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Fast track væk fra naturgas i Danmark og Europa

Forsyningssikkerhed, energipolitik og energiplanlægning i et sikkerhedspolitisk lys

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MARCH 8TH 2022

Fast track to independence of natural gas in Denmark and Europe

Security of supply, energy policy, and energy planning from a security policy perspective

By Brian Vad Mathiesen, Professor in Energy Planning at Aalborg University, and Pernille Hagedorn-Rasmussen, senior expert, Danish Society of Engineers, IDA

The world is undergoing our third energy crisis, and no one knows how long this crisis will last. This memo describes some options for action on a fast track to independence of Russian natural gas and of fossil gas altogether. Since the current crisis may last long and we also need to solve the climate crisis, the track leading away from the natural gas crisis is green. In this memo, the measures are divided into three time perspectives: Acute measures, measures with short-term effect, and measures with medium-term effect. Some of the proposals are measures that may find application at the EU level, and a substantial part of them are targeted at Danish political measures. It is assessed that Danish gas consumption can be reduced by up to 79% in 5 to 8 years through focused measures. In Europe and the EU, the challenge is harder due to the large dependence of gas for heating and power. Here it is assessed that consumption can be reduced by 30% in 5 to 8 years. To attain this, however, major and radical changes in industry and heating supply in the short term are called for. In an acute situation, Denmark/Europe can bring down consumption by 33% and 35%, respectively, conditional upon 10% energy savings in power and heating, and a close-down of industrial production or a switch to coal and oil. To reach a situation in which we are 100% independent of Russian natural gas, total consumption of gas in the EU must be reduced by some 31%. Consumption reductions can be supplemented with imports of natural gas from other parts of the world. It should be noted that the share of Russian natural gas fluctuates from one year to another in the total natural gas consumption of Europe and the EU.

Energy policy is also security policy

Energy policy turned into security policy and economic policy after the 1973 embargo. The huge dependence of oil and the first and second energy crises kickstarted various strategies in Europe to reduce our dependence of oil. In Denmark, this meant that standards were introduced to reduce the energy consumption in buildings, we saw campaigns for energy and power savings, and district heating and natural gas were expanded through coordinated heat planning. Furthermore, the focus on extraction of oil and natural gas in the North Sea gained momentum, and support schemes for the development of renewable energy were introduced, in particular for wind power. In addition, it was sought to expand the use of coal in combined power and heating - later also natural gas – as the generation of natural gas from the North Sea went up. In other parts of Europe as well, various strategies were introduced such as increasing the extraction of oil and natural gas and vast shifts to coal and nuclear power. This meant that countries such as the Netherlands and Great Britain have a huge consumption of natural gas, as natural gas was found in the underground just like in Denmark.

Denmark is in a good position in the present natural gas crisis compared with Europe in general; district heating is used for heating far more than in other countries, and our power generation has next to no natural gas in the production mix. In addition, we have relatively few industrial undertakings in

Denmark with very high natural gas consumption. Throughout the years, Denmark has led an energy policy and conducted an energy planning that has had a positive impact on security of supply, but also on climate and the environment along with innovation, jobs, businesses, exports, and the balance of payments.

The EU stands on the shoulders of the European Coal and Steel Community whose aim it was to work for more mutual trade and security of supply as a means to ensure peace in Europe. After some years, the European cooperation became the single market, but the EU failed in ensuring the security of supply in a number of areas, including energy. However, energy policy came on the agenda at EU level up through the noughties with more and more objectives in the field of climate. In the last two years the EU has also adopted a zero-carbon objective by 2050. This objective supplements the energy union that was launched by the previous Commission as a huge prestige project in 2015[1]. Many of the measures under the energy union have been successful in regard to renewable energy and energy efficiency both of which contribute to phasing out fossil fuel. When we look at the dependence of natural gas, however, there have been no other measures than those ensuring access to several markets. It is positive that LNG terminals have been established (liquid natural gas) and that the EU in general has access to several natural gas markets. At the same time, however, investments have primarily taken place internally in the EU gas infrastructure through infrastructure support in the so-called PCI lists (Project of Common Interest)[2], and there has been no focus on reducing the need for natural gas. By contrast, natural gas has been seen as a transition fuel in the phasing out of coal and oil and as a support to renewable energy in the proposal for a green taxonomy launched by the EU Commission recently. Everything indicates that this approach will now be changed for always. The magnitude of the challenge relating to a diversion away from natural gas differs much among the countries. Figure 1 shows the distribution of consumption among countries. The Danish share is extremely small by EU standards.

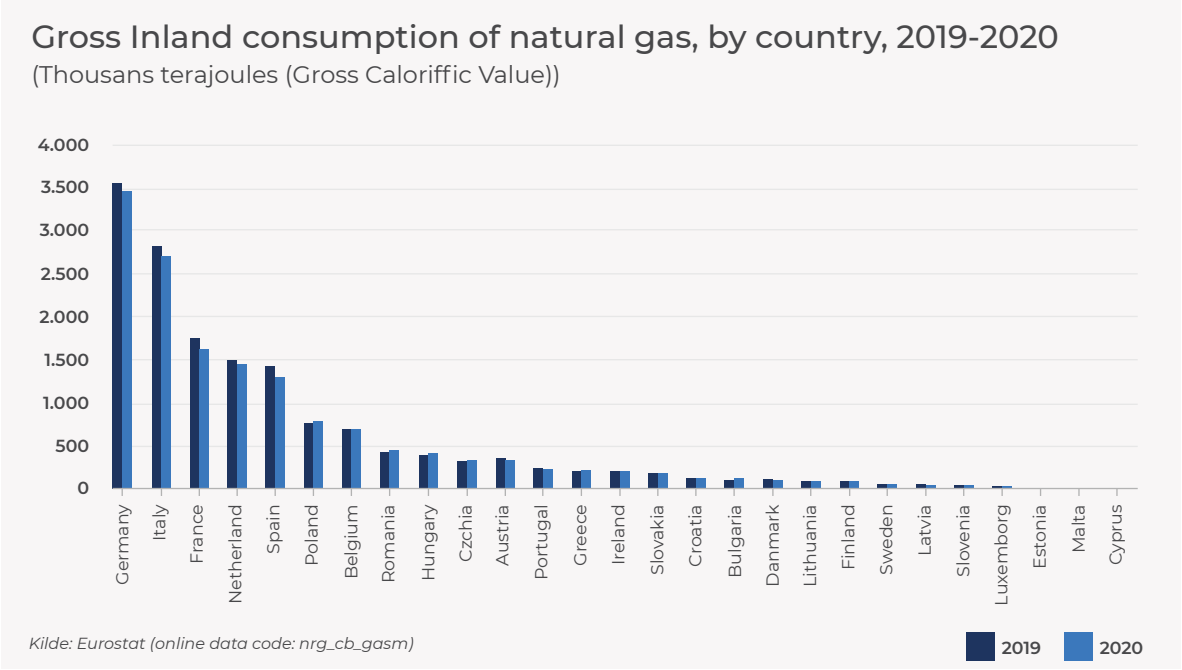

Figure 1, Consumption of natural gas broken down on EU Member States. Note: excl. Great Britain and other non-EU countries[3].

[1] energy.ec.europa.eu/topics/energy-strategy/energy-union_en

[2] energy.ec.europa.eu/topics/infrastructure/projects-common-interest_en

[3] ec.europa.eu/eurostat/statistics-explained/index.php?title=Natural_gas_supply_statistics

For many years, Denmark has been in a quite unique situation in Europe as we have been net exporters of energy. Since the beginning of the domestic natural gas generation in the early eighties Denmark has been self-sufficient and a net exporter of natural gas[4]. Right now, however, the largest oil and gas field, the Tyra field, is closed for redevelopment, making Denmark a net importer. The Tyra field is expected to reopen in June 2023[5]. In a Danish context and compared with Danish consumption, the Tyra field is large, but in a European context it only contributes modestly to total natural gas supply in Europe. Depending on the year and developments in Danish gas consumption we will be able to export between 40 and 60 PJ. This corresponds to some 3 per mil of the EU27 gas consumption of 15,000 PJ. The sources of European imports of natural gas, oil, and coal appear from Figure 2. Europe is not just dependent on imports of natural gas, but also of coal and oil. In 2020, 38% of EU27 imports of natural gas came from Russia. In 2010, this share was 31%. In 2020, the EU import dependence of natural gas amounted to 84%. This means that when looking at total gas consumption in the EU, EU Member States must bring it down by some 31% to overcome the dependence of gas from Russia by 100%.

Main origin of primary energy imports, EU, 2010-2020
(% of EU imports)

	Hard coal (based on tonnes)										
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Russia	22.4	21.9	20.2	23.9	25.1	26.4	28.7	35.4	39.5	43.5	49.1
United States	15.3	16.6	20.7	18.5	17.0	12.4	11.9	14.8	17.3	16.8	15.2
Australia	9.6	8.2	8.0	8.8	7.5	11.1	15.3	10.8	11.0	13.1	13.5
Colombia	15.4	18.6	19.1	16.4	17.0	19.3	18.7	15.9	12.6	7.7	5.4
Canada	1.9	2.3	1.9	2.1	3.1	1.6	2.3	2.4	2.4	2.2	2.3
Kazakhstan	0.2	0.3	0.3	0.3	0.7	0.5	0.6	0.6	0.9	2.1	1.8
South Africa	9.6	8.6	7.4	7.1	9.1	7.7	5.1	4.7	2.7	2.7	1.2
United Kingdom	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.9	0.7	1.0	1.1
Mozambique	0.0	0.1	0.0	0.2	0.3	0.5	0.7	1.2	1.6	1.5	0.8
Others	25.5	23.2	22.2	22.6	20.0	20.3	16.7	13.2	11.2	9.5	9.3
	Crude oil (based on tonnes)										
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Russia	34.7	35.1	33.9	34.5	31.4	29.7	32.4	30.7	29.6	26.8	25.7
Norway	7.7	7.2	6.8	8.1	9.2	8.4	7.9	7.7	7.2	6.9	8.7
Kazakhstan	5.6	5.9	5.3	6.0	6.7	6.8	7.0	7.6	7.1	7.3	8.4
United States	0.0	0.0	0.0	0.0	0.0	0.2	0.6	0.9	2.4	5.2	8.1
Saudi Arabia	6.0	8.3	9.1	8.7	9.0	7.9	7.7	6.5	7.4	7.7	7.8
Nigeria	3.8	5.6	7.2	7.2	8.3	7.7	5.2	5.8	7.0	7.8	7.7
Iraq	3.3	3.7	4.3	3.8	4.8	7.8	8.5	8.4	8.6	8.9	6.6
United Kingdom	5.6	4.5	4.4	4.2	4.2	4.0	4.1	4.1	3.9	4.9	5.6
Azerbaijan	4.5	5.1	4.0	5.0	4.6	5.3	4.6	4.6	4.6	4.5	4.6
Others	28.8	24.5	24.9	22.5	21.8	22.4	22.0	23.6	22.4	20.0	16.7
	Natural and liquified natural gas (based on terajoule (gross calorific value - GCV))										
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Russia	30.6	32.2	31.9	36.6	33.3	33.6	39.6	38.4	37.9	38.0	38.2
Norway	19.3	19.4	21.1	19.0	21.0	20.7	16.3	16.6	16.1	14.7	18.5
Algeria	13.1	12.2	12.1	11.1	10.5	9.5	12.3	10.5	10.8	7.2	7.5
Qatar	5.4	5.1	3.9	3.4	3.0	3.3	3.0	3.8	4.2	5.0	4.2
United States	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.6	2.9	4.0
United Kingdom	3.3	3.6	2.9	2.5	2.7	3.4	2.5	2.3	2.2	2.5	3.4
Nigeria	3.8	3.8	2.9	1.5	1.3	1.8	2.0	2.5	2.6	3.3	3.0
Libya	2.6	0.6	1.7	1.5	1.9	1.9	1.3	1.1	1.1	1.3	1.1
Others	22.0	23.1	23.3	24.4	26.3	25.9	23.0	24.5	24.6	25.1	20.1

Source: Eurostat (online data codes: nrg_ti_sff, nrg_ti_oil and nrg_ti_gas)

Figure 2, Imports of coal, oil, and natural gas to EU27, by country[6]

[4] ens.dk/sites/ens.dk/files/OlieGas/ressourcer_og_prognose_2021_dk.pdf

[5] corporate.totalenergies.dk

[6] ec.europa.eu/eurostat/statistics-explained/index.php

Gas and natural gas consumption in the Danish and European energy system

Taking our starting point in 2020 we must bear in mind the COVID-19 pandemic of this year; energy needs and consumption were different than, for instance, in the year 2018. Furthermore, higher energy prices have changed the market, and the war in Ukraine will also affect industrial production and exports. Therefore, there are a number of uncertainties associated with consumption expectations for the coming years. When computing total gas consumption, it is furthermore important to note that gas is traded on a market, and it flows in and out of Denmark. Natural gas in the Danish energy system primarily plays a role in relation to industry and heat generation. Stated in PJ the Danish primary energy consumption in 2020 amounted to 656 PJ, of which natural gas accounted for some 83 PJ or approx. 13% of our total energy consumption. Denmark furthermore has a generation of 21 PJ of biogas, most of which is upgraded (14 PJ) to enter the gas system. In 2020, biogas accounted for approximately 20% of the gas distributed in Denmark, and gas consumption stands for 16% of the energy consumption. Table 1 shows imports and generation of gas in Denmark.

	Natural gas	Biomethane	Biogas	Gas generation
Natural gas generation (excl. flaring)	50	-	-	50
Natural gas generation (incl. flaring)	63			63
Biogas generation in Denmark	-	-14	21	7
Biomethane generation (based on biogas)	14		14	
Netto imports	34	-	-	34
Natural gas flaring	-13	-	-	-13
Change in natural gas storage	-5			-5
Statistical difference	-4			-4
Total gas quantity in Denmark (incl. flaring)	87	-	21	109
Total gas quantity in Denmark (excl. flaring)	74		21	95

Table 1, Gas generation and imports in Denmark, 2020, according to Energy Statistics 2020 of the Danish Energy Agency (PJ)

When considering measures to limit Danish gas needs, one must take into account the entire quantity of gas consumed from the gas grid. A reduction of the gas consumption makes a difference whether it affects biogas or natural gas: all gas is distributed on a market, so all other things being equal it will reduce the need for imports of Russian gas to Europe. If the aim is to make Denmark and the rest of Europe independent of imports of Russian gas, all types of gas consumption are relevant. **All gas needs must be scrutinized and reduced wherever possible.**

[1] energy.ec.europa.eu/topics/energy-strategy/energy-union_en

[2] energy.ec.europa.eu/topics/infrastructure/projects-common-interest_en

[3] ec.europa.eu/eurostat/statistics-explained/index.php?title=Natural_gas_supply_statistics

	Natural gas	Biometh-ane	Biogas	Gas con-sumption	Distribu-tion
Power generation (CPH)	7	1	9	17	18,6%
District heating (mainly boilers)	10	2	1	14	14,2%
Industry	25	5	1	30	31,3%
Manufacturing industries	23	4	1	28	
Agriculture, forestry, and horticulture	1	-	-	2	
Building and construction	-	-	-	-	
Heating of buildings etc.	28	5	-	33	34,6%
Trade and services	7	1	-	8	
Single-family homes	17	3	-	21	
Blocks of flats	3	1	-	4	
Transportation	-	-	-	-	0,3%
Urban gas	-	-	-	1	0,7%
Losses etc.	-	-	-	-	0,1%
Totalt	70	14	11	95	100%

Table 2, Gas consumption in Denmark, 2020, Energy Statistics from Danish Energy Agency (PJ)

In industry, gas consumption amounts to 30 PJ corresponding to 31% of total gas consumption. 35% is used for heating of buildings; this can be replaced by district heating or heat pumps. There are around 380,000 natural gas heaters in Denmark consuming together around 21 PJ annually. In addition, there is a gas consumption just below 4 PJ in large buildings such as blocks of flats[7].

Of the remaining gas consumption, 14% is used for district heating generation and 19% for power generation. Natural gas in power generation has seen a steep decrease in recent years, and in 2020 natural gas accounted for 7 PJ or 4% of the fuel needs for power generation. The capacity relating to power generation is an important aspect of our security of supply of power. Therefore, the gas supply for power generating units is important – also acutely in a situation of deficient supply.

In 2019, the energy mix in the EU mainly consisted of five different sources: Petroleum products (incl. raw oil) (36%), natural gas (22%), renewable energy (15%), nuclear power (13%), and solid fossil fuel (13%)8. Internally in the EU we see a large variation among the countries; in Italy and the Netherlands, for instance, natural gas accounts for more than 35% of the energy mix, whereas in Denmark it only makes up 13%, as mentioned above. Around 40% of the final consumption is for heating, the remaining part is used for power generation and industry, respectively, including non-energy purposes[9].

[7] Gasanvendelse | Gasfakta

[8] Where does our energy come from? (europa.eu)

[9] acer.europa.eu/gas-factsheet

Natural gas is imported in gas pipes, primarily from Russia and Norway, but also to a minor extent in the form of LNG by ship; here, the United States and Qatar are significant suppliers to the EU, just above Russia10. In 2021, gas from Russia made up around 35% of EU+UK total gas imports[11].

Europe, and thereby Denmark, must be prepared for a situation where natural gas from Russia is shut off. If Russian gas is acutely shut off, Danish companies will be decoupled from the gas grid to secure heat customers. In the other EU countries, we see similar plans.

If a situation of gas shortage arises all of Europe will be affected. Denmark is in a good position, but should Denmark see shortage of gas we have contingency plans in compliance with EU legislation. In case of acute lack of gas, authorities may launch various emergency measures to comply with the EU requirement for security of supplies.

It may be necessary to switch to other fossil fuels in the period from a sudden shut off of supplies up to and after the winter of 2022/2023. Some companies can relatively easily switch to oil, while other companies in the EU can switch to coal. In Europe as a whole, we must furthermore increase our requirements for gas storage to prepare for a harsh winter.

If we are to become independent of Russian natural gas, we need planning - Danish and European energy planning. In the short term, a strict prioritisation is called for, and especially the 2022/2023 winter can be critical[12]. In the medium term (5-8 years) we will be able to reduce consumption and secure autonomy through other sources, such as biogas generation and imports from the rest of the world.

The gas crisis shows all too clearly that we have not had enough focus on energy planning, neither in Denmark nor the EU, and we have failed to take the consequences of the safety elements associated with the energy system.

The green transition is the answer to diversion away from natural gas and fossil fuels in the medium term.

In the fastest and smartest possible way Denmark must become independent of natural gas and contribute to the EU doing the same. Since 2006, IDA has drawn up four visions for Denmark's roadmap away from fossil fuels towards renewable energy. Most recently in 2021, IDA presented our Climate Response 2045[13]. In the EU, we have an objective of a zero-carbon Europe in 2050.

There are a number of scenarios for an energy efficient energy system in Germany and Europe, based on renewable energy in 2050[14]. It is decisive that we distinguish between temporary, acute solutions, transitional solutions, and solutions in the medium-term perspective; and it is decisive that these solutions do not constitute a barrier or a decelerator to a zero-carbon energy system in the EU and Denmark no later than by 2050.

[10] bruegel.org/2022/01/can-europe-survive-painlessly-without-russian-gas
Three countries provided almost 70% of liquefied natural gas received in Europe in 2021

[11] extranet.acer.europa.eu/en/Electricity

[12] bruegel.org/2022/01/can-europe-survive-painlessly-without-russian-gas

[13] energyplan.eu/IDA2045/

[14] Tyskland: sciencedirect.com/science/article, Europa: sciencedirect.com/science/article

At the moment, we see very high prices of power, natural gas, and petrol and diesel, and this leads to a significant reduction in consumption. Focused energy saving campaigns can furthermore reduce the pressure on the European energy supply. Savings should also be directed at countries with large shares of renewable energy or nuclear power as well as district heating. If, for instance, we lower the temperature by one degree, we save around 5% of the energy consumption for heating. If we bring down Danish power consumption, we will be able to send more wind turbine power to Europe. Bringing down consumption of oil for transportation gives better opportunities for us replacing natural gas with oil in other fields. All savings will have a positive impact. Focused campaigns can originate from different channels. They may be coordinated nationally, but it is possible to combine them with a commitment of local utilities to conduct focused campaigns and to focus their efforts.

In 2009, the EU adopted a regulation on gas supply security in the wave of the first Ukraine crisis[15]. By and large this regulation is similar to what we already had in Denmark. It secures supply of gas to power and heating customers by requiring how much natural gas must be in storage, and by having a list of companies with large consumption that can be shut off in an emergency situation. This model has worked for around ten years. The EU should consider introducing higher requirements in the present situation and develop a model for natural gas that can handle major incidents, for instance by increasing the requirements for storage. Historically, stocks of coal and oil have secured the emergency preparedness and security of supply of countries. In the present situation, the emergency preparedness for oil and coal in relation to stocks and interruptible consumption should be revisited, since already now we see very high prices, and since we are to expect that part of the natural gas consumption will be replaced by oil and coal in the acute, short-term situation.

The EU should enter international agreements to secure further delivery of natural gas through LNG terminals as well as oil and coal to Europe in an acute situation. Such agreements can alleviate the worst consequences in a deficiency situation by setting more stringent requirements for storage. Such measures, evidently, should not be a barrier to a real transition to renewable energy and application of energy efficiency.

It is a precondition for a fast transition that manpower for design, approval, and establishment of new equipment is available and that the production capacity for such technologies is adjusted upward. In Denmark, we already have labour shortage within, for instance, the expansion of district heating, and the labour market is tight in the construction, design, and approval stages. Denmark and the EU should make sure that labour is channelled to the green transition focusing on a phaseout of natural gas in the coming years. The supply chain for key technologies such as district heating, heat pumps, wind turbines, photovoltaic panels, insulation materials, and technologies for the electrification of various types of industry must be secured. To avoid bottlenecks, supply chains within logistics, materials, and production capacity should be examined acutely in view of alleviating any problems that may hamper the transition in the short-term perspective.

The transition calls for consideration of a number of issues of importance to the long-term transition. This covers, for instance, securing power capacity, but also ensuring fewer operating hours along with the expansion of renewable energy. Another issue is a full stop to the establishment of new gas needs in the heating sector, industry, and the transportation sector. In addition to using coal and oil in an acute situation in which we must considerably scale down our natural gas consumption we can increase the quantity of biomass and examine whether to continue the operation of nuclear power plants. For biomass, coal, and oil we must make sure that consumption is diverted to power when and if it is possible after the end of the acute situation.

[15] energinet.dk/Gas/Forsyningssikkerhed/Den-danske-forsyningssikkerhedsmodel

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For Denmark, a fast transition of the gas consumption in industry, in home heating, and in district heating will efficiently divert us from the need for imports of gas. Thereby, Denmark will also take up less of the gas generated in Europe, so it can be used in the rest of Europe. In Denmark, we can also speed up our plans for the generation of biogas and examine if it is possible to accelerate the completion of Baltic Pipe (natural gas pipe between Norway across Denmark to Poland) and the completion of the Tyra field. Baltic Pipe will be able to transport around 380 PJ, corresponding to 3-4 times the present Danish gas consumption and to 2.5% of the EU natural gas consumption. Biogas, the Tyra field, and Baltic Pipe will each give a major contribution to the Danish consumption of gas, but only a minor contribution at the European scale.

Whether or not we end up with a sudden shut off of gas imports and imports of fossil fuels in general, it is necessary to think strategically about which measures will reduce the need for gas in the fastest possible manner. In this context it must be decided to which extent and how the generation of green gas must remove our dependence of natural gas. **We must act acutely** and at the same time establish measures that make a difference in the **short-term perspective of 2-3 years;** other measures must also be decided fast but will only make a difference in the **medium-term perspective of 5-8 years.**

Acute European measures and shutdown in case of sudden stop to Russian gas

- **Information about energy savings.** All European countries should launch citizen-focused information campaigns on energy savings in the power and heat consumption in homes, preferably coordinated with local utilities that are already in contact with citizens and companies. It should also be considered to make energy saving campaigns in the field of transportation, liable to reduce the pressure on Europe's oil consumption.
- **Updated emergency preparedness towards fossil fuels.** The EU should consider introducing higher requirements than in the present model for emergency preparedness towards natural gas, for instance by increasing the requirements for storage. In the present situation, the emergency preparedness for oil and coal in relation to stocks and interruptible consumption should be revisited. The purpose is in an acute situation to be able to secure consumption critical to society, such as power and heating as well as selected industries. Higher requirements for the filling rate of gas stocks must alleviate an even more critical situation in case of a harsh winter in the heating season of 2022/2023; it cannot, however, prevent that we may have to shut off selected companies in a not-too-distant future.
- Temporary fuel shift to coal and oil and international agreements on imports of LNG, oil, and coal. Through international cooperation the EU should secure agreements on imports of LNG, oil, and coal deliveries with the aim to increase production outside Russia over a number of years, and to enable a situation quickly to become independent of natural gas from Russia. Such agreements must have a temporary nature not binding the EU to fossil fuel but enabling a real green transition.
- Acute safeguarding of manpower for projects aiming at the reduction of European dependence of natural gas. At the moment, we already see a number of bottleneck problems in Denmark when it comes to realisation of construction projects and engineering and approval assignments. At the EU level, manpower must be secured for energy efficiency measures, electrification, district heating, and the establishment of wind and solar power. This may be secured, for instance, through downscaling of major construction projects in voluntary agreements, through compensation or low-interest climate loans pulling manpower in the direction, especially, of the heating sector.
- Full stop to establishment of all new gas needs. It must be safeguarded that we do not establish new gas consumption in industry, in home heating, and in the transport sector. Peak and reserve load in the power and heating sectors must be exempted from a complete shut-off. In a longer-term perspective, this element must be covered by biogas etc.

Acute Danish measures and shutdown in case of sudden stop to Russian gas

- **Launch of citizen-focused information campaigns on energy savings.** Coordination of communication nationally and commitment from utilities to conduct campaigns on savings in power, heating, and energy consumption in general, preferably in cooperation with energy companies.
- **Broad national cooperation on emergency preparedness in the energy supply sector** presenting proposals across authorities, companies, and organisations for how to manage the crisis, and safeguarding of dialogue and coordination among players in Denmark. Work should be done continuously in the coming years with input to an emergency preparedness plan for energy supply in the EU. In addition, knowledge-sharing should be ensured among companies in Denmark and the EU affected by a shutdown about technologies liable to secure a fast green transition within the different industries.

- **Fast-working national task forces focused on the transition to district heating, transition of industry, and individual heat pumps**
    - Cooperation across authorities, utilities, and major natural gas companies on a fast reduction of the natural gas consumption, including knowledge-sharing, coordination of purchasing measures, and acceleration of the transition.
    - Central unit or travel unit to support analyses and project assessments in relation to authority tasks that are normally assumed in the local authorities with focus on district heating.
    - Identification of bottlenecks on the labour market and investigation of options for alleviating delays in the transition, for instance through new priorities and discontinuation of other projects, on a voluntary basis or through compensation, with foreign manpower, etc.
    - Stop imports of other forms of energy from Russia, such as biomass, coal, and oil, and secure supplies through new international agreements in EU cooperation (cf. above).

European measures effective in the short-term perspective (2-3 years)

- Ensuring the continuation and institutionalisation of energy saving campaigns when the acute situation is over.
- **Widely branched measures regarding energy efficiency and electrification of European industry.** This includes the establishment of knowledge centres/energy advice/travel units distributed on sectors, establishment of support schemes similar to the Danish model in which you can get support for transition to power or district heating, if you have a concrete project proposal with payback periods. Projects with long payback periods (4-10 years) and large potential reductions of natural gas consumption should have priority. With the present high energy prices, projects with short payback periods are expected to be implemented without or with minor support. Knowledge centres divided according to industries can secure the dissemination of knowledge on energy optimisation of internal processes, knowledge on electrification and temperature limitations, industrial symbiosis among neighbouring companies, use of district heating in companies, and transmission of surplus heat for district heating in nearby homes.
- **Establishment of foundation for new start of at least 8,700 district heating grids in Europe by 2030[16].** Europe has almost as much surplus heat as it takes to ensure home heating. Support for new facilities may be limited to 20% of construction costs, dependent on local ownership and on whether there is a plan for the stepwise expansion to the rest of the city.
- **Securing the EU supply chain for energy technology** for the establishment of wind turbines, photovoltaic panels, district heating, individual heat pumps, and electrification of industry. To avoid shortages in logistics, materials, and production capacity in key industries in the green transition all parts of important supply chains should be investigated, and all problems should be addressed.
- **Establishment of several LNG terminals in European ports.** Germany has just informed about their plan to establish several LNG terminals, and this may also be relevant in other parts of Europe.

[16] energinet.dk/Gas/Forsyningssikkerhed/Den-danske-forsyningssikkerhedsmodel

- **Security of supply for power capacity.** All power generating plants in Europe that are able to generate power do so at the moment due to the price level. If there are capacities within coal and nuclear power that were planned to be closed it should be investigated whether such facilities can stay in operation. For example, it should be investigated whether nuclear power plants in Germany planned for closure in 2022 can be kept in operation in due consideration of safety and economy. Generally, it is a problem in Europe that power capacity is closing due to lower operating time, because we need to maintain power capacity, but reduce operation time in order to balance renewable energy. It should be considered to establish a capacity market or to secure power capacity through public means. Already today, part of the power capacity at decentral plants in Denmark has disappeared, and in several locations in Europe there is a risk of power shortage.

Danish measures effective in the short-term perspective (2-3 years)

- **Ensuring the continuation and institutionalisation of energy saving campaigns when** the acute situation is over.
- **Revisit support schemes for energy efficiency and electrification of industry.** Projects with long payback periods (4-10 years) and high potential reductions of natural gas consumption should have priority. Campaigns should be focused on different sectors, and energy advice/travel units targeting small companies should be established (cf. above).
- **Requirements for heat planning in the 98 Danish municipalities** in view of establishing a basis for each building owner to know whether district heating will be established in the area, or whether to establish an individual heat pump. Find inspiration in Varmeplan Danmark 2021 (Heat Plan Denmark)[17].
- **Setting up requirements for duration of municipal case handling** concerning district heating to put a stop to the purchase of new gas boilers.
- **Prioritising large buildings and building complexes with gas supply.** Prioritise connection of large buildings, such as blocks of flats and public buildings to the district heating grid. In the reduced rent accommodation sector alone, 40,000 homes are heated with natural gas.
- **Providing better options for district heating utilities to take over natural gas boilers** before establishing district heating. This is to ensure that district heating is expanded where there is a heat basis and that it is not undermined by individual heat pumps. It can be supplemented with district heating utilities setting up heat pumps on a temporary basis. If needed, more funds must be set aside for this element.
- **Securing domestic power capacity.** Security of supply within power must also be secured in Denmark and Europe. Some natural gas is used for power and heat generation. This capacity should remain on gas. Biogas should be prioritised for power generation and use in industries where it is not possible to convert to power.
- **Clarifying whether biogas generation can be increased.** Biogas covers a good 20% of gas consumption. It should be investigated whether it is possible to increase biogas generation without having major derived effects on our food production, for instance in the form of reduced areas available for food and competition towards feed for pigs and cattle. Increasing quantities of biogas must not lead to a larger consumption of gas in general, and it must not be seen as a Danish security of supply, but as a contribution to European self-sufficiency. Denmark is and can become a larger net exporter of biogas[18].

[17] energinet.dk/Gas/Forsyningssikkerhed/Den-danske-forsyningssikkerhedsmodel

[18] IDAs_klimasvar_2045_ver_02062021.pdf (aau.dk)

European measures effective in the medium-term perspective (5-8 years)

- **Continuing efforts within energy savings** across utilities. This includes sharing of experience among utilities in the Member States.
- **Securing continuous improved anchoring** of transition to district heating and electrification of industries in the different Member States. This includes dissemination of best practice regarding energy planning, approvals, and case handling.
- **Securing that the "Energy Efficiency First" principle is implemented** in all sectors consuming energy, including regulations for buildings, industry, and transportation. Objectives regarding energy efficiency in the EU are high as it is. They do not need enhancement in general. However, there is a need for them to be implemented in the Member States and that they are followed up by new instruments. When it comes to buildings, directives must focus on the climate shield, and site-specific thinking should be avoided, as it impedes the establishment of district heating solutions; focus should be more on the climate shield.
- **Common EU energy policy to focus also on security and self-sufficiency in renewable energy**
  The climate agenda must be supplemented with security and supply, and many tracks are possible. Reducing dependence of petrochemical production for chemicals industry, for instance ammonia through Power-2-X.
  For renewable energy coordinating measures must be implemented concerning the planning of offshore wind with special focus on the North Sea. For onshore wind, best practice should be shared across countries, and for photovoltaic panels19 focus should be on having the market drive the establishment of photovoltaic panels on large roofs of more than 100 m2. The power markets in Europe should be sub-divided and be more cost-real, for instance a division of Northern and Southern Germany. The EU should survey foreign ownership of infrastructure critical to society and promote local ownership in new renewable energy projects, district heating, etc. in view of future-proofing our energy infrastructure and supply. It would be a benefit to promote initiatives for local energy communities.

Danish measures effective in the medium-term perspective (5-8 years)

- **Long-term planning for expansion of renewable energy.** Long-term planning for expansion of renewable energy, on as well as offshore. Location of new renewable energy is a key issue for us to achieve synergies and minimise costs associated with the grid. This must include a plan for location offshore, and Denmark needs a political prioritisation of the areas.
- **Surveying the possibilities of a revision of the renewable energy act.** The renewable energy act should give more incentives for local plot owners and citizens' groups to find ideas and to become co-owners of renewable energy facilities. The compensation scheme must be replaced or supplemented by requirements for local co-ownership.
- **Wind and solar power planning in municipalities.** Onshore wind turbines constitute the cheapest form of power generation. All local authorities should revisit their wind turbine plans to find further possible locations. The solar power field should be subjected to a similar planning process in which a national overview in a solar power strategy is supplemented with a designation of suitable areas with industrial roofs and other areas. Photovoltaic panels should not be uncritically established on agricultural land. It might be considered to introduce green, amber, and red zones based on input from Danish transmission system owner Energinet about weaknesses and strengths of the grid or about areas that have already much renewable energy. Both of these elements should take the grid into consideration. The location of renewable energy should focus extensively on the present and future location of power consumption; this should avoid that the grid becomes a bottleneck and that facilities are not delayed or unnecessarily costly.

- **Moving from stand-alone tendering to cluster tendering of renewable energy projects.** Denmark is planning to establish 5-6 GW of new offshore wind capacity by 2030. Historically, Denmark has tendered one offshore wind turbine project at a time in view of supporting a predictable and stepwise establishment of the offshore wind industry and its value chain. This pace can be increased by streamlining authority processes and focusing on clusters of offshore wind farms where the entire package is tendered on the market in one batch.
- **Clarifying whether the objective of 100% green gas in Denmark can be brought forward to 2030.**The Danish Green Gas Strategy from 2021 has an objective of 100% green gas in 2035 in the Danish gas consumption. If the objective is brought forward to 2030 and the expansion of biogas generation is speeded up, Denmark may become a net exporter earlier than expected. Increased generation must take into consideration our food production.
- **Increased national and municipal integrated strategic energy planning** including tasks relating to the definition of district heating areas and promotion of establishment and realisation of energy savings, and removal of zonal barriers to geothermics, large heat pumps, large heat stocks, etc. Strategic energy planning includes transportation, Power-2-X, etc. Regional planning processes with non-binding strategies may make way for the location of new renewable facilities in a way that they are integrated in the cheapest and smartest possible way in the energy supply system, and that the energy planning is coordinated across municipalities.
- **District heating coverage of 63-70%.** Heat planning and initiatives with an effect in the short-term perspective are continued so that the district heating coverage reaches between 63 and 70% in 5-6 years, along with ensuring that other built-up areas get individual heat pumps.
- **Ensuring utilisation of surplus heat.** The rules on utilisation of industrial surplus heat have been revised, and options for the establishment of geothermics have been improved. This area should be monitored so that still more quantities of surplus heat are utilised and that sources from Power-2-X, data centres, and geothermics can create a more robust supply.
- **Exploring the possibilities of establishing large district heating transmission pipes.** The possibilities of connecting more industrial surplus heat and exploiting renewable energy and of connecting new homes that used to use natural gas are potentially better in the transmission of heat over larger distances. In the light of high energy prices, the possibilities of establishing transmission grids in Eastern Jutland and from Kalundborg over Holbæk to Roskilde and the Greater Copenhagen area should be explored.
- **A revision of the power markets and zoning** must ensure more local exploitation of renewable energy by having local power grid fees act as an incentive to turn on or off one's consumption instead of wasting renewable energy by turning off the wind turbines. In addition, the power markets should secure well-working PPA agreements ensuring the necessary expansion with onshore wind power, offshore wind power, and solar power, and it should secure the profitability of ensuring peak and reserve loads in the long-term perspective. This is a particular challenge due to a low number of operating hours. A change in fees may wisely be supplemented by planning and zoning of expedient locations of renewable energy and location of new consumption in relation to Power-2-X, data centres etc. The aim is also to ensure the utilisation of surplus heat and other synergies.

Danish transition away from natural gas

In a medium-term perspective, a 70% reduction of the natural gas consumption in Danish industry is possible, without a shift to fossil fuel. This reduction is primarily attained through electrification and to a minor extent from the introduction of energy efficiency measures in industry. A special challenge in a Danish context is the cement and chemical industries due to the need for very high temperatures; this limits the potential for electrification. At the global EU level, the picture is more or less the same - a reduction of at least 70% is possible in a medium-term perspective without shifting to fossil fuel. Just like in Denmark, the most challenging element in Europe is the chemicals industry followed by iron and steel production. Cement production is less predominant in a global EU perspective compared with the situation in Denmark. In industry, the transition pace up to 2030 as expected so far was modest in Denmark and Europe, and generally it did not result in a considerable reduction of the natural gas consumption, but in an increase of energy efficiency and renewable energy. With increased effort and determination in Danish and European industries, well-known technologies that are extensively accessible can be implemented, and the transition can be speeded up.

Electrification of industry, expansion of district heating and heat pumps will call for a substantially faster implementation than expected so far. With a focused effort, it is potentially possible in Denmark to arrive at a 100% natural gas phase-out in the heating sector in 5-6 years.

In total, the proposals for Danish measures sum up to a reduction of 79% of Danish gas consumption. This leaves Denmark with a gas need of some 20 PJ. This gap can be covered by biogas, thereby making us independent of imported gas regardless of the fate of Danish natural gas generation. In practice, the exchange takes place on an international market, so it is important that the Danish reduction in gas consumption also contributes to making Europe less dependent of imported gas. The Tyra field and Baltic Pipe, as mentioned, can contribute to a minor extent to the security of supply of Europe, each by about 2.5% of the EU natural gas need.

In this memo, we have not calculated the potential for a reduction of the natural gas consumption in Europe in the same detail as for Danish consumption. But in a 5-8 years' perspective the reduction potential is significantly lower when it comes to power and heating supply. A realistic guess would be a European reduction of 30% of the natural gas consumption overall, if industry is determined to shift to power as in Denmark, in case that 25% of the heating supply is changed, and if the power supply based on natural gas is kept at the present level, despite increasing power needs. Some of the reduction of the heat consumption can be attained by savings and some through the expansion of district heating.

If 38% of European imports consist of Russian gas, and the import share amounts to 84%, the EU must reduce its natural gas consumption by 31% to completely divert away from Russian gas. Thereby, there is a gap between 30% reductions in the medium-term perspective and the gas imports from Russia. In the medium-term perspective, this difference must be covered by increasing imports of LNG and, on a temporary basis, a shift to coal and oil. In this context it is important to point out that, firstly, more information can be brought forward about what measures each country will implement and, secondly, that it is uncertain to which extent it is possible to increase generation of LNG at the international level. It should furthermore be noted that the share of Russian natural gas fluctuates from one year to another in the total natural gas consumption of Europe and the EU.

In Denmark as in Europe, this situation calls for substantial energy savings - also in renewable energy consumption, along with the establishment of large quantities of new capacity within wind turbines and photovoltaic panels.

TJ	2020		Acute plan Winter 2022-23		Short and medium-term perspectives 2030
	Gas consumption	Measures	Gas consumption	Measures	Gas consumption
Power generation (CPH)	17.714	Savings	15.943	Savings, conversion to renewable energy in the power system (wind turbines and photovoltaic panels)	8.857
District heating (mainly boilers)	13.561	Savings	12.205	Savings, electrification, conversion to renewable energy (geothermics and solar heat)	2.712
Industry	29.917		4.742		8.490
Manufacturing industries	27.973	Omlægning til fossile brændsler og nedlukning	2.797	Savings, electrification	8.392
Agriculture, forestry and horticulture	1.594		1.594	Savings, electrification	80
Building and construction	351		351	Savings, electrification	18
Heating of buildings etc.	32.988	Savings	29.689		0
Trade and services	8.522			Savings, conversion to district heating, and individual heat pumps	-
Single-family homes	20.562			Savings, conversion to district heating, and individual heat pumps	-
Blocks of flats	3.904			Savings, conversion to district heating, and individual heat pumps	-
Transportation	332			Electrification	-
Urban gas	644			Electrification	-
Losses etc.	110				110
Total	95 265	Total reduction 33%	63.599	Total reduction 79%	20.168