ENERGINET

POSSIBLE SOLUTIONS FOR GAS NEEDS

Energinet's long-term development plan 2022 – Solution catalogue

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LONG-TERM DEVELOPMENT PLAN 2022 – SOLUTIONS FOR GAS

This report describes the possible tools which Energinet may use to address the needs identified in "Long-term development needs in the gas system". The solution catalogue should therefore be regarded as an extension to the report.

The aim is to obtain a clear picture of the planning activities, as a starting point for dialogue regarding the solutions which will be investigated and ultimately selected.

POSSIBLE SOLUTIONS FOR GAS NEEDS – NOW AND IN THE FUTURE

The green transition is picking up pace and presenting challenges for the Danish gas system, which must be adapted and developed if we shall avoid that it becomes a bottleneck in the climate transition. This requires wide-ranging decisions and timely solutions.

This solution catalogue provides a general overview of the many solutions and tools Energinet is working with to address identified needs in the gas grid. The catalogue will form the basis for close dialogue with stakeholders, and new solutions and tools can be added to the examples here to produce a common draft list of possible solutions. This draft list of solutions is also intended to guarantee coordination of the optimal solutions across the gas and electricity sectors.

More renewable energy requires a bigger toolbox

Energinet is always trying to expand the toolbox at its disposal to address the needs. In the following pages we describe a range of solutions designed to meet the needs of the future: construction solutions, operational solutions and market solutions as well as dialogue-based initiatives and third-party solutions. The list is not exhaustive, but is a good starting point for dialogue and cooperation around the opportunities, constraints and effectiveness of the solutions.

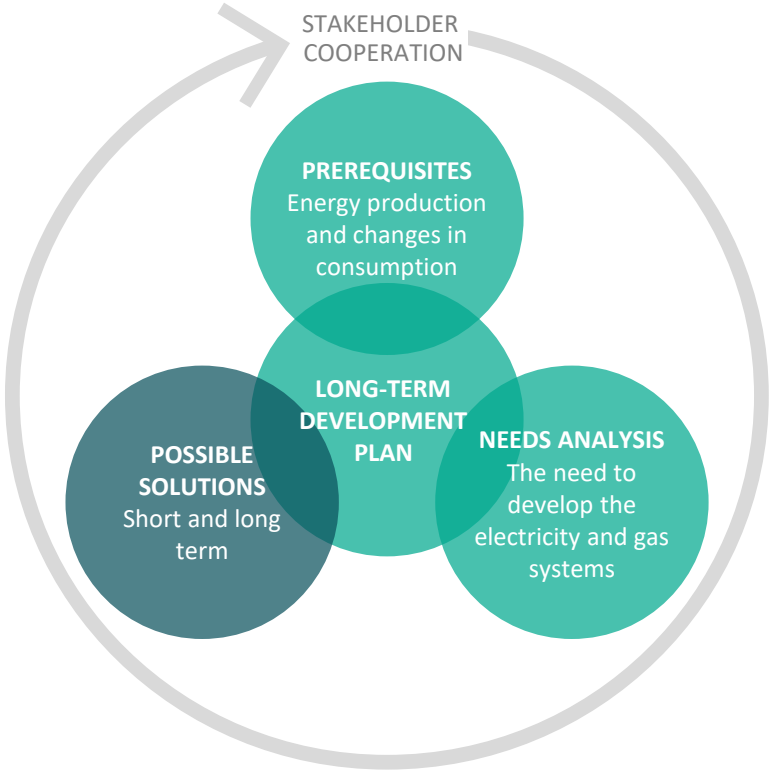
The green transition will be visible in the landscape

As the green transition picks up speed, renewable energy will become more visible in the landscape, and Energinet has the important task of ensuring that the new solutions cause as little inconvenience as possible to people and to nature. Energinet is also working hard to balance the energy trilemma: converting the electricity and gas systems to transport green energy; maintaining a very high level of security of supply; and keeping it affordable for consumers and society.

Where can you find out more?

Discover more about the needs identified in the gas grid and find background material at:

Needs analysis for the gas system: www.en.energinet.dk/gas-needsanalysis2021
Background material for the gas system: www.energinet.dk/gas-baggrund2021 (Danish)



Energinet's long-term development plan

The solution catalogue is an important part of our long-term development planning. In line with the assumptions used, the needs analysis forms a basis for investment decisions and thus for the solutions which are intended to guarantee a high degree of security of supply now and in the future. There are many unknowns and therefore the process is iterative, meaning that we revise and update our plan as we go if the assumptions change, and new needs arise.

WORK ON SOLUTIONS IS BASED ON THE DEVELOPMENT NEEDS

Energinet has analysed the long-term development needs of the gas system and found that solutions are needed support the development of the gas system. Energinet continuously works with several types of solutions, which can be grouped under four main categories. The solution types and the main development needs are described on the following pages. The needs analysis and the solution catalogue forms the basis for a dialogue on how both known and new solutions can be brought into play, when solving the identified needs.

DEVELOPMENT NEEDS

LOCAL SURPLUS OF BIOMETHANE MUST BE HANDLED

AVOID LOST GAS AT REVERSE-FLOW FACILITIES

ADJUST THE CAPACITY

OPERATIONAL OPTIMIZATION OF M/R-STATIONS

SOLUTION TYPES

CONSTRUCTION SOLUTIONS

OPERATIONAL SOLUTIONS

MARKET SOLUTIONS

THIRD-PARTY SOLUTIONS

DIFFERENT SOLUTIONS TO ADDRESS DIFFERENT NEEDS

Energinet is continuously working on various ways to resolve development needs in the gas grid. They reflect and support a future with a large proportion of biomethane and lower gas consumption. Below you will find the four main solutions we are working with.

CONSTRUCTION SOLUTIONS

Construction solutions allow the existing gas systems to be developed, either by building new connections and stations or upgrading existing ones. Developing and maintaining the transmission systems is essential in order to transport energy from where it is produced to where it is consumed.

OPERATIONAL SOLUTIONS

Certain challenges can be tackled within the system by making operational changes. An operational solution could connect consumption and local production by rethinking how the characteristics of the infrastructure are used so the energy moves more easily around the system, removing the need to invest in new facilities or pipelines or to develop a market solution.

MARKET SOLUTIONS

Market solutions can ensure that energy is produced and consumed in a flexible and intelligent way. As such, they can refine production and consumption in a way that makes the best possible use of our transmission grid, reducing and/or postponing the need for construction solutions.

THIRD-PARTY SOLUTIONS

Energinet does not always have the best solution. Other market players can contribute with a solution; not just market solutions where Energinet compensates producers or consumers, but clever solutions where addressing a need could be a business idea for a third party. For example, new consumers could use the local surplus of renewable energy.

POSSIBLE SOLUTIONS AND NEW INITIATIVES MUST MEET FUTURE NEEDS

Energinet's needs analysis for the gas system 2021 presents a number of challenges for the gas system towards 2040 which may need to be solved in order to maintain a high degree of security of supply for the Danish people. We present here the 6 main areas identified, where solutions are needed. The following pages dive into the specific potential solutions and initiatives for each of these needs.

BIOMETHANE PRODUCTION MUST BE LINKED TO CONSUMERS

Towards 2040 the biomethane surplus will grow, and solutions to manage it will be needed in several areas in Denmark.

THERE MUST BE SUFFICIENT CAPACITY IN PERIODS WITH HIGH CONSUMPTION

We must find solutions to adapt the gas system so it provides the necessary capacity while keeping the operating expenses down.

HIGH OXYGEN CONCENTRATION IN THE GAS MUST BE ADDRESSED BEFORE EXPORT

As the volume of biomethane injected into the gas system increases, we expect there to be issues around the oxygen content in the gas. These issues must be resolved before the gas is exported to neighbouring countries.

THE CLIMATE IMPACT OF THE GAS TRANSMISSION SYSTEM MUST BE REDUCED

Energinet's climate objectives envisage CO_2 neutrality in the operation of the gas transmission system in 2050. The energy used to operate the transmission system must be CO_2 neutral in 2030.

THE INFRASTRUCTURE MUST FOLLOW DEVELOPMENTS IN SOCIETY

Urban development and new transport infrastructure will reduce the distance between the gas infrastructure and towns, roads and railways. For safety reasons there are regulation for making the gas infrastructure near buildings and transport infrastructure safe. At Energinet, we monitor the development and try to find the right solutions.

THE USERS DEFINE THE NEED FOR FUTURE GAS CAPACITY

Every other year Energinet conducts an incremental capacity process to screen the users' (the shippers') capacity needs in the Danish gas system.

For the first time, Energinet has invited market players to submit non-binding expressions of interest in the need for a hydrogen infrastructure.

POSSIBLE SOLUTIONS FOR GAS NEEDS

These pages go into more detail about the possible solutions of the gas system needs towards 2040.

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HOW A BIOMETHANE SURPLUS OCCUR

A surplus of biomethane occurs in the distribution system and is a result of more biomethane being injected into the local grid than what is being used, and that the excess biomethane cannot be transported away. If consumption is not high enough, biomethane production will have to be constrained in order to maintain balance in the distribution system.

BIOMETHANE PRODUCTION MUST BE LINKED TO CONSUMERS

Increasing biomethane surplus up to 2040

The needs analysis for gas shows that there will probably be a biomethane surplus in several areas in the period 2025-2030. Up to 2040 the biomethane surplus will grow, and solutions to manage it will be needed in even more areas in Denmark. With the right solutions, the biomethane surplus can be avoided or minimised as inexpensively as possible. Biomethane surplus are a challenge even today, and Energinet and Evida, the distributor, are currently adapting the gas system so that all the biomethane can be utilised.

Shortage of capacity in reverse-flow facilities

The needs analysis indicates that the existing and planned reverse-flow facilities will not have enough capacity in the long-term to manage the biomethane surplus which is anticipated as biomethane production increases and gas consumption declines. Therefore, further changes to the gas system might be required in order to exploit the full potential of biomethane production.

The following pages outline possible solutions to address biomethane surplus in general, and an example of solution packages for one particular area where Energinet is expecting a biomethane surplus. More areas are described in the appendices.

SOLUTIONS TO ADDRESS LOCAL BIOMETHANE SURPLUS

Local biomethane surplus occurs in the distribution system and it is primarily Evida's responsibility to manage the biomethane. Energinet and Evida has a tool box of solutions each, and it is not possible to say in advance which one will contain the best solution to a particular problem.

Energinet and Evida have different ways to manage the biomethane surplus. This page presents some of the solutions we have studied in previous projects concerning biomethane surplus.

EVIDA'S SOLUTIONS TO ADDRESS LOCAL BIOMETHANE SURPLUS

Construction solutions

- Interconnection of different distribution grids with new and existing pipes. Interconnecting distribution areas means that the gas can flow freely over a wider area with higher combined consumption. Measuring equipment may be necessary in order to guarantee the quality of gas across the distribution areas.
- Distribution areas operate under different pressure. It may be necessary to install compressors in the distribution system to ensure that gas can be moved from one area to another.

Operational solutions

- The volume of the gas system is very large. Small biomethane surplus can be managed by allowing the pressure to increase, causing the gas to be stored in the gas pipes. This is known as linepack.

Market solutions

- Small, transient gas surplus can be managed by asking some big consumers connected to the distribution grid to increase their consumption for a while – if possible and in return be compensation for the costs incurred. This solution is currently being developed.

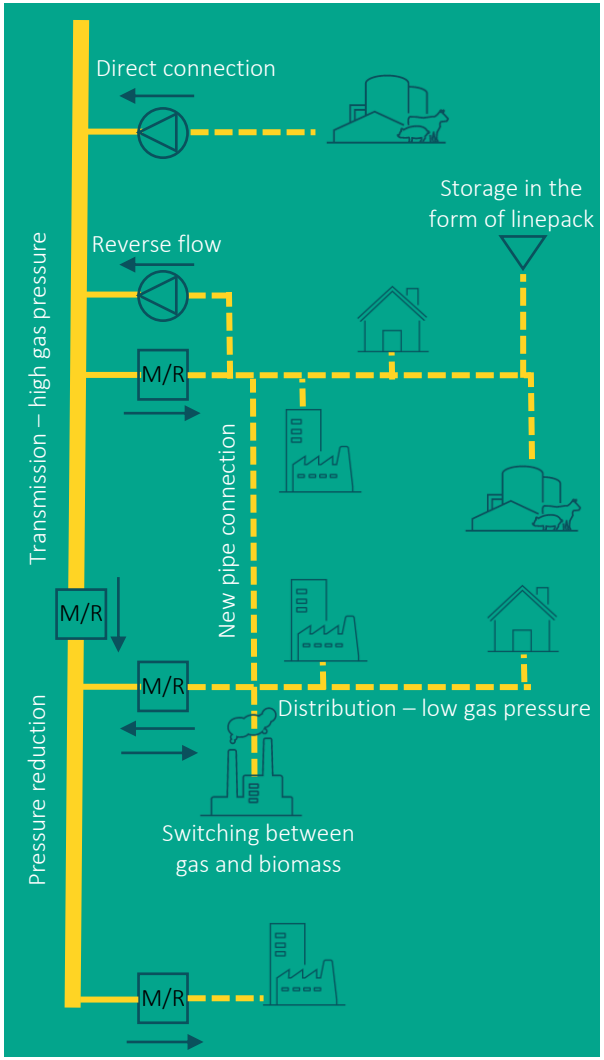
ENERGINET'S SOLUTIONS TO ADDRESS LOCAL BIOMETHANE SURPLUS

Construction solutions

- Reverse-flow facilities help moving the gas from areas with low pressure to areas with high pressure. The reverse-flow facility also removes the odorant.
- Existing reverse-flow facilities can be expanded. This can be done by replacing the compressors to obtain a higher maximum capacity or by adding extra compressors to the facility. An extra compressor also has the benefit of providing a backup to cover compressor outages.
- A mobile reverse-flow facility can resolve the issue of biomethane surplus temporarily or for a short period until the decision is made about a permanent solution. It is a solution that will have to be developed from the permanent solutions that are in use today.
- Biomethane production facilities can be connected directly to the transmission system. This is likely to increase the cost of connection and operation for the biogas plant.

Operational solutions

- It is possible to operate parts of the gas transmission system at a lower pressure, allowing the gas to flow freely across the distribution and transmission system to adjacent areas. This requires multiple modifications to the system.



LOCAL BIOMETHANE SURPLUS AT SORØ AND RINGSTED – POSSIBLE SOLUTIONS

This page presents four examples of how local biomethane surplus in an area can be managed using the solution catalogue. Energinet has no free transmission pipes in the area that could be used to store the biomethane. Our solutions are therefore limited to reverse-flow facilities. Solutions are also possible from Evida or other market players.

Solution package 1: New reverse-flow facility

An isolated solution for managing the biomethane surplus in each area would be to build a reverse-flow facility in the particular area where the surplus occurs. This solution ensures that biomethane surplus can be returned to the transmission grid, and that reverse-flow facilities will be built as new biogas plants come on stream.

Solution package 2: Connection between Sorø and Ringsted and a single reverse-flow facility

Evida or Energinet builds a new pipeline between Sorø and Ringsted. This allows the biomethane surplus to be returned with just one reverse-flow facility in the area.

Solution package 3: Upgrade the connection from Zealand to Copenhagen

There are interconnected pipes at distribution level all the way from Ringsted to South Zealand to Copenhagen, but the existing design of the pipeline network means that gas cannot flow freely. There are a number of initiatives available to Evida to allow more gas to be consumed over a larger area (marked on the map). Reverse-flow facilities may be unnecessary in the short-term with solution package 3, potentially reducing the need for reverse flow in the long-term.

Solution package 4: Local market solutions

Solution package 4 is about developing market solutions that can activate local flexibility, if available. If new consumption emerge as a result of the market solutions in one of the areas, this might reduce or perhaps completely eliminate the need for other solutions.

The examples of solution packages are simply outlined examples, and they must be analysed in more detail to ascertain the basis for initiating a concrete project.

EXAMPLES: M/R HØJBY AND M/R KOELBJERG

The needs analysis indicates a need for more capacity following the conversion of Fyn Power Station. Meanwhile, M/R Koelbjerg will probably have to be moved when a new railway line is laid across Vestfyn.

M/R Højby has been modified in the past to accept a lower gas offtake. The station could be modified again to support a larger offtake.

THERE MUST BE SUFFICIENT CAPACITY IN PERIODS WITH HIGH CONSUMPTION

The transmission grid as a whole has shown itself to be adequate for future operations, but it may be necessary to modify some M/R stations to be compatible with how the system will be used in future:

- Some M/R stations are used much less than intended due to increasing local biomethane production and declining gas consumption.
- Other M/R stations can expect to be used more because of significant new consumption in some areas.

Following are some examples of solutions to adjust the gas system so it provides the necessary capacity while keeping the operating expenses down.

ENERGINET'S SOLUTIONS

Construction solutions

- Adapt the M/R stations to provide less or more capacity.
- Shut down – temporarily or permanently – M/R stations supplying areas already supplied by another M/R station over a grid interconnection. This solution is also supported by interconnection of distribution areas (Evida's solution).
- New transmission pipes or compressor stations to increase the capacity of the transmission grid.

EVIDA'S SOLUTIONS

Construction solutions

- Interconnect the distribution grid so that consumption over a larger area is covered from fewer stations.

Integrating projects

- Investigate whether some stations can be dispensed with/merged to save costs in operation and maintenance. For example, is M/R Egtved large enough to supply Southern Jutland? In that case, can we do without M/R Terkelsbøl and M/R St. Andst?
- If changes are made at M/R stations, the changes must be coordinated with Energinet's other projects concerning the M/R stations.

OXYGEN FROM BIOMETHANE

Oxygen from biomethane comes from raw biogas which has been converted into gas of the same quality as natural gas. Oxygen is not an issue if the gas is used in Denmark. The oxygen standard differs in neighbouring countries, potentially causing a problem when the biomethane is exported. One solution is to remove oxygen at the reverse-flow facility, where at present, odorant is removed before the gas is carried into the transmission grid.

HIGH OXYGEN CONCENTRATION IN THE GAS MUST BE ADDRESSED BEFORE EXPORT

Upgraded gas from biogas plants contains a small proportion of oxygen, and the amount of oxygen permitted in Danish gas is higher than in neighbouring countries.

Based on the needs analysis, we expect there to be issues around the oxygen content of exported gas as the volume of biomethane injected into the gas system increases.

Increased biomethane is not thought to be a problem provided there is transit of North Sea gas so that blending with natural gas is possible. Any changes to the transit of Danish or Norwegian North Sea gas could determine whether the oxygen content is a problem or not.

ENERGINET'S SOLUTIONS

Construction solutions

- Build equipment to remove excess oxygen at reverse-flow facilities.
- Build equipment to remove excess oxygen at border points.

Operational solutions

- Mixing with natural gas, for example in Baltic Pipe, ensures that the oxygen level does not exceed the limit value.

Market solutions

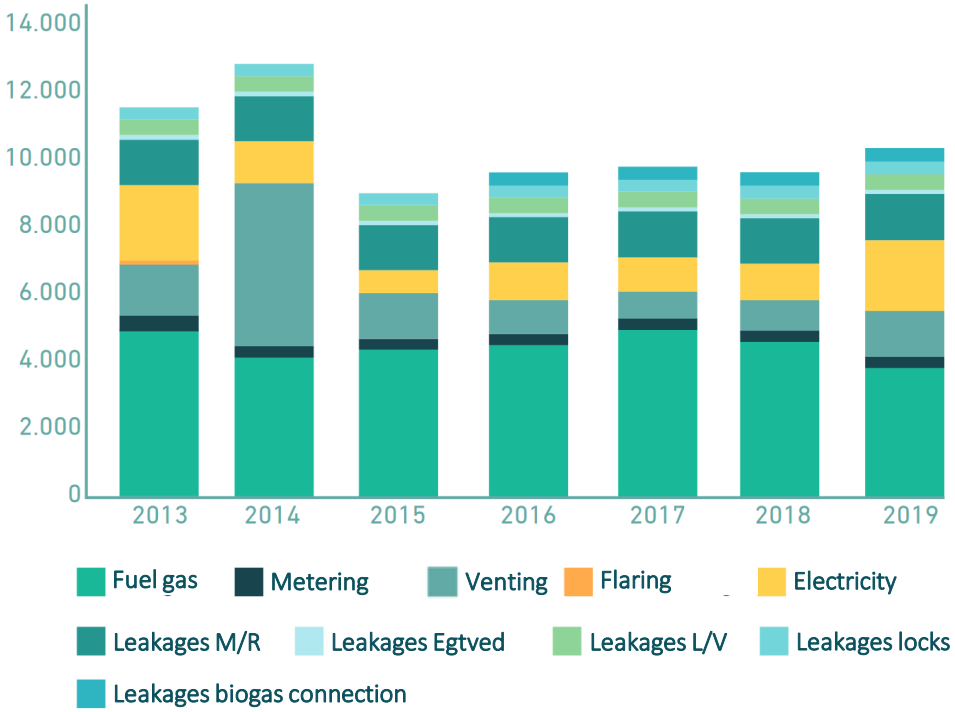
- Harmonised gas standards for oxygen content in Denmark, Sweden, Germany and Poland – so that a higher oxygen content is not a problem in relation to gas quality requirements.
- Stop the export of gas to neighbouring countries subject to stricter oxygen requirements than Denmark.

Third-party solutions

- Requirements for the design of upgrading facilities which results in a lower oxygen content in the gas – this would need investments in upgrading facilities at the biogas plants.

TOTAL EMISSIONS FROM THE GAS TSO IN CO_2-EQUIVALENTS

Emission Ton CO_2-e.q.



From Energinet's CSR Report 2020

ENERGINET'S CLIMATE GOALS FOR THE GAS SYSTEM

Energy consumption for operation of the transmission grid must be CO_2 neutral by 2030, and emissions from natural gas must be CO_2 neutral by 2050.

THE CLIMATE IMPACT OF THE GAS SYSTEM MUST BE REDUCED

Energinet's climate objectives envisage CO_2 neutrality in gas system operations. The climate impact from operations primarily stems from the energy used to operate the system, from leaks, and from maintenance when methane emissions cannot be avoided.

ENERGINET'S SOLUTIONS

Construction solutions

- Invest in heat pumps to replace gas boilers at M/R stations. Reduce gas consumption for gas preheating.
- Invest in a mobile compressor to handle gas during maintenance, so it can be returned to the gas grid instead of being released into the atmosphere.
- Replace measuring equipment to reduce metering emissions.
- Invest in mobile flare systems so that gas can be flared during maintenance instead of being released into the atmosphere.

Market solutions

- Buy green gas and electricity to run the system.
- Impose stricter emission requirements when buying new equipment and designing facilities.

Operational solutions

- Continuously shutdown M/R stations when they are not needed for shorter or longer periods.
- Reduce pressure before maintenance so that as much gas as possible is used before the system has to be emptied.
- Fixed routines and equipment to check for leaks whenever the facilities are visited.
- Smart operation of the compressors depending on the emission factor of the electricity system.

SAFETY REQUIREMENTS – CLASS LOCATION

One important factor in the dimensioning of gas pipes is something called the class location concept. Class location is defined on the basis of how many people are expected to be in a safety zone of 200 meters on each side of the gas pipeline. The requirements for solutions to maintain the gas system safety is raised as the number of buildings/persons within the zone increases.

THE GAS INFRASTRUCTURE MUST FOLLOW DEVELOPMENTS IN SOCIETY

Urban development and new transport infrastructure will reduce the distance between the gas infrastructure and towns, roads and railways. For safety reasons there are regulations for making the gas infrastructure safe around buildings and transport infrastructure. Urban development, with denser construction in the zone around the gas pipeline, may require safety solutions.

Energinet has ongoing projects analysing the need to reroute or strengthen existing infrastructure.

ENERGINET'S SOLUTIONS

Construction solutions

- The gas infrastructure is relocated "1:1", in other words it is reconstructed with the same specifications but at a new location.
- The gas infrastructure is strengthened, for example by using plastic or concrete around the pipes.
- The gas infrastructure is downgraded, i.e. the maximum pressure is reduced so that the section satisfies a higher safety requirement – thereby allowing more construction within the safety zone around the gas pipeline. For example the design pressure could be reduced to a lower pressure than in the rest of the transmission system. This may require modifications.

Integrating projects

Safety requirements for the gas infrastructure also apply to Energinet's M/R stations. Some M/R stations to be relocated may also be covered by other needs. One example of this is M/R Koelbjerg.

CONSTRUCTION SOLUTIONS WILL BE SUPPLEMENTED BY OTHER INITIATIVES

The map shows an overall package of possible changes to the gas transmission grid and is intended to illustrate how much work is required to convert the gas system to green supply.

The construction solutions shown should not be viewed isolated – they will be supplemented by other initiatives such as operational and market solutions. If the market solutions are effective, it may be possible to reduce the scope of the construction solutions.

PERSPECTIVES TOWARDS 2040

The map shows a possible set of adaptions which Energinet could implement to the gas system to ensure that gas consumption is 100 percent biomethane by 2040.

Adaptions must be made to parts of the gas system so that the biomethane can be distributed between the areas. In addition to Energinet's investments, Evida will need to make a number of changes, which are not shown here.

The possible modifications to the gas system were identified at a workshop in which stakeholders from Evida, Gas Storage Denmark and Energinet discussed the result of the needs analysis.

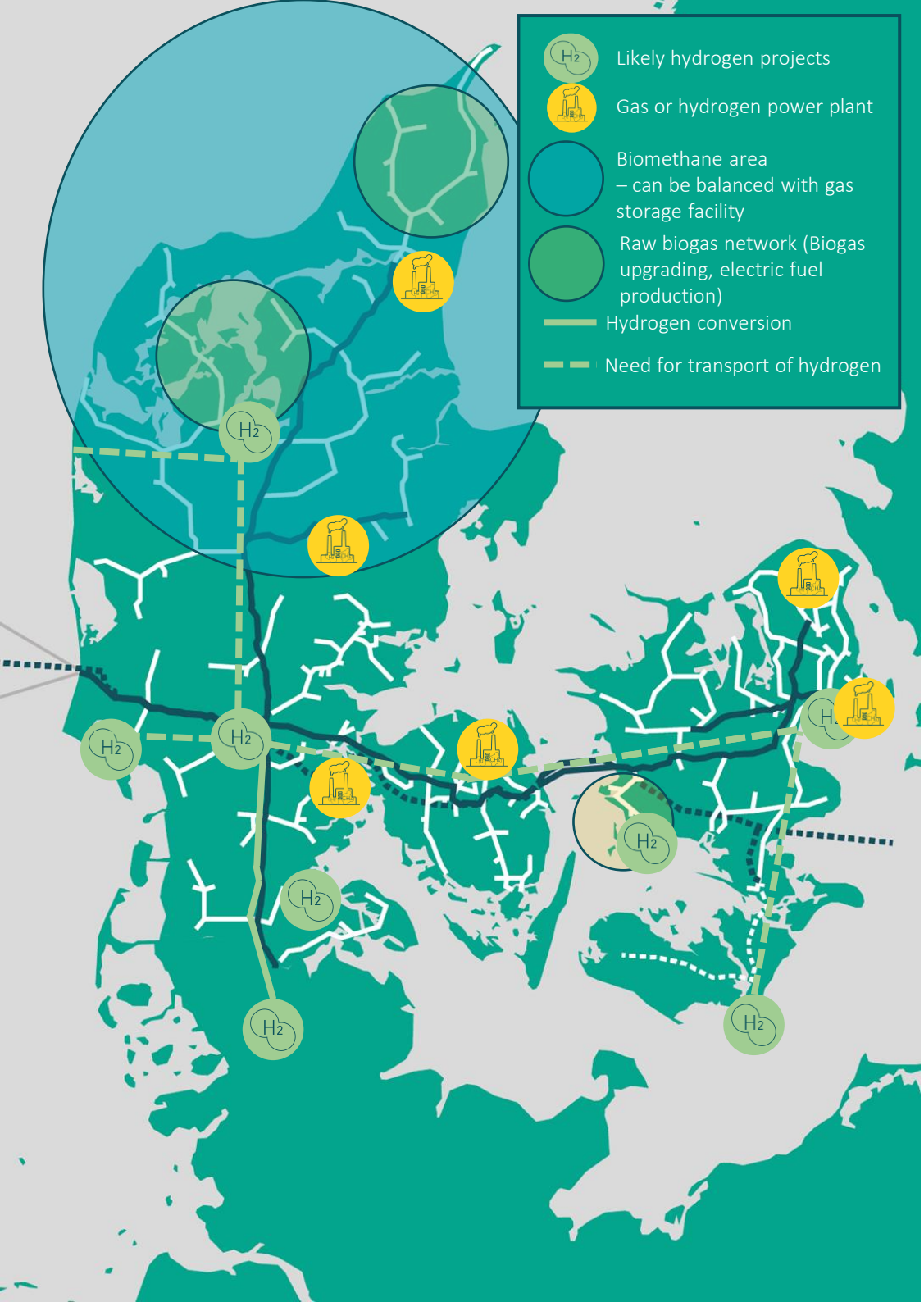
The technical construction solutions should not be viewed isolated, but will be combined with other initiatives. In all cases, market initiatives or other non-construction solutions should be explored that might address the needs more cheaply.

Flexible and robust solutions

Energinet may need to implement solutions to pressing problems in the next few years. Future development are uncertain in terms of where new biogas plants will be built and where the impact of changing consumption patterns will be felt, and to reflect this it may be best to opt either for flexible or for robust solutions.

Flexible solutions could be temporary solutions or market solutions which can be set up quickly and inexpensively, but which have higher operating costs. They can be used until it is clear that there is definitely a long-term need.

For infrastructure investments, it may be worth choosing a more robust solution which can do slightly more than meeting the immediate need. A more robust solution will cost a little more up front, but will pay for itself in the long-term if the need grows.



LONG-TERM USE OF THE GAS SYSTEM

Long-term perspective – lower gas consumption and space for hydrogen

It is important not to lose focus on the long-term objectives – and the system we are working towards. The expectation is that methane gas consumption will decline significantly, green gas production will increase, and there will probably be a need for the production, consumption and transport of hydrogen. It is important that the solutions chosen to address challenges in the short-term pull in the same direction as this future development, rather than simply solving the acute problems now. That means we can avoid investments in the short-term which are not appropriate for the long-term.

The role of gas in the electricity and heating systems

In the electricity and heating systems, all the indications are that in future, the role of gas will mainly be to cover peak load and to act as a backup. This could be during periods when there is no sun or wind, but consumption is high. This may create a need to increase gas supply capacity to the power stations even though total consumption is reduced dramatically. Depending on the location in Denmark, and whether these power stations are to be supplied directly from the transmission grid or from the distribution grid, it may be necessary to adjust the capacity at M/R stations.

Conversion of the gas grid

In the long-term, there may be a need or a wish to convert parts of the gas transmission or distribution grid to other gases, such as hydrogen, raw biogas or CO_2, so that better use can be made of the system in order to produce liquid fuels. Much of the gas system is earmarked for the transport of biomethane and natural gas for many years to come and cannot be converted.

There are likely to be smaller sections where consumption falls so low that it is worthwhile for society to close down small sub-grids, which can then be released for other uses.

One possible solution, which could release the transmission grid for hydrogen transport for example, is to divide the gas grid into small methane islands, which can balance themselves. This requires sufficient storage facilities within the area. Central and Northern Jutland, for example, could balance biomethane production by using some of the Lille Torup gas storage facility. The transmission pipeline to the area could then be released for other uses.

APPENDIX: GEOGRAPHICAL OVERVIEW OF BIOMETHANE SURPLUS

LARGE BIOMETHANE SURPLUS ON ZEALAND

In this area, the analyses show that in 2030 there will be a bioas surplus of between 0.3 and 12 million Nm^3 – mostly in the summer months. Towards 2040, the surplus will grow to between 20 and 30 million Nm^3.

There is uncertainty, mainly around where new biogas plants will be built.

BIOMETHANE SURPLUS AT SORØ AND RINGSTED

Between 2025 and 2030, a biomethane surplus is expected at Sorø/Stenlille, Ringsted and at the new connection to Lolland/Falster. After 2030, according to the current assumptions, there will be a surplus in all three areas. In the short-term, there is uncertainty about the size of the surplus.

SOLUTIONS FOR BIOMETHANE SURPLUS AT SORØ AND RINGSTED

Construction solutions:

- Mobile and modular reverse-flow facilities at Ringsted and Sorø.
- Classic reverse-flow facilities at Ringsted and Sorø or Stenlille.

In addition to the above solutions, it has been analysed whether the transmission pipeline from Stenlille can be used to store biomethane. This solution would require a new transmission pipeline from Stenlille gas storage facility to the gas grid, so the costs are considered to be excessive.

Market solution:

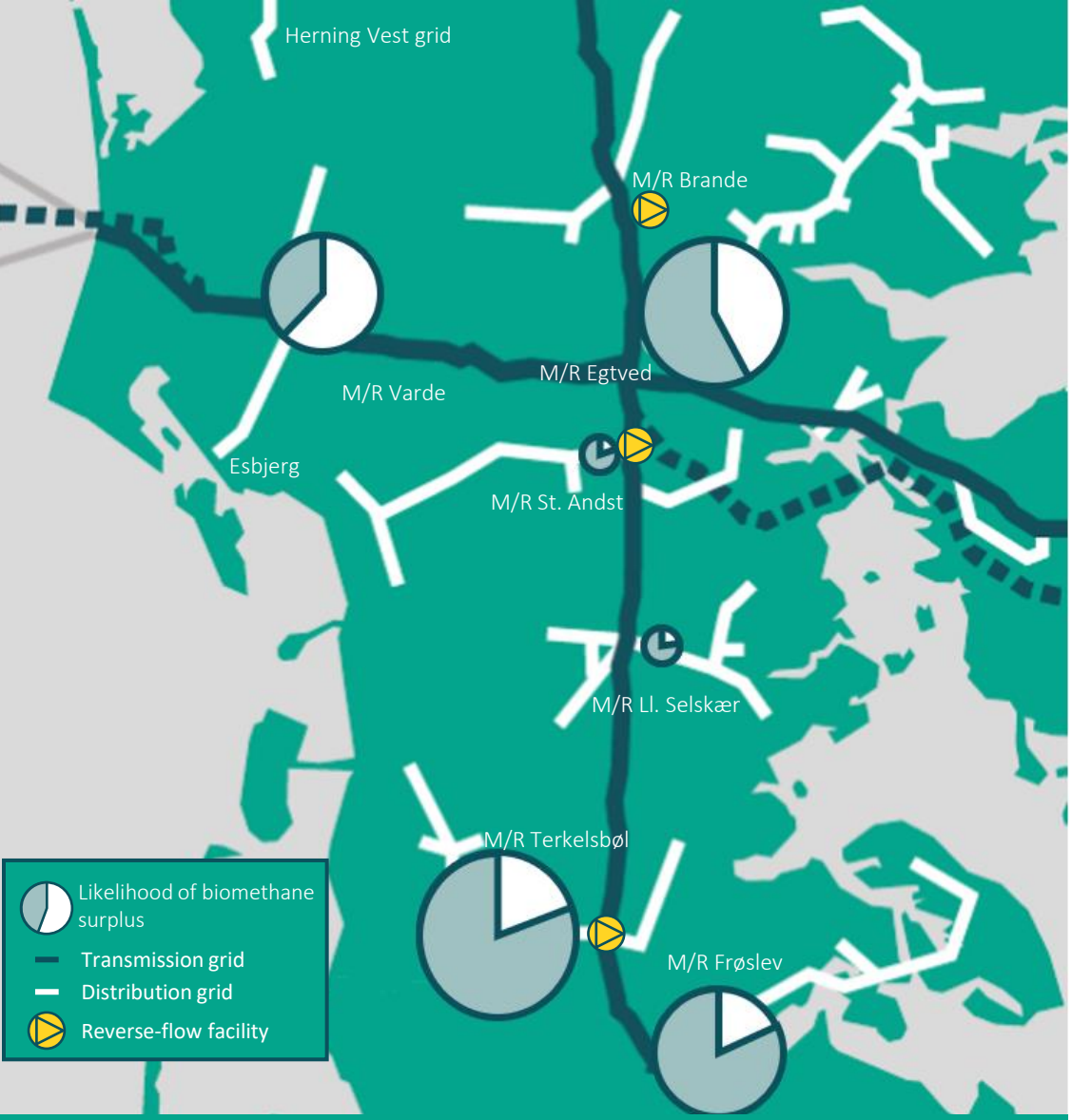
- Market model with incentives to buy more gas during the summer months in both Ringsted and Sorø.

Operational solutions:

- Pressure control in Ringsted to a unified level – Evida's operational solution.

Third-party solution:

- Interconnection of the distribution grid between Ringsted and Sorø, with Evida building a new pipeline between the areas.
- Opening the distribution grid between Ringsted and Copenhagen and introduce gas quality trackers – Evida's solution.
- New consumption on Eastern and Southern Zealand.
- Gas-to-liquid factories or production of biomethane-based LNG for heavy transport.
- Downward regulation of biomethane production in the summer months.



BIOMETHANE SURPLUS AT VARDE

In this area, the analyses show that in 2030 there will be a biomethane surplus of between 0 and 7 million Nm^3. Towards 2040, the surplus will grow to between 2 and 20 million Nm^3.

There is uncertainty, mainly around where the new biogas plants will be built.

BIOMETHANE SURPLUS AT VARDE

Between 2025 and 2030, it is likely that there will be a biomethane surplus in the Varde/Esbjerg area. The biomass potential is not seen to be fully exploited yet, and at the same time this might also be an area where it becomes possible to methanise biogas with hydrogen.

Various factors affect whether and where biomethane is produced. In particular, the establishment of new biogas plants is expected to depend on whether they win bids for state subsidies. Furthermore, some biogas plants may be located where they can be connected to other grids with more capacity or where reverse-flow facilities have already been built.

SOLUTIONS FOR BIOMETHANE SURPLUS AT VARDE

Construction solutions:

- Reverse-flow facilities will probably have to be equipped with oxygen removal facilities as there is otherwise a risk of exceeding oxygen content limits for gas exports to Germany.
- Interconnection to St. Andst and possible expansion of the reverse-flow facility at St. Andst. If this goes ahead it will be a joint Evida and Energinet project.

Market solutions:

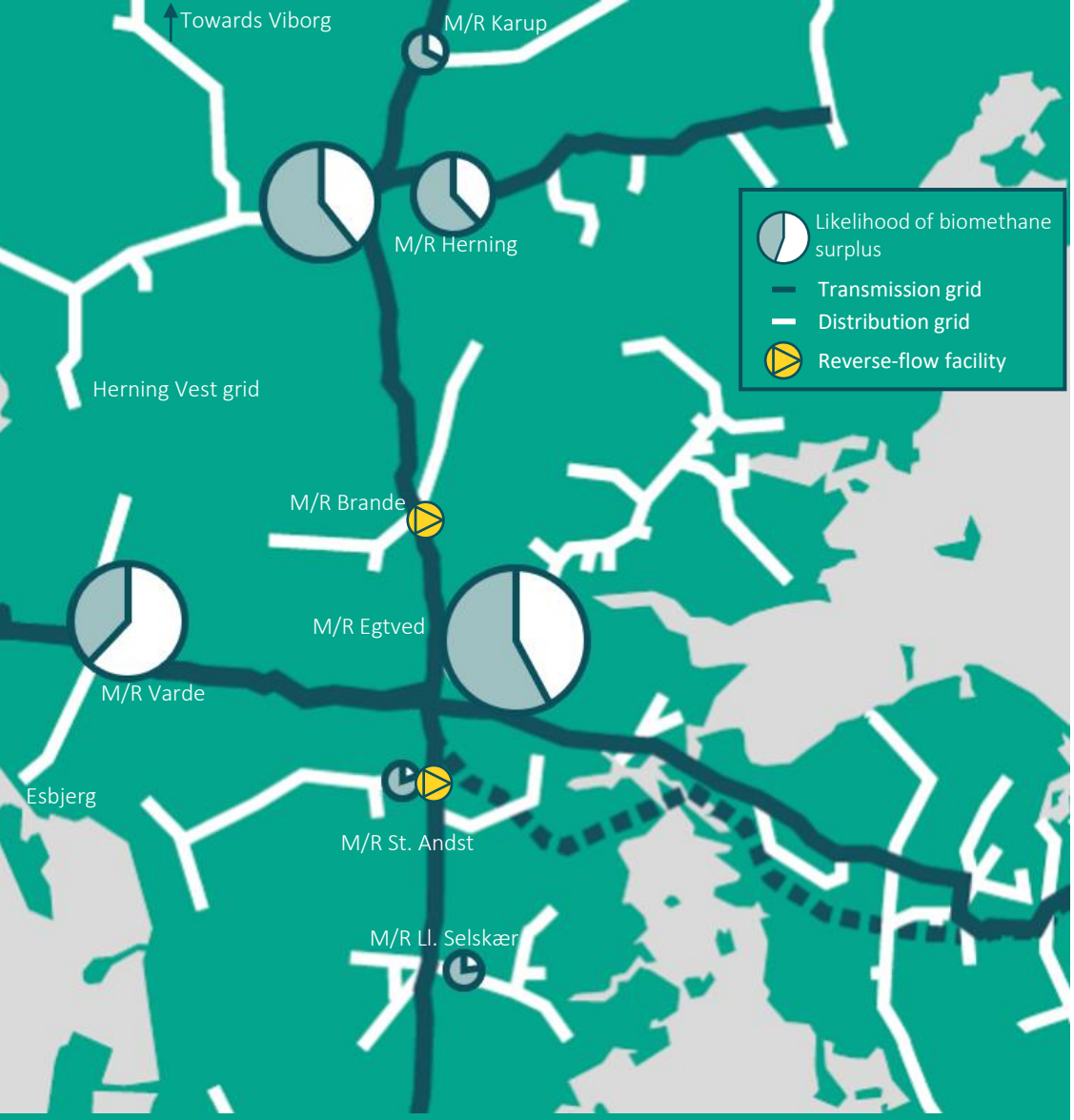
- Market model with incentives to buy more gas during the summer months.

Operational solutions:

- Use of linepack and active pressure control.

Third-party solutions:

- Interconnection to the Herning Vest grid – this may require an expansion of the reverse-flow facility in Viborg and a capacity increase from Herning to Viborg. This is an Evida solution.
- LNG production in Esbjerg or other increased use of biomethane for transport.
- Power-to-X projects in Esbjerg (fuel factories) which use biogas as a raw material.
- Increased gas consumption in the summer months.



BIOMETHANE SURPLUS AT EGTVED

In this area, the analyses show that in 2030 there will be a biomethane surplus of between 0 and 20 million Nm^3. Towards 2040, the surplus could reach up to 40 Nm^3.

There is uncertainty, mainly around where the new biogas plants will be built.

BIOMETHANE SURPLUS AT EGTVED

Between 2025 and 2030, a biomethane surplus is likely in the Egtved/Horsens area because biomass potential is not seen to be fully exploited yet.

Whether or not a surplus occurs depends in particular on whether biogas plants in the area win bids for state subsidies.

SOLUTIONS FOR BIOMETHANE SURPLUS AT EGTVED

Construction solutions:

- Reverse-flow facility
- Interconnection to St. Andst and possible expansion of the reverse-flow facility at St. Andst. If this goes ahead it will be a joint Evida and Energinet project.
- Interconnection to the Herning grid – this may require an expansion of the reverse-flow facility in Viborg and a capacity increase from Herning to Viborg. This is an Evida solution.

Market solutions:

- Market model with incentives to buy more gas during the summer months.

Operational solutions:

- Use of linepack and active pressure control.

Third-party solutions:

- Power-to-X projects (fuel factories) which use biogas as a raw material.
- Increased gas consumption in the summer months.

BIOMETHANE SURPLUS IN CENTRAL JUTLAND

In this area, the analyses show that in 2030 there will be a biomethane surplus of between 3 and 15 million Nm^3. Towards 2040, the surplus will grow to between 30 and 60 million Nm^3.

There is uncertainty around where new biogas plants will be built and how gas consumption patterns will change.

BIOMETHANE SURPLUS IN CENTRAL AND NORTH JUTLAND

Between 2025 and 2030, it is likely there will be a biomethane surplus in Central and Northern Jutland. The biomass potential is not seen to be fully exploited yet, and at the same time this might also be an area where it becomes possible to methanise biogas with hydrogen. Whether or not a surplus occurs depends in particular on whether biogas plants in the area win bids for biomethane subsidies.

Aalborg Portland has entered into an agreement to connect to the gas grid. The supply of gas to Aalborg Portland has the potential to eliminate the biomethane surplus in Aalborg and reduce the surplus in Haverslev. Furthermore, projects involving LNG production in Frederikshavn and Hirtshals may have a similar impact.

In Viborg, a new reverse-flow facility is currently being built which returns gas from the entire area, but there is congestion in the distribution grid because all the gas must be transported to Viborg.

SOLUTIONS FOR BIOMETHANE SURPLUS IN CENTRAL AND NORTH JUTLAND

Construction solutions:

- Increase the capacity of the reverse-flow facility at Viborg, boost the transfer capacity from Herning and Haverslev to Viborg with compressors. Joint Evida and Energinet project.
- Permanent pressure reduction in the Lille Torup-Aalborg pipeline and a new compressor to send gas from Haverslev to the transmission pipeline.
- New reverse-flow facilities at Herning, Haverslev and Aalborg.
- Connect the Lille Torup gas storage facility to the Viborg grid and use the storage facility to balance biomethane and consumption.

Market solutions:

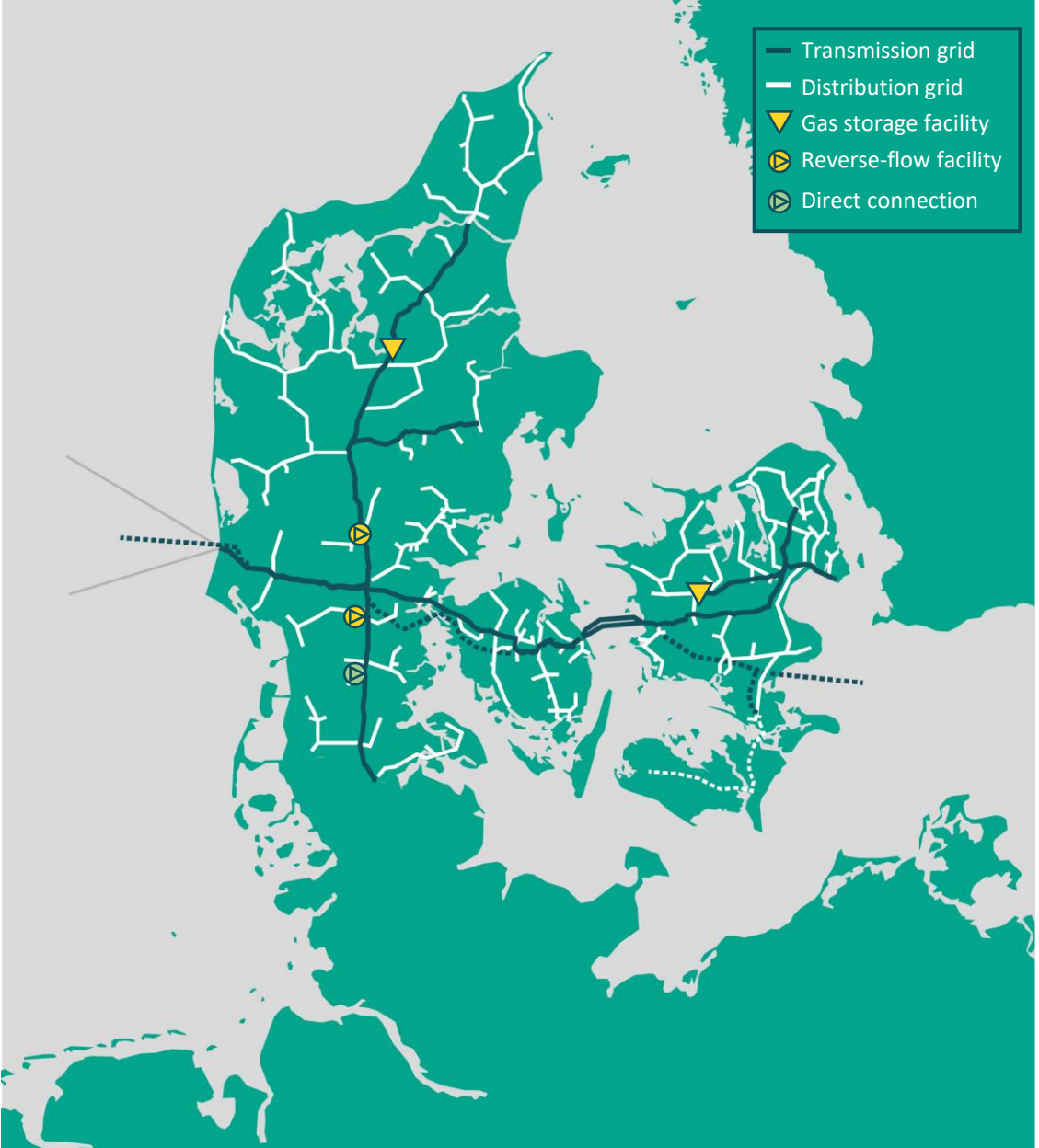
- Market model with incentives to buy more gas during the summer months.

Operational solutions:

- Continue pressure reduction of the Lille Torup-Aalborg pipeline.
- Operational solutions: use linepack and active pressure control.

Third-party solutions:

- As for Egtved



GAS TRANSPORT AND STORAGE

Danish gas consumers are supplied via the distribution grid which is the responsibility of Evida. The distribution grid is connected to the gas highway – the transmission grid – through Energinet's metering and regulator stations (M/R stations) throughout the country.

THE DANISH GAS SYSTEM

The transmission grid runs across Denmark. The gas consumers are supplied via distribution grids which are connected to the transmission grid at Energinet's M/R-stations throughout the country. The Danish gas system also consists of two gas storage facilities – in Ll. Torup in northern Jutland and Stenlille on Zealand.

The gas is mainly transported from the transmission grid to the distribution grids, but two M/R-stations (and three more on the way) have facilities allowing gas to be transported in the other direction. These are called reverse-flow facilities. A different type of reverse-flow facility is a compressor facility, where a biogas plant is directly connected to the transmissions grid. One facility of such has been established in the gas system.

Transmission grid

The transmission grid consists of a high-level network which in the past distributed North Sea gas to the distribution grid, which distributes the gas to the individual consumers. The gas is under high pressure in the transmission grid, and high volumes are transported. Energinet is responsible for the gas transmission grid.

Local and regional distribution grids

Evida is responsible for the regional and local distribution grids which transports the gas the last mile to the individual consumers. The regional distribution grid distributes the gas regionally, and the local distribution grid distributes the gas at a very local level. In this report, the term 'distribution grid' is used as a generic term for Evida's local and regional distribution grids.

GLOSSARY

AF20
The Danish Energy Agency's Analysis Assumptions for Energinet, 2020 (In Danish "Analyseforudsætninger 2020, AF20"). Energinet must plan the power and gas systems according to the Danish Energy Agency's annual projections concerning the generation and consumption of electricity, gas, district heating, etc. These Analysis Assumptions are based on political decisions and on projections concerning the market and technological development.

Evida

Evida owns, operates and maintain the gas distribution system

Fuel gas

Gas used at M/R-stations to preheat the gas to prevent if from cooling down too much when the pressure is reduced.

Gas-to-liquid

Process that converts gas, such as natural gas or biomethane, into a liquid fuel such as petrol, diesel or aviation fuel.

Green gas

Green gas covers biomethane, which is produced at biogas plants from livestock manure and organic waste from food consumption as well hydrogen, which is produced by water electrolysis using green power from wind and solar energy.

Linepack

Storage of gas in pipelines by allowing the gas pressure to increase.

LNG

LNG is an abbreviation of Liquefied Natural Gas, which forms when natural gas is cooled.

Methanisation

A process in which hydrogen and CO_2 are combined to form a synthetic biomethane. Allows the output from biogas plants to be increased by 70 percent because biogas contains about 35 percent CO_2.

Mobile compressor

A mobile compressor is an equipment that can move the gas to other places in the grid if e.g., a gas system has to be emptied in connection with maintenance.

Meter and regulator station (M/R-station)

Connection between Energinet's transmission grid and Evida's distribution grids. The meter and regulator station measures and regulates the gas pressure.

Odorant

Chemicals added to gas in the regional and local distribution grids to give it a smell.

Power-to-X (abbreviated to PtX)
Denotes the process in which power is used to produce hydrogen by water electrolysis. Hydrogen can be used on its own as a green energy source, or as a component in green fuels or other green products (hence the 'X').

Redundancy

When reverse-flow facilities or meter and regulator stations, for example, are designed to allow parts of the facility to break down without affecting operation. For example, there are two compressors when only one is needed.

Peak-load consumption

Consumption when the system is under the highest load. Defined as consumption when the temperature is -13°C.

Stations

Generic term for facilities in the gas transmission system including meter and regulator stations.

Reverse-flow facility

Facility which sends biomethane from the distribution grid to the transmission grid.

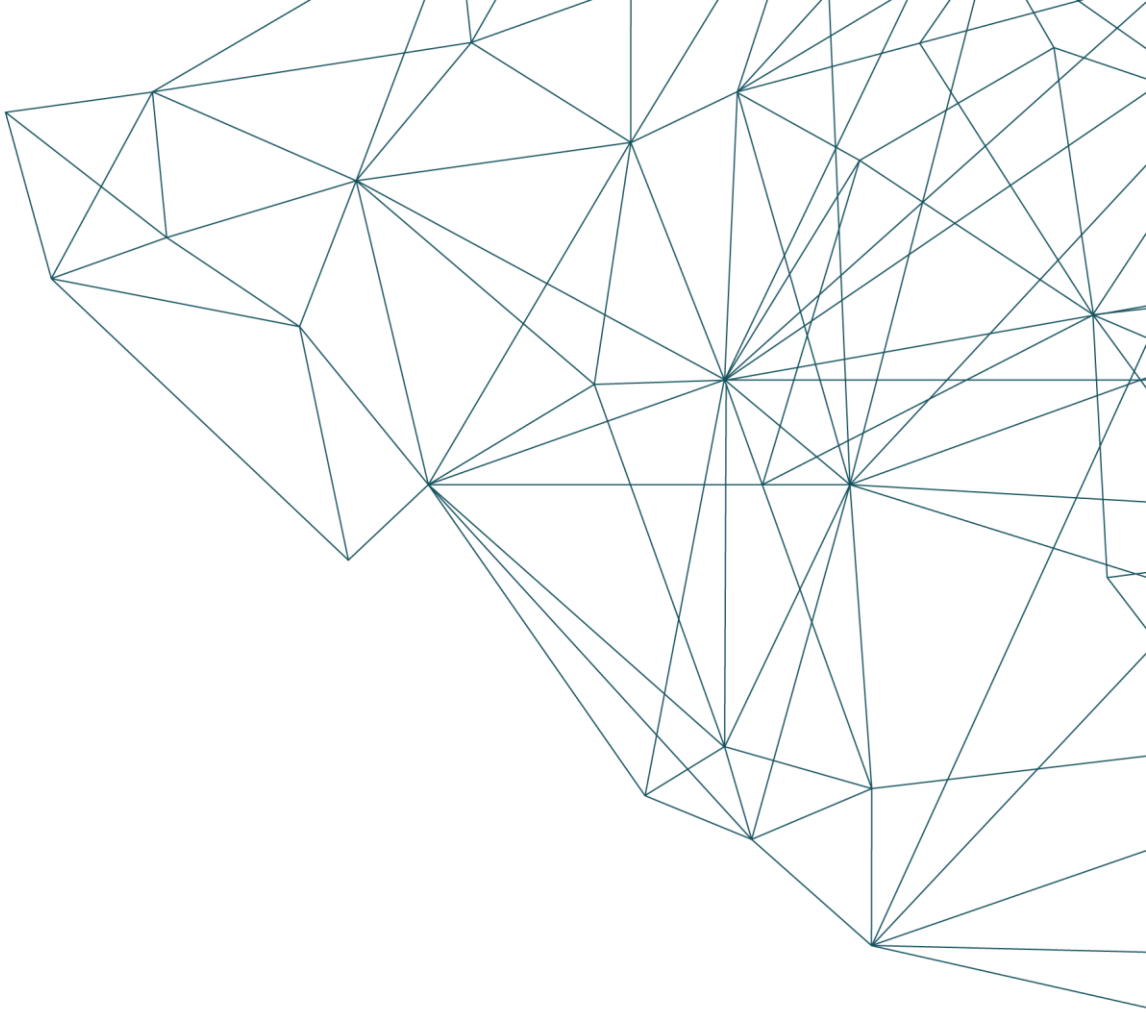
Shippers

Companies that buy capacity for the transportation of gas in Energinet's transmission grid. For example, gas traders, gas producers or other companies needing to send gas to or through Denmark.

ENERGINET

Tonne Kjærsvej 65
7000 Fredericia
Tlf 70 10 22 44

info@energinet.dk
www.energinet.dk



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