-month disruption period, for Lithuania, Estonia, and Finland in the scenario of a total halt of Russian supplies to the EU.[24]

> *The only underground storage facility in the region is located on Latvian territory, which means that Estonia depends on international cooperation to guarantee security of gas supplies, thus Estonia should constantly engage with regional players on the matters of energy security and cooperation.*

Russian climate policy and energy export[s]

Russia is the leading exporter of energy resources to the EU member states. It has established itself the world's largest producer of crude oil (including lease condensate) and the second-largest producer of dry natural gas. Russia also produces significant amounts of coal. The country's economy is highly dependent on hydrocarbons and energy is one of their main export articles. **The revenues from export of oil and natural gas (primarily to the EU market) account for more than 50% of the federal budget revenues of Russia, this makes Russia dependent on the EU market and its market share.**

Russia is not only exporting oil and gas, but also electricity. After completing market integration into the Nord Pool Spot trading area, Estonia and its neighbors started to discuss the possibility to decouple their electricity systems from the Russian and Belorussian grids. According to the CEO Estonian national grid operator, as long as Estonia is a part of the united Russian electricity system, the risk of disruption of electricity supply or system dysfunction remains great.[25] Potential synchronized operation of the Baltic region with the Central Europe frequency area means that the Estonian electricity system's frequency will be controlled together with other electricity systems belonging to the united electricity system of continental Europe. But desynchronizing is a very costly project and can only be carried out with huge support from the EU.

Until the desynchronization is implemented, Russia remains important to control system's frequency. For the Baltic region an improved climate policy in Russia would be significant due to the continued energy trade, especially imported electricity, which can add to emissions in the region given that some Russian supplies are produced from fossil fuels.

Russia has historically had high emissions related to the flaring of natural gas. In 2009, the Decree on Measures to Stimulate the Reduction of Air Pollution from Associated Gas Flaring Products was adopted, targeting a utilization rate of 95% for

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[24] Communication from the Commission to the European Parliament and the Council on the short term resilience of the European gas system. Preparedness for a possible disruption of supplies from the East during the fall and winter of 2014/2015., Brussels, October 10, 2014. https://ec.europa.eu/energy/sites/ener/files/documents/2014_stresstests_com_en_0.pdf

[25] "Baltic states could be separated from Russia's electricity grid by 2025", The Baltic Times, January 13, 2015. http://www.baltictimes.com/baltic_states_could_be_separated_from_russia_s_electricity_grid_by_2025/

associated petroleum gas by 2012. Since this target has not been met, additional incentives for compliance were added in 2012.

After the collapse of the Soviet Union due to economic decline in all post-soviet states, emissions in Russia dropped in the 1990s, with a historic low of just below 2 GtCO2e in 1998—down 40% from 1990 levels. Since then, emissions have increased steadily, but are still below 1990 level, as energy intensive industries never fully recovered. However, a steady but moderate growth of emissions averaging around 1,1% for greenhouse gas emissions is expected to continue on the same trend until 2030, unless increased investment in abatement policies and technologies is carried out.

Russia's climate policy environment has a clear focus on energy production and demand. It has formulated two energy intensity targets in different pieces of legislation, which refer to different target years and baselines. An energy intensity target of a 40% reduction between 2007 and 2020 was adopted by the "Decree on Certain Measures to Increase Energy and Ecological Efficiency of the Russian Economy," in 2008. In 2009, Russia adopted the Energy Strategy 2030 and the Energy Efficiency Federal Law., which include a slightly different energy intensity target of 44% reduction between 2005 and 2030[26].

[26] UNFCCC, 2012; Sharmina et al., 2013

5. Climate Policy 2050

The following chapter covers the 8 guidelines developed by the working group assembled by the Ministry of Environmental Affairs.

System As a Whole (Guideline 1)[27]

Guideline 1: Energy consumption centers, new capacity planning, and production/consumption management should be based on a fully efficient and functioning system.

This guideline states that all future development of energy consumption/production systems should be efficient and rational. It is very hard to argue against this guideline, as efficiency and rational decision making help to improve the energy security and reduce the environmental impacts of energy sector.

Energy security is improved and environmental impact is reduced due to lower energy consumption which is realized through more efficient production and use of energy.

Industrial Processes (Guideline 2)

Guideline 2: Low CO2 emission technologies should be implemented in industrial processes, and resources should be used with maximal efficiency.

Construction materials, cement production:

Estonia repurposes oil shale ash by using it in cement and other construction materials, this is a positive trend in using resources with maximum efficiency leading to a decrease in CO2 emission in Estonia's energy system.

In Lääne-Viru County Kunda Nordic Cement is using oil shale to heat cement chimneys and pouring the ash created into cement content. The first building material industry segment that started using oil shale was the cement industry. Eesti Energia in 2014 re-used 128,000 tons, of this nearly 70 percent of is used in Estonia. Most of the ash is used in construction, where it is a component in the production of Portland cement. The content of oil shale ash is similar (clay minerals) to the raw material of cement.

The waste rock from oil shale separation units has constantly been used as a building material. Due to the low resistance to freezing and the occurrence of micro-fractures from blasting this aggregate is suitable only for road or construction site ballast material.

Enefit planned to sell part of the ash from the Enefit280 factory as clinker substitute to the cement industry, creating CO2 savings that offset emissions from the Narva Oil factory. Clinker substitution by suitable ash is widely accepted in the cement industry worldwide as a means of reducing CO2 emissions from cement production. The Narva

[27] The following eight guidelines are all drawn from the Estonian Ministry of the Environment's 2050 document

Power Plant is already selling ash for this purpose and Enefit has discussed likely additional future demand with existing and potential buyers. **It is reasonable to take credit for CO2 emissions resulting from the use of clinker substitute material, as long as the sold ash is used to back out clinker production, and not replace another clinker substitute material from the cement market.**[28]

Chemical industry:

Oil shale is used in chemical industry. Two important chemical sectors are characteristic specificities of the Estonian Chemical Industry: Oil shale chemistry and producing of rare earth metals and their oxides. Chemical industry share in processing industry is about 5,2% and its contribution to Estonian GDP is 0,8%.[29] Increasingly stringing European Union environmental regulations could undermine competitive chemical industry for Estonia.

Energy efficiency projects in the private sector require relatively short payback times due to capital constraints and the decision of the companies to pull their funds on energy efficiency projects, which are generally considered to be of high risk thus of higher investment costs. Some EU countries have followed the market-based mechanism to address energy efficiency in industrial sector. France, UK, Italy have chosen the white certificate system of encouraging investments in energy efficiency measures by defining obligatory certificate targets for national energy suppliers. Certificates, traded on national platform, could be denominated by energy measures (i.e MWh).

White certificate system can be called **moderate measures of climate policy** as they include the fining system in case suppliers fail to present the required number of white certificates at the end of a certification period. This system addresses several problems: the motivation to invest into energy efficient projects is compensated not only by low energy bill by the compensation for their initial spending. Moreover, the industries become consciously focused on the issue of energy saving.

Weak measures include raising awareness, which would include educational programs to help industry sector participants identify opportunities in their manufacturing process in line with technological development in other sectors. *Business seminars, workshops and networking would lead to good-practice sharing, especially on the level of small-scale and medium enterprises.*

Strong measures a binding taxation system for industries (from "aspirational" to binding measures). McKinsey suggests that the abatement potential from the available levers could be achieved through measures in industry sector. The Polish case showed a potential from optimization of heavy industry using byproducts as slag to substitute the clinker in cement production, yet technical possibilities restricted the progress to only 40% substitution. Over half the potential is on chemicals, where optimizing processes and catalysts would permit a reduction in emissions by around 5MtCO2e on Poland's example.

The ETS has the potential to be the driving policy force dictating Estonian oil shale use, the current effects of the ETS on oil shale are relatively insignificant due to the low price of carbon emissions under the ETS and to Estonia's exemptions as a newer member state. Until 2019, Estonia will receive free carbon allowances for power

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[28] Enefit ,. https://www.enefit.com/air
[29] The Federation of Estonian Chemical Industries (FECI), "Chemical industry in Estonia". http://www.keemia.ee/en/chemical-industry-in-estonia

producers; therefore, if carbon prices remain low, the transition to purchasing allowances will have little effect on oil shale use. Accordingly, the Estonian government has responded by implementing **stricter national energy and environmental standards** than currently required by current EU policy in anticipation of further changes. A stronger measure would be in introduction of binding policies.

With negative trends in Estonia's industry growth, Estonia has positive chances to pursue low carbon scenario onwards.

Limiting total GHG emissions to 110% of 2005 emissions levels will be easily attainable due to the drop in economic output associated with the 2008 recession, as well as to the subsequent concentration of economic growth in non-energy-intensive sectors.

Building Efficiency (Guideline 3)

Guideline 3: The renovation of existing building stock and planning/construction of new building stock should be based on fully economically- and energy-efficient system, in order to achieve maximal energy efficiency in all uses of existing building stock.

Guideline 3 addresses improved building efficiency and is an important sector for emissions reductions as policies targeting building efficiency can simultaneously reduce emissions and increase energy security at a net societal economic gain. **Given the high carbon intensity of Estonian energy production, curtailing energy demand produces significant greenhouse gas reductions. Decreased demand also puts less strain on energy infrastructure and domestic non-renewable resources while reducing the need for energy imports all of which bolster energy security.** McKinsey reports that many of these efficiency improvements have a negative carbon abatement cost, indicating unrealized societal economic benefits, even in the absence of a carbon price.[30]

> *Unrealized economic gains persist because of agency issues arising from the diverse, and at times competing, interests of building stakeholders including builders, owners, renters, etc. Additionally, energy efficiency measures may not have a quick enough payback period to be attractive given their upfront costs. This is particularly true of new buildings and appliances with high upfront costs. Residential customers with limited disposable income likely apply a high discount rate to investments, such as energy efficiency measures leading to underinvestment.*

McKinsey reports the building sector to be the largest energy efficiency opportunity for Poland and the Czech Republic.[31] Within the building sector **improvements in the building envelope account for largest opportunities for emissions abatement**.[32] Though bottom-up data on energy efficiency opportunities for Estonia are not available, the situation is likely similar as Estonian buildings are relatively old and energy inefficient compared to buildings in comparable European countries (see Household Energy Consumption, next page). The gap between Estonian household energy consumption and those of other northerly European countries results from a

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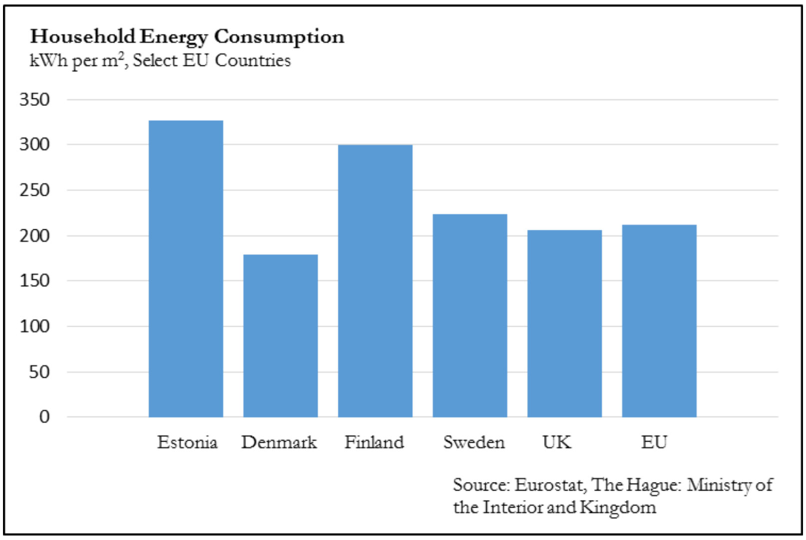
[30] McKinsey & Company, "Pathways to a Low-Carbon Economy; Version 2 of the Global Greenhouse Gas Abatement Cost Curve," 2009.
[31] McKinsey & Company, "Assessment of Greenhouse Gas Emissions Abatement Potential in Poland by 2030," 2010.
McKinsey & Company, "Cost and Potentials of Greenhouse Gas Abatement in the Czech Republic," 2008.
[32] Ibid.

combination of lower thermal efficiency of building envelopes and lower energy efficiency appliances. Given that the populations in the comparison countries are wealthier than the Estonian population, the comparison populations likely apply a lower discount rate, making them better able to take advantage of energy savings from high efficiency appliances.

Household Energy Consumption
http://www.bmwfw.gv.at/Wirtschaftspolitik/Wohnungspolitik/Documents/housing_statistics_in_the_european_union_2010.pdf



McKinsey reports that the average abatement cost of improving building efficiency to be -18 EUR/tCO2e in Poland, indicating an opportunity for a net societal gain.[33] This is in line with McKinsey global estimates and estimates for the Czech Republic, both of which show a negative cost.[34] Given that global estimates and estimates for Poland and Czech Republic, countries with similar building stock, all demonstrate negative cost, we believe **energy efficiency measures in Estonia will also offer opportunities for net economic gain**. How this gain is distributed and the potential costs to the government of realizing this gain are dependent on the specific policy implanted to overcome the underlying agency problem.

As a simple indicator of the opportunity available from building energy efficiency, if the average household energy consumption per unit area decreased by 20% by 2050, energy consumption would be reduced by 2.2TWh annually. *This is a reasonable reduction given that current Danish residential energy consumption is already 45% less per unit area than Estonian consumption*.[35] This is a conservative estimate of energy savings as it assumes average household area does not increase with higher prosperity. Furthermore, this estimate excludes efficiency gains from commercial buildings. Converting energy savings to carbon abatement potential is dependent on

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[33] McKinsey & Company, "Assessment of Greenhouse Gas Emissions Abatement Potential in Poland by 2030," 2010.
[34] McKinsey & Company, "Pathways to a Low-Carbon Economy; Version 2 of the Global Greenhouse Gas Abatement Cost Curve," 2009.
McKinsey & Company, "Cost and Potentials of Greenhouse Gas Abatement in the Czech Republic," 2008.
[35] Eurostat, "Conventional dwellings by occupancy status, type of building and NUTS 3 region," 2011.
Kees Dol and Marietta Haffner, "Housing Statistics in the European Union 2010," The Hague: Ministry of the Interior and Kingdom Relations, 2010.
http://www.bmwfw.gv.at/Wirtschaftspolitik/Wohnungspolitik/Documents/housing_statistics_in_the_european_union_2010.pdf.

the carbon intensity of Estonian energy generation and the distribution between electricity and heat consumption. At the current carbon intensity of 926 kt CO2e/TWh efficiency savings would amount to approximately 2Mt CO2e annually.

While efficiency in both residential and commercial/public buildings is important, improvements to household efficiency are most important for two reasons. First, household consumption is larger than commercial/public energy consumption. According the IEA, approximately 50% of total final energy consumption in Estonia is building consumption; 32.8% of total final consumption is residential compared to 18.1% for commercial and public buildings.[36] Secondly, commercial and public operators are likely able to apply a lower discount rate to energy efficiency measures than private households with less available capital, and as such are likely already more efficient.

Strong measures to capture the benefits of increased building efficiency include reducing the minimum energy efficiency of new or renovated buildings and introducing efficiency standards for new appliances. These measures would overcome agency issues, but increase upfront costs for new buildings and appliances potentially leading to a lower turnover rate and increasing the lifetime of older, inefficient buildings and appliances. The higher the mandated efficiency standards, and thus cost, the stronger the incentive to hold on to old technology. Current building efficiency standards already require new buildings to have energy consumption comparable with average Danish residencies.[37] Thus, to reduce average energy consumption, the turnover or renovation rate must be increased.

Weaker measures such as subsidized financing for buildings or appliances meeting certain efficiency standards can make energy efficient technology more cost competitive in the short term while imposing fewer restrictions on property. Financing subsidies or other benefits can increase the acceptable payback time for energy efficiency measures and have the added benefit of not increasing the minimum investment for newer technologies, as efficiency mandates could. Such measures could take the form of a revival or expansion of the 2009 KredEx support to residential energy efficiency investments. Due to the adverse effect of high standards on turnover and renovation rates, **if properly designed, weaker measures may better achieve Estonian climate goals**.

Electricity Networks (Guideline 4)

Guideline 4: The planning, building, maintenance, and reconstruction of the energy grid should be based on an economically and energy efficient system with the goal of achieving maximum energy and resource efficiency. Electricity and heat (also cooling) networks [should] operate according to free-market principles, in which all market participants have the ability to buy or sell power on the network without discriminatory conditions.

Acting on inputs (e.g. fuel sources) and outputs (e.g. industrial processes) is not the only way Estonia can achieve greater efficiency in its energy system; as Guideline 4 suggests, it can do so by changing the way it plans, builds, maintains, and reconstructs the energy system itself.

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[36] IEA, "Estonia 2013," 2013. https://www.iea.org/publications/freepublications/publication/Estonia2013_free.pdf.
[37] Ibid.

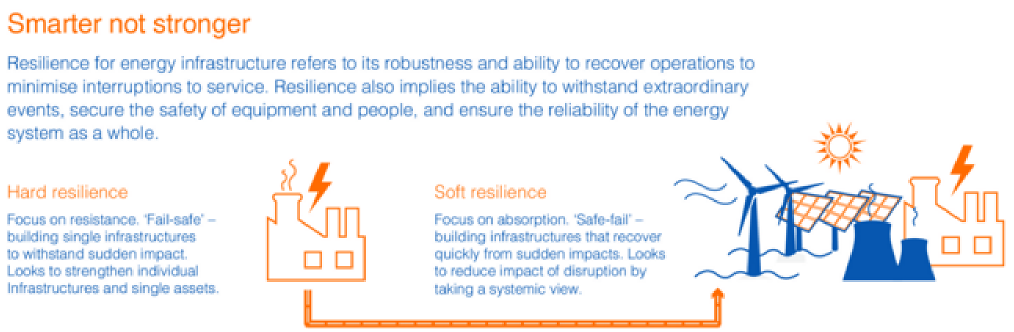
In 2014, losses due to grid transmission amounted to some 2.6% of the 14.5 TWh transmitted by the network[38], a percentage that is not expected to decrease even in the long-term future.[39] Thus, the need for greater efficiency in the system is certainly present.

In addition to investing in better infrastructure that further reduces transmission losses—keeping in mind the adage that the cleanest and cheapest source of energy is the energy not consumed in the first place—another obvious way to increase the efficiency of the system is by what is called **smart grid** technology. *A relatively complex issue given that there's no single thing that makes an electricity system "smart"*—smart grids instead being a collection of instruments and technologies aimed at increasing the efficiency, resilience, and environmental friendliness of a given system[40]—it is clear based on the examples of certain operators in the US and Western Europe that the application of such technologies increases system performance. Thankfully, such improvements are likely to be made in the near future due to the launch of the Estfeed[41] platform by Elering, Elektrilevi, the Eesti Taastuvenergia Koda (Chamber of Renewable Energy) and VKG Soojus [VKG Heating], which aims to bring about efficiency gains with the help of "near-real-time data"[42]

The Guideline also calls for basing grid access according to the free-market principle of non-discriminatory access. This can indeed help, given that it would **eliminate distortions** from anti-competitive/monopolistic behavior, distortions that cause **inefficiencies**. However, there are numerous potential drawbacks here: first, in relative terms the gains from energy savings in this domain are much smaller than with the other sectors. Even a highly efficient "smart" energy grid that transmits electricity produced from fossil fuels will still be a considerable cause of pollution. While this objection is addressed in the other parts of this section, another objection is that the large investments needed to increase system efficiency may not be politically viable.

Hard vs Soft resilience

Source: World Energy Council (https://www.worldenergy.org/wp-content/uploads/2015/09/Infographic-Resilient-Energy-Infrastructure.jpg)



But: framed as an energy security move, the political viability of such investments increases—after all, **smarter grid is indeed more resilient**. US states whose regulators favored smart meter technology earlier (e.g. Maryland, Virginia) have seen less impact from extreme weather events than did others such as New Jersey as well

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[38] Elering, http://elering.ee/electricity-consumption-and-production-in-estonia-2/
[39] See graph, p. 30 http://elering.ee/public/Infokeskus/Uuringud/Estonian-Long-term-Energy-Scenarios.pdf
[40] Interview with Emmet Tuohy, *Energetika.net*, 2015
[41] "Mis on Estfeed?", http://estfeed.ee/mis-on-estfeed/
[42] Taavi Veskimägi, ''Lokaalsest globaalseks, tsentraalsest hajutatuks'', *Postimees*, January 28, 2016, p. 16

as more **secure** as well—it can thus gain more wide-ranging political support. It is also a potential source of Estonian export-led growth, with the Estfeed platform itself ideally suited for those countries just beginning to implement remote metering.[43]

Oil Shale Sector (Guideline 5)

Guideline 5: The use of oil shale should move towards the production of higher value-added products, with the goal also of minimizing the CO2 emissions resulting from the production process. Retort gas, as a byproduct of oil shale production, will find use in a majority of heat and electricity production, thereby helping reach the goal of obtaining a higher energy output level from oil shale.

Guideline 5 suggests the oil shale industry should transition to production of shale oil and retort gas as well as other value added products. The given assumptions for the BAU scenario developed by the working group suggests this transition will occur under market forces and current policy (ETS carbon price and cessation of carbon allowances). Given that oil shale combustion accounts for the majority of Estonian carbon emissions, reduction in emissions from oil shale use, such as this transition, is necessary to achieve the stated emissions reduction target. While KKM's model predicts the occurrence of this transition, this result is not robust. This result is highly sensitive to oil price and the price of carbon emissions in the ETS. Even if KKM believes this unlikely, given the importance of oil shale to overall Estonian emissions, KKM should evaluate a complimentary BAU forecast where global oil price remains below the substitution price to better understand the possible range of the baseline scenario.

Given the unique nature of the Estonian oil shale industry and the possibility of transition from direct combustion to shale oil retorting and chemical production, estimates on the cost of carbon abatement are not available from analogs in Poland or the Czech Republic. **Weak measures** to facilitate the transition from combustion to shale oil production would most likely be a continuation of the status quo with the EU ETS incentivizing shale oil production as it is a less carbon intense use of oil shale resources. Since this strategy relies primarily on market forces, it ensures the transition occurs only if the opportunity is profitable (accounting for the cost of carbon). **This is both the benefit and the crux of reliance on market mechanisms: the development is cost efficient, but the preferred outcome cannot be guaranteed.**

The effect of limitations or prohibitions on the combustion of oil shale to force the transition of the industry to shale oil production could be minimal if the transition would have occurred anyways due to market forces. In this case the policy to shift to shale oil production could expand the industry and increase government revenues. In the absence of a profitable oil market, however, **moderate or strong measures** limiting oil shale combustion will weaken the sector and have a disproportionate impact on the local economy of Ida-Viru County and consequently the ethnic Russian population. The sector represented 4% of the Estonian economy in 2013 or about 750 million Euro, concentrated in the northeast.[44] Additionally, **depending on market conditions for shale oil, a strong prohibition against or limitation on direct combustion of oil shale could jeopardize Eesti Energia, which provided 114m Euro in state**

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[43] Veskimägi, *Postimees*, ibid.
[44] IEA, "Estonia 2013," 2013.
https://www.iea.org/publications/freepublications/publication/Estonia2013_free.pdf.
Eurostat, "GDP and Main Components," 2016.

revenue in 2014, and devalue its state owned assets.[45] Given the unique nature of the Estonian oil shale sector, the costs of these measures during a weak oil market cannot be estimated from the information provided in the McKinsey reports.

Setting costs aside, the effect of a transition from oil shale combustion to shale oil production (*precipitated by either by market forces or policy*) on Estonian energy security can be managed. Electricity previously produced from oil shale will have to be imported or produced by new domestic generation, both of which will likely increase electricity prices. Unless electricity can be produced from retort gas, which is a byproduct of shale oil production and therefore offers low priced electricity.

> *Use of retort gas for electricity generation only threatens energy security if the energy supplied by retort gas could not be replaced by alternative domestic generation or imports at an acceptable cost if low oil prices bring an end to retort gas production.*

Wind and biomass also have the ability to replace limited amounts of oil shale capacity from domestic sources and are discussed in more detail in their respective sections.

Alternative measures to reduce the carbon emissions from the use of oil shale include continuing direct combustion, but retrofitting power plants with carbon capture and sequestration (CCS) technology. If Estonia maintained current electricity generation portfolio, but rebuilt or retrofitted all oil shale plants with CCS technology, emissions would be reduced by up to 12.5 Mt CO2e per year.[46] McKinsey estimates the **societal cost** of carbon abatement from CCS applied to coal plants at 44-57 EUR/t CO2e for the Czech Republic after 2020 and 32-39 EUR/t CO2e after 2030 in Poland. *These costs are likely underestimates as fewer demonstration plants have been constructed than McKinsey anticipated at publication, decreasing the assumed cost reduction achieved from "learning-by-doing"*.

Widespread adoption of CCS in Estonia is, however, unlikely for several reasons. Cost of oil shale could increase if oil prices rebound making shale oil production more profitable resulting in investment in unused CCS capture retrofits. The cost of CO2 transport, while a relatively small component of total cost, is especially high for Estonia because **Estonia lacks the appropriate geology** for substantial sequestration. Transporting carbon also introduces the political difficulty of cross border storage arrangements, or alternatively, EU level policy could restrict carbon sequestration to offshore sites. Estonian costs for CCS would be higher than costs in Poland or the Czech Republic as these countries have local storage resources, whereas storage resources closest to Estonia are in southwestern Latvia and the southern Baltic Sea.[47] Transport, is however, the least expensive portion of the CCS chain, which McKinsey estimates at 5-10 EUR/t CO2 e using current technology and knowledge for the Czech Republic.[48]

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[45] Standard & Poor's Ratings Services, "Eesti Energia AS," 2014. https://www.energia.ee/-/doc/10187/pdf/concern/info_S&P_09042014_eng.pdf.
[46] Assumes 90% capture efficiency, which is standard for current capture technology
[47] Alla Shogenova, Kazbulat Shogenov, Rein Vaher, Jüri Ivask, Saulius Sliaupa, Thomas Vangkilde-Pedersen, Mai Uibu, and Rein Kuusik. "CO2 Geological Storage Capacity Analysis in Estonia and Neighbouring Regions," *Energy Procedia* 4 (2011): 2785-92.
[48] McKinsey & Company, "Cost and Potentials of Greenhouse Gas Abatement in the Czech Republic," 2008.

While CCS remains a difficult path and risky path for Estonia, its potential to singularly achieve over 90% of Estonia's needed emissions reductions make it an important alternative measure for consideration. Given that the majority of CCS costs are in the capture stage, where technologies are most immature and have the ability to be adapted specifically to oil shale power production, we recommend support for research into capture technologies tailored to the Estonian situation, while adopting a "wait-and-see" approach on the development of global CCS projects and the price of oil.

CO2 emissions taxation (Guideline 6)

Guideline 6: Large-scale energy and industrial CO2 emission taxation policy should be based on a pan-European ETS system. Tax policy instruments aimed at further reduction of CO2 emissions can be applied to the energy production and other industrial sectors, which will remain under the ETS system if it is economically justified and if it helps to contribute to the goal of reducing national CO2 emissions.

As Guideline 6 points out, large-scale energy production as well as industrial energy consumption will be subject to the pan-European emissions trading system (ETS), which in theory can push these companies into reducing the carbon intensity of production, thereby helping Estonia to meet its national emissions targets. Indeed, ETS systems are often described as "cap and trade" implements, whereby a hard ceiling on emissions is declared, forcing companies that wish to emit carbon dioxide to then buy permits auctioned on an open market. If the ceiling is hard enough, more carbon-intensive fuels such as oil shale will clearly become more expensive.

Carbon pricing

Source: 2015 Energy Trilemma Index (https://www.worldenergy.org/wp-content/uploads/2015/11/Trilemma-what-is-the-energy-trilemma.jpg)

However, prices for those permits have been dropping recently, lowering the incentive for companies to use cleaner energy and making oil shale more cost effective.[49] The impact of the ETS on the incentive structure of companies like Eesti Energia has been further reduced by the fact that the Estonian government has not allowed it to retain

[49] Ibid., "Could Estonia's oil shale bolster Europe's energy security?"

the income from the sale of permits to invest in its own facilities; instead, these funds were diverted to general government revenues.[50]

Even under a weak scenario (in which a more effective ETS is not implemented at the European level), however, the Estonian government could still likely pursue at least some similar CO2 reduction instruments—in part because it will still need to meet broader commitments it has made abroad, and in part because it would like to foster the growth of renewables production at home. *Moreover, given the global trade in renewable-energy certificates, under a weak scenario Estonia can actually export renewable electricity in this fashion—even in quantities larger than it needs at home*.

In a strong scenario, of course, an aggressive ETS system would provide a powerful incentive for plants to reduce emissions, especially given the mooted timeline that would increase the share of allowances-based production beginning in 2020. The resulting cost of allowances could dramatically change the economics of efficiency measures and shorten the time needed to recoup costs in carbon reduction—albeit at significant harm to the oil shale production industry, as mentioned in our discussion of the previous guideline as well as elsewhere in this report.

Renewable Energy (Guideline 7)

Guideline 7: Heat and electricity production should gradually begin to rely more widely on renewable domestic sources of energy, with a view towards increasing societal well-being and the need to ensure energy security/security of supply.

Guideline 7 calls for the gradual introduction of renewable electricity and heat to reduce carbon emissions and increase energy security. Estonia has significant potential for wind power generation, which under the projected climate roadmap constitutes the majority of Estonian power generation by 2040.

The benefit of wind as a zero emissions source of power is obvious from a climate change perspective. **The interaction of wind power and energy security is, however, more complex.** As part of a diversified and appropriately balanced portfolio, *wind can strengthen energy security by reducing the need for energy imports*, by reducing depletion of domestic fossil fuels, and by its sustainable nature. High penetration wind power, however, without a high proportion of backup capacity or storage, is insufficient to ensure security of supply for Estonia.

Wind is an intermittent source of electricity and is thus an imperfect substitute for dispatchable power such as thermal generation.[51] In addition to being intermittent, wind production is highly correlated on a regional scale.[52] Correlated wind patterns reduce the extent to which wind's intermittency can be mitigated by networking geographically dispersed wind farms. Assessments of European wind power suggest wind patterns are highly correlated on the continental scale and that Estonia is poorly

[50] Airi Andresson, "EU GHG emission trading system: effects on Estonian electricity sector", National Audit Office of Estonia. http://www.environmental-auditing.org/LinkClick.aspx?fileticket=8fJhzL4Ohz8%3D&tabid=254

[51] Paul L. Joskow, "Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies," *American Economic Review,* 101, no. 3 (2011): 238-41. http://web.mit.edu/ceepr/www/publications/reprints/Reprint_231_WC.pdf.

[52] Cosseron, Alexandra, C. Adam Schlosser, and U. Bhaskar Gunturu., "Characterization of the Wind Power Resource in Europe and Its Intermittency," Report no. 258, MIT Joint Program on the Science and Policy of Global Change, 2014. http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt258.pdf.

positioned geographically to reduce variability via interconnection of wind farms in Estonia and neighboring countries.[53]

The problems of intermittency at high-penetration can be mitigated by dispatchable backup generation capacity—either domestic or imported—or energy storage. Since Estonia lacks the topology for significant pumped hydro storage and since chemical based energy storage has not been demonstrated at utility scale, we do not consider energy storage as a likely solution in the foreseeable future. Import can also become problematic if connected countries also adopt high wind penetration portfolios.

As long as wind remains at low-penetration levels the rest of the system can adjust for the variable profile of wind generation, but as wind generation increases the costs for the rest of the system to adapt increase. At an eventual level of intermittent generation, the costs to dispatchable generators of excessive ramping and reduced revenues from decreased capacity factors will result in dispatchable generators leaving the market. Under the current regulatory system, the responsibility would then fall to Elering, the transmission system operator, to supply electricity in the event of low wind output. Already Elering has invested in additional emergency capacity, the need for which will increase with renewable penetration.[54] Since emergency generators operate, by definition, at low capacity factors (i.e. they operate for only a few hours out of the year) they are not profitable ventures and their cost is passed on to consumers in the form of network tariffs. Thus, even if the costs of wind power is lower on a levelized cost basis, wind power will likely be significantly more expensive than thermal plants due to the hidden cost of increased dispatchable reserve power.[55] *If natural gas is used to supply reserve power additional security of supply concerns are raised*. Elering's newest reserve plant at Kiisa provides a potential solution maintaining flexibility to run on natural gas or fuel oil. [56]

The question of who pays the cost of integrating intermittent power is the central policy question guiding the long-term development of wind power in Estonia. A strong market based approach could internalize the system costs of intermittent power by requiring wind capacity to be coupled with available dispatchable generation, passing the cost on to producers which introduce intermittency to the system. While notionally fair, such a policy would slow the deployment of wind power in Estonia and the reduction of greenhouse gas emissions. An alternative market mechanism would provide for capacity markets, where dispatchable generators are paid to be available by the government or TSO (passing costs on to electricity consumers). This mechanism would be conducive to investment in wind power, but more costly from a system perspective as grid stability becomes an exploited commons. Aspects of this system are already in place under the current Electricity Market Act, which pays for the availability of qualifying power generation should carbon prices rise and under Elering's responsibility to provide emergency reserves as the national TSO.

McKinsey estimates the **cost of carbon abatement from wind power at 76 EUR/t** CO2e for the Czech Republic.[57] Since the Czech Republic has poor wind resources,

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[53] Ibid.
[54] Elering, "Emergency Reserve Power Plants Inaugurated in Estonia," 2014. http://elering.ee/emergeny-reserve-power-plants-inaugurated-in-estonia/.
[55] Paul L. Joskow, "Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies," *American Economic Review,* 101, no. 3 (2011): 238-41. http://web.mit.edu/ceepr/www/publications/reprints/Reprint_231_WC.pdf.
[56] Elering, "Emergency Reserve Power Plants Inaugurated in Estonia," 2014. http://elering.ee/emergeny-reserve-power-plants-inaugurated-in-estonia/.
[57] McKinsey & Company, "Cost and Potentials of Greenhouse Gas Abatement in the Czech Republic," 2008.

Estonian costs would be reduced since constructed wind farms would be more productive. On the other hand, the poor capacity for wind in the Czech Republic serves to limit the proportion of intermittent power in the Czech system, keeping costs down. Estonian costs for low levels of wind penetration would likely be lower than the Czech estimates, but at higher levels of penetration Estonian costs would be significantly higher than the estimate. Given that the Estonian system capacity to absorb variability is complex and uncertain the point at which wind power imposes steeper costs and should be considered “high-penetration” is uncertain.

> *Given its local potential, wind will be an important part of Estonian supply, but it is necessary to understand the full costs of wind at a system level and its limitations as a source of reliable power if the climate roadmap is to reduce emissions in a way that is both cost effective and ensures secure energy supply.*

Biomass (Guideline 8)

Guideline 8: The state will promote the development, research, and cost-effectiveness/sustainable added value of renewable energy production technologies and of biomass.

Increased use of biomass as a primary energy source is encouraged by Guidelines 7 and 8. Guideline 7 calls for an increase in domestic renewable generation generally and Guideline 8 specifically targets increased use of biomass through government support and regulation ensuring sustainable use between both energy production and other value added products.

Unlike wind power, biomass is a source of dispatchable power and does not face the grid integration issues characteristic of intermittent renewables. Given its domestic source and dispatchability, biomass readily meets Guideline 7’s stipulation that renewables be used to increase Estonian energy security. Expansion of biomass, however, faces limits to the extent it can be used economically and sustainably.

The most sustainable use of woody biomass is to limit production to sustainably sourced residues. This ensures use is sustainable, does not increase ecological impact, and does not compete with higher value added wood based products. In 2006, sustainable production of wood residue was estimated at 1.5 million cubic meters per year, containing 2.7 TWh of energy content.[58] This is a conservative estimate of the sustainable use ceiling and compares to an expected electricity consumption (plus losses) of 12.7 TWh annually in 2050 and 4.5 TWh for heat.

Of course, the full energy density of wood cannot be transformed into useable product. IEA estimates modern, biomass fueled, combined heat and power plants can operate at 85-90% efficiency.[59] This, however, assumes a suitable market for generated heat exists and is often the limiting factor, as this arrangement produces more heat than electricity and *electricity demand typically exceeds the demand for heat*, especially in warmer seasons. Given its greater efficiency, greater profitability, and current subsidies, most of the recent growth in Estonian biomass has been in the form of CHP plants. Power only biomass plants typically operate at 33-45%

[58] Inforse, “Sustainable Energy Vision for Estonia,” 2011. http://www.inforse.org/europe/pdfs/Estonia-note.pdf
[59] IEA, “Biomass for Power Generation and CHP,” 2007. https://www.iea.org/publications/freepublications/publication/essentials3.pdf

efficiency.[60] Co-firing biomass with coal or oil shale can achieve similar efficiencies as dedicated biomass power only plants, but is limited by the proportion of the biomass feedstock that can be accommodated. Typical pulverized coal plants can use 10% biomass feedstock with minor adjustments and up to 20 with additional retrofits.[61] Switching pulverized coal plants to a 15% forest residue co-fire can reduce emissions by 12% including lifecycle emissions from processing and transport. Circulating fluidized bed (CFB) combustion, the technology used by Estonia's newest oil shale plants, is more flexible and is thus better suited for co-firing higher proportions of biomass. Adjusting current oil shale CFB boilers to co-fire with biomass would require important updates to fuel feeding mechanisms and change the ash content, affecting possible downstream uses of ash, but would require a relatively low capital cost. Alternatively, new CFB plants such as Eesti Energia's Auvere plant can be specifically designed for co-firing oil shale with biomass; the **Auvere plant can operate at up to 50% biomass, reducing the CO2 emissions by half**.

In additions to limitations to sustainable use, biomass faces unique economic limitations. Unlike most forms of power production where economies of scale tend to favor fewer, larger, centralized plants, the low energy density of unrefined biomass limits the optimum size of biomass plants. Given that woody biomass is bulky for its relative energy content, the costs of collecting, transporting, and storing biomass are higher than conventional fuels. Furthermore, the farther biomass is transported in fossil fuel burning vehicles, the weaker the assumption that biomass is a carbon neutral source of energy becomes. Limitations to size increase capital costs per unit of generating capacity compared to larger plants of the same type. Similarly, the small-medium sized operations best suited to biomass use may face difficulty securing financing for new capacity.

The conditions of the overall energy market will also affect the economics of biomass plants. Wood, as a more marginal source of energy, becomes more attractive as other fuel prices increase. Recent growth in biomass has been buoyed by rising oil (and thus oil shale) prices as well as rising costs of natural gas. Now that oil and gas prices have fallen precipitously, the economic forces for further increases in biomass capacity are weaker. The previously discussed disadvantages of low energy density are exacerbated by cheap access to higher energy density fuels. Given the high risks posed by a fluctuating energy market and the small size of biomass plants, the IEA reports that even if oil shale combustion declines, insufficient market forces may exist to increase biomass power generation.[62]

In the Czech Republic, McKinsey estimates the cost of GHG abatement from biomass at 59 EUR/ t CO2e, noting that GHG abatement is cheaper when building new gas fired capacity than new biomass capacity in the near term.[63] IEA estimates the costs of new biomass capacity at $2400-$4200 per kW for units larger than 50 MW with capital costs increasing significantly for smaller plants. Transitioning current systems to co-fire biomass would be significantly cheaper at $300-$700 per kW.[64]

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[60] Ibid.
[61] Amanda D. Cuellar and Howard Herzog, "A Path Froward for Low Carbon power from Biomass," *Energies* 8, no. 3 (2015): 1701-15
[62] IEA, "Estonia 2013," 2013, pg. 112. https://www.iea.org/publications/freepublications/publication/Estonia2013_free.pdf.
[63] McKinsey & Company, "Cost and Potentials of Greenhouse Gas Abatement in the Czech Republic," 2008.
[64] IEA, "Technology Roadmap: Bioenergy for Heat and Power," 2012. https://www.iea.org/publications/freepublications/publication/2012_Bioenergy_Roadmap_2nd_Edition_WEB.pdf

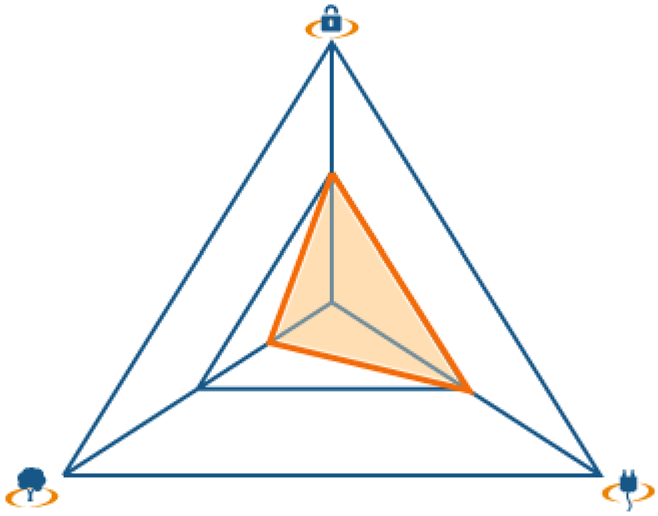
6. Summary of the impact of climate policy on energy security

As a preliminary conclusion we provide the estimates designed to measure the maximum amount of carbon abatement from a specific area holding everything else constant. The estimates we provide evaluate each specific means of operating a single policy lever and capture some portion of the total possibility and implication on costs and security effects. It is useful for getting a feel for the relative importance of certain areas.

Lever	Details/scenario	Gene-ration (TWh)	Demand Reduction/ Generation Curtailment (TWh)	New Emissions (kt/TWh)	Replace-ment Emissions (kt/TWh)	Abate-ment Poten-tial (kt)	Cost	Secu-rity	Notes
Building Efficiency	Reduce average residential building energy consumption by 20% by 2050	0	2,2	0	926	2037	+	+	
Oil Shale Transition	All oil shale use transitions from combustion to retorting and retort gas combustion due to high oil price and ETS (BAU_KPP Base Scenario)	5,38	9,10	465	1280	9160	+	O	* Security dependent on electricity generation replacement. 3.72TWhe generation gap
Oil Shale Transition	All oil shale use transitions from combustion to retorting and retort gas combustion due to strong government policy	5,38	9,10	468	1280	9160	-	O	
Oil Shale CCS	All Narva plants continue to operate but are retrofitted with CCS technology allowing 90% capture and storage	9,10	9,10	128	1280	10493	-	+	No Efficiency Penalty
High Penetration Wind Power	Wind Power up to 5% curtailment described by Elering (2175 MW)	4,19	4,19	0	1280	5366	-	?	
Low Penetration Wind Power	Wind Power up to 10% of current generation , assumed 22% capacity actor (average achieved capacity factor over 2010-2014)	1,12	1,12	0	1280	1434		O	
CHP Biomass	CHP combustion of 1.5 million cubic meters of logging residues at 85% efficiency	2,31	2,31	0	926	2139	-	+	
Biomass Co-firing	Narva plants converted to 20% co-firing of biomass leading to a 16% reduction in lifecycle CO2 emissions (pulverized coal analog, actual reductions should be greater)	9,10	9,10	1075	1280	1865	-	+	

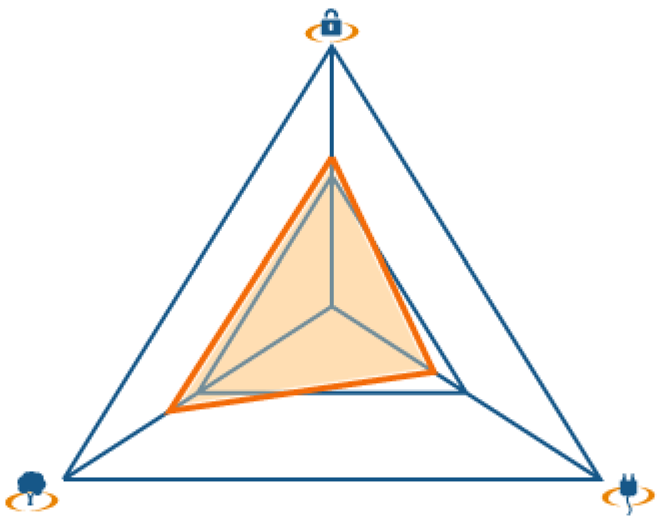
Estonian Energy Trilemma *before* the implementation of the Guidelines

Source: World Energy Council (http://www.worldenergy.org/data/trilemma-index/country/estonia/2015/)



Estonian Energy Trilemma *after* the implementation of the Guidelines

Source: forecast of the authors



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