THESIS – MASTER'S DEGREE PROGRAMME

TECHNOLOGY, COMMUNICATION AND TRANSPORT

ENERGY SOURCES FOR DEFENCE FORCES

Mobile and fixed a backup power solutions.

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Abstract

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Abstract

The aim of the thesis was to find out alternative forms of electricity generation for the Defence Forces. In the background of the topic were the emission reduction targets that will guide future energy production forms in a slightly more emission-oriented direction. This thesis reviews various forms of electric power generation that could be utilized in backup power generation. The power requirement of the backup power machine varies in this thesis from 300 to 2000 kVA. The backup power solution must be suitable as a fixed or movable unit.

The thesis reviews a few goals of the European Commission. Those goals will change the automotive and construction industries. Automotive and construction industries are very strongly connected to the construction of backup power plants. In this thesis, EU Commission studies, standards, studies, online pdf files, literature and the author´s own experience of backup power engines were utilized. During the thesis, a few energy companies were also asked how they see the future of backup power plants and different forms of energy. The companies were interested in the topic and their responses were very similar. This information was utilized in the preparation of this thesis.

The thesis reviews the changing factors of the backup power plants, which could potentially reduce emissions. The thesis also examines the different energy options and storage methods that are available.
In the thesis a light comparison of a few different energy solutions that could be suitable for backup power use was made. From these, the most appropriate option was selected with a view to future objectives, and a solution will be prepared on the basis of a needs assessment. The thesis was commissioned by the Finnish Defence Forces and the appendices contain essential information for the Defence Forces. The thesis proposed to the Defence Forces the use of biofuel in backup power engines and examined the possibilities of hydrogen solutions.

Keywords
Backup power, Energy source, Finnish Defence Forces and Defence Properties

PREFACE

This thesis provides information on current energy sources and possible future options. The thesis reviews different forms of energy and how they could fit into the environment of Finnish Defence Forces. Thanks to all those who contributed to the thesis. Special thanks to the Defence Forces Logistics Department for accepting this thesis. Thanks to the people of the Defence Forces, from whom I received support for various issues, and the development of ideas for the thesis. As well as many thanks to my family who have supported the study in their own way. Thanks to the teachers who have given the best knowledge about the energy field to the students.

Pieksämäki 08.06.2021
Joni Kolehmainen

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ABBREVIATIONS AND DEFINITIONS

EU	Europe
PEM	Proton Membrane
FC	Fuel Cell
ECM	Electrolysis Cell Module
DOE	Department of Energy
TEG	Thermoelectric Generator
TES	Thermal Energy Storage
RTG	Radioisotope Thermoelectric Generator
SMES	Superconducting Magnetic Energy Storage
LNG	Liquefied Natural Gas
CNG	Compressed Natural Gas
SNG	Synthetic Natural Gas
CH4	Methane
LUT	University of Lappeenranta
UPS	Uninterruptible Power Supply
DRUPS	Diesel Rotatory Uninterruptible Power Supply
P2X	Power to X

1 INTRODUCTION

At the beginning of the thesis, the Defence Forces and the Defence Properties are presented. The European Commission has set targets to reduce its carbon footprint. The thesis follows possible development of road vehicles, as this has a direct impact on fuel distribution and engine technology, which directly affects what kind of products different engine factories will start producing in the future. The thesis covers different energy sources. The thesis provides basic information about energy sources and basic information about the technologies they need. The energy sources covered in this thesis revolve around the concept of Power-To-X. Energy sources such as natural gas, biogas, hydrogen, photovoltaics, wind power is covered in this thesis. The thesis outlines an alternative backup power solution for a few buildings. These buildings are undergoing renovation projects in the future and this thesis highlights a few options for implementation. The sites will have the possibility of fixed and mobile backup power. A need assessment includes, basic information of the project, cost level estimation and a couple preliminary AutoCAD drawings. During the thesis, a few companies were also asked about their visions for the future. The questions can be found in Appendix 12 and the answers in Appendices 37 - 40. Questions and answers are not in the public version. These answers have been utilized in the preparation of the thesis.

2 ORGANIZATION PRESENTATIONS

2.1 Defence Forces

The Defence Forces protects the Finnish territory, the people's livelihoods and the freedom of action of the state leadership, and defend the legal order of the community, if necessary, by military means, in the event of an armed attack or an external threat to Finland. The structure of Defence Forces is shown in Figure 1. The peacetime organization of the Defence Forces consists of Defence Command, the Land Forces, the Navy, the Air Force and the National Defence College. Under the Defence Command operates different departments, which are the Defence Forces Command System Center, the Defence Forces Service Center, the Defence Forces Intelligence Department, the Defence Forces Research Institute and the Defence Forces Logistics Department. (The Finnish Defence Forces, 2021) The core task of the Defence Forces Logistics Department is to ensure the efficient use of the Defence Forces' performances and the execution of operations in all circumstances (The Finnish Defence Forces Logistics Deparment, 2021). This thesis has been completed for the Defence Forces Logistics Department.

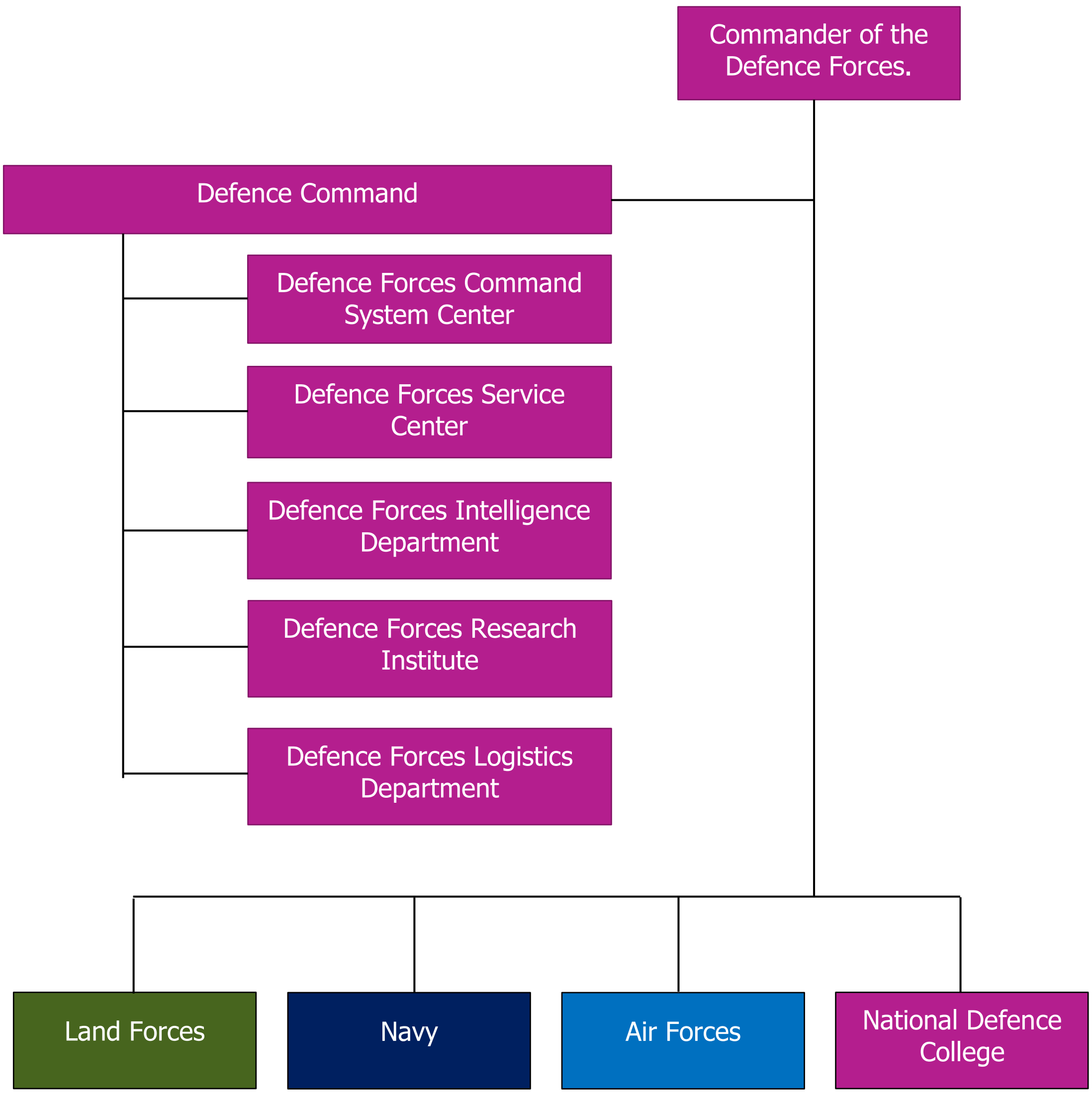

FIGURE 1. Structure of the Defence Forces. (The Finnish Defence Forces, 2018)

2.2 Defence Properties

The Defence Properties began operations on January 1, 2021 as a subsidiary of Senate Properties. Senate Properties and Defence Properties are under Senate Group. The structure of the Defence Properties is shown in Figure 2. The Senate Properties operate under the Ministry of Finance, the Defence Properties operate under the Ministry of Defence. The Defence Properties own the properties of the Defence Forces and provide the Defence Forces with maintenance and services in all circumstances. The defence property provides various services to the Defence Forces, such as construction, property maintenance, environmental services and energy services. Different services emphasize the security aspect, which is handled by the Defence Properties Security Unit. (The Defence Properties, 2021)

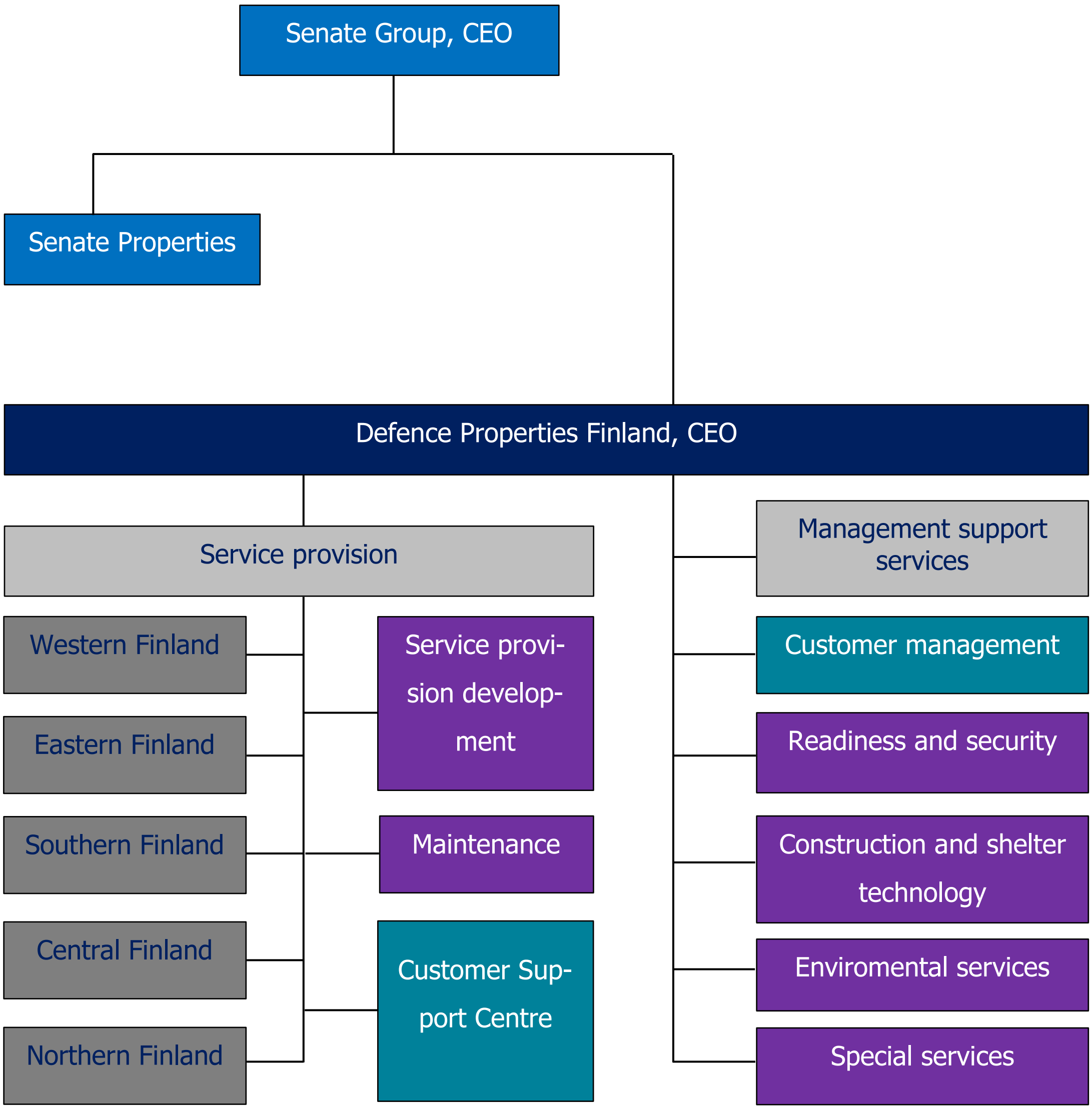

FIGURE 2. Structure of the Defence Properties. (The Defence Properties, 2021)

3 OBJECTIVES SET BY THE EUROPEAN COMMISSION

3.1 Introduction

This section provides information on the goals and studies set by European Commission. European Commission strongly supports innovations and new development projects, that aim to put the EU at the forefront of energy development and carbon reduction. In this section, a few points have been highlighted that relate to and support this thesis. The EU will also regulate (Appendices 1 – 3) the emission ratings of generators for backup power generators, taking into account production volumes and material support for future years.

3.2 Situation of the renewable energy industry in Europe

The EU has set up a Green Development Deal to encourage different states and actors to invest in carbon neutrality in all their activities. EU is also aiming to create a modern, resource efficient and competitive economy that is carbon neutral by 2050. This deal is called the 'Green deal'. (European Commission, 2020)

The total capacity of solar electricity in the EU in 2019 was about 134 gigawatts, which is forecasted to increase to about 370 gigawatt in 2030. The aim is to create a strong in-house know-how and supply for photovoltaics in Europe, although Asia is currently the leading supplier in this field. (European Commission, 2020)

The EU's hydrogen strategy aims for an electrolysis capacity of 40 gigawatts of renewable hydrogen, with the aim of producing around 10 million tons of renewable hydrogen for the EU's energy system by 2030. Around 24 - 42 billion € will be spent on these investments. In 2019, the EU had about 50 megawatts of production electrolysis capacity. (European Commission, 2020)

Demand for Lithium batteries is forecasted to increase from 200 gigawatt hours in 2019 to approximately 2,000 gigawatt hours by 2030. The growth in the forecast is mainly based on the electrification of vehicles. Demand for Lithium batteries has significantly reduced their price, as well as significantly improved the energy density of these batteries. (European Commission, 2020)

3.3 European hydrogen strategy

Europe's first development goal in the hydrogen strategy is renewable hydrogen, which is mainly produced by wind and solar energy. Renewable hydrogen is considered a good option, suitable for integration into the energy system to achieve the EU's long-term climate neutrality and pollution goals. (European Commission, 2020)

The European Commission's hydrogen strategy has well highlighted the challenges associated with hydrogen production and commercialization. This thesis takes a position on the same issues that have arisen in the EU hydrogen strategy. Renewable hydrogen could be a good idea for a strategy, while at the same time building other infrastructure through which renewable electricity, such as wind and solar, can be obtained.

4 PROSPECTS FOR THE FUTURE OF ROAD TRANSPORT

4.1 Industrial

The transport industry is involved in many things, such as fuel production and distribution. Monitoring and improving the carbon footprint of fuels has a direct impact on engine technology and it's industry. As engine technology evolves and requirements become more stringent, different alternatives to produce energy begin to emerge. As the transportation industry begins to turn into a certain direction in technology, change can happen very quickly, even if other infrastructure is not fully built for this purpose. However, some changes take time. As the generator production decreases, it directly affects the spare parts and availability of that product. This has a direct impact on serviceability and repair situations. As the production of backup power engines decreases, this can lead to the renewal of existing equipment and the recovery of these dismantled parts in the remaining equipment. The impact of the automotive industry is shown in principle in Figure 3. Vehicles and non-road vehicles just as backup power generators are regulated by the same regulations. (The European Parliament and of the Council, 2016)

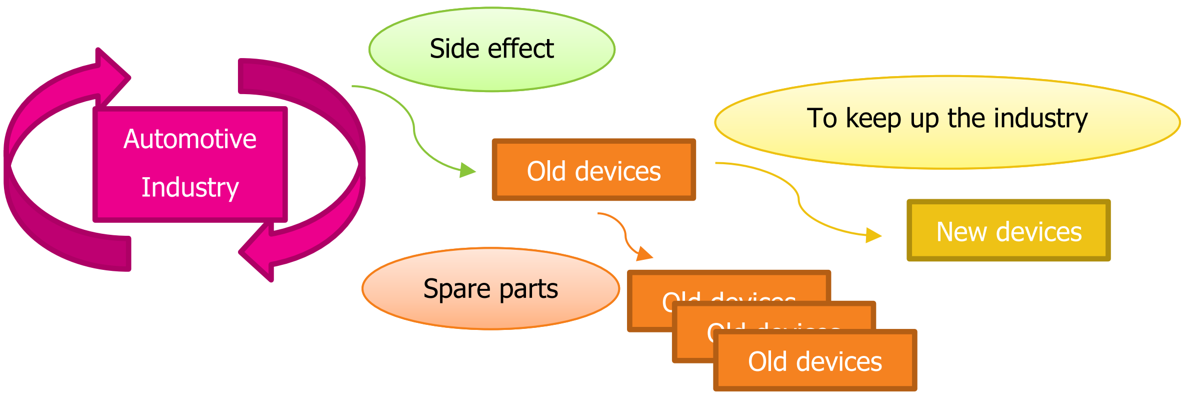

FIGURE 3. The impact of the automotive industry on backup power technology.

4.2 Prospects

The Finnish Automotive Information Center has prepared a report on the propulsion forecast of the car fleet. The report describes foreseeable technological developments, changes in legislation and control measures, and consumption patterns based on the development of different driving forces. This thesis focuses on the driving force of trucks, which has a direct impact on the development of engine technology and the changes in driving forces in this relationship. Light hybrid technology combined with diesel will evolve, and thereby reduce emissions, and the importance of renewable diesel will increase as an emission reducer. However, while new technologies are arriving, they do not fully replace the mileage achieved with diesel. Since the EU has set targets for car manufacturers, truck manufacturers are expected to reduce their carbon footprint. The target is to reduce carbon footprint by 2025 -15% compared to 2020 values, and for 2030 -30% compared to 2020 values. The above values are shown in Appendix 4. Manufacturers can implement changes in technology in a neutral way, for which the EU has not set any restrictions. The Appendices 5 - 8 contain tables of estimates of how different technologies will change. (Autoalan Tiedotuskeskus, 2021)

5 PROSPECTS FOR THE FUTURE OF CONSTRUCTION

5.1 Industrial

The goals of the construction industry have a direct impact on the topic of this thesis, and are one of the reasons why this topic should be considered more broadly. In order to achieve the construction goals of reducing the carbon footprint, these issues must also be taken into account in reserve power technology and implementation. In the construction industry, emphasis will be placed on energy efficiency and renewable energy sources. This should also be taken into account when considering backup power energy. There will be changes in buildings and structures, and this will have an impact on backup power. These changes can free up energy production for really critical functions, when other energy needs are produced in other ways. Consideration should be given to what systems would be fed purely by backup power. This is illustrated in Figure 4.

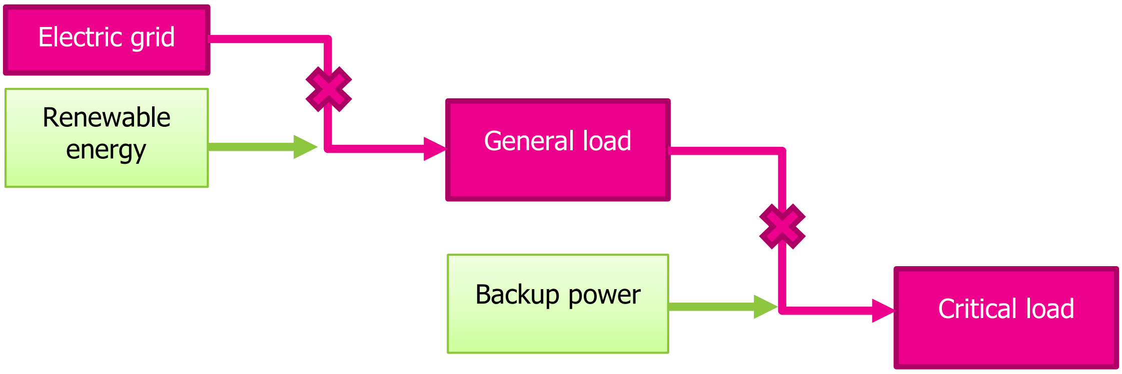

FIGURE 4. Electricity grid structure and clear distribution for backup power.

5.2 Prospects

In the construction industry, Finland's goal is to become carbon neutral by 2035. This goal is pursued with the help of energy, technology and forest industries. The carbon footprint roadmap has been prepared for Finnish buildings and construction. The roadmap has identified the main points that can be used to achieve carbon neutrality in 2050. Construction must take into account the entire life cycle of the building, which starts with the design and ends with the demolition of the building. Below is Figure 5, which shows the carbon footprint reduction targets to be achieved. (RT, 2021)

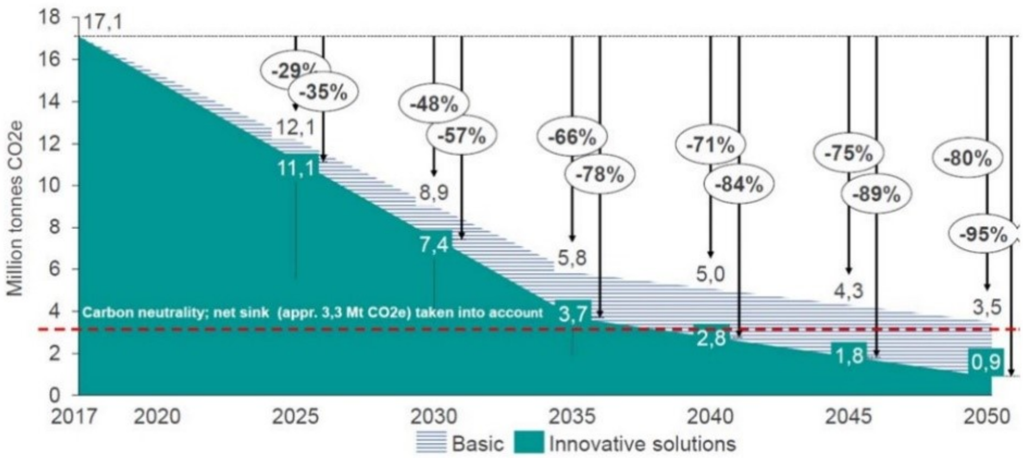

FIGURE 5. Carbon footprint reduction targets for the construction industry for different years. (RT, 2020)

6 BACKUP POWER TECHNOLOGY

6.1 Main points of the backup power machine

Fixed backup power engines currently in use are mainly diesel machines. The following figure 6 shows the main points of backup power engines that affect the operation and emissions of the generator. The backup power plant operates, on some fuel, the end product of which is exhaust gas and heat and electricity. In order for the backup power unit to operate for long periods of time, the cooling of the machine and the room must be taken into account.

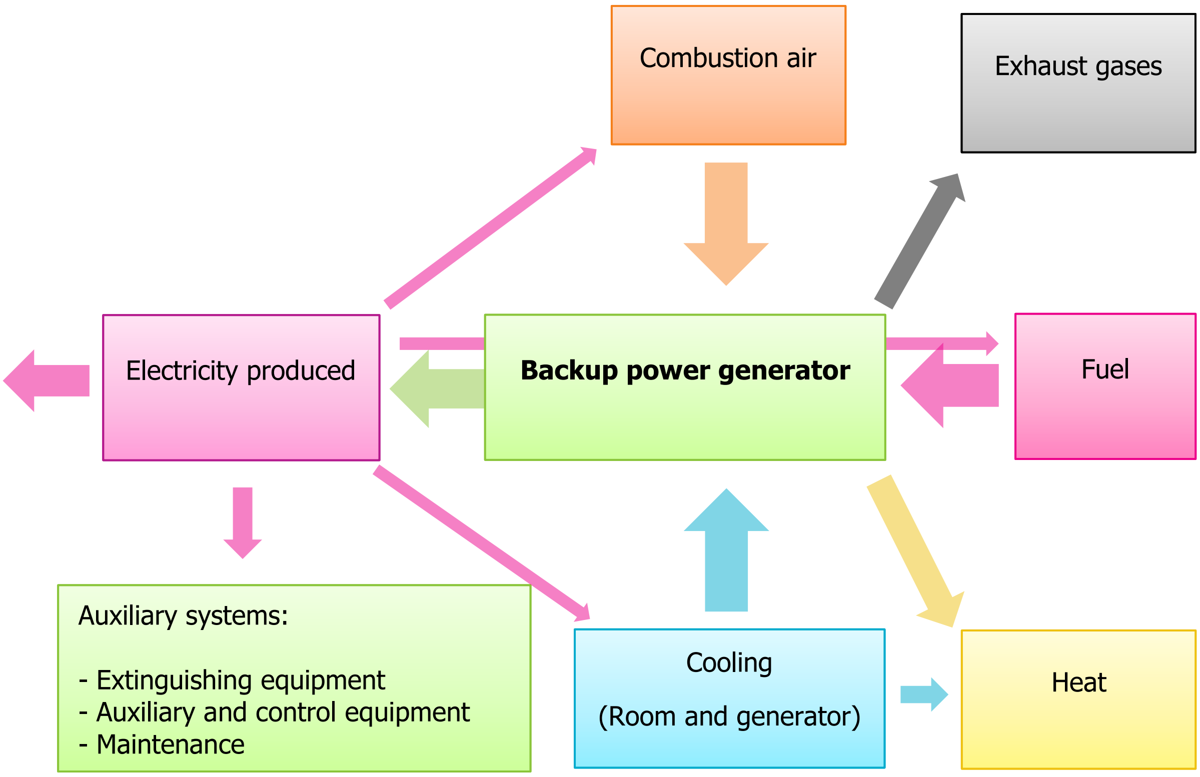

FIGURE 6. Factors affecting the backup power plant.

6.1.1 Fuel

It is easiest to influence the emissions of a backup power plant through fuel. In fuel emissions, consideration must be given to what resources are used, when the fuel is made. It should also be taken into account, from where it has been transported and how it is stored. The European Parliament and the Council of the European Union in Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources, has highlighted the points that affect the carbon footprint of a fuel. (The European Parliament and the Council of the European Union, 2018) Figures 7 - 10 have been prepared taking into account the history of fuel production, what is mentioned in the Directive (EU) 2018/2001.

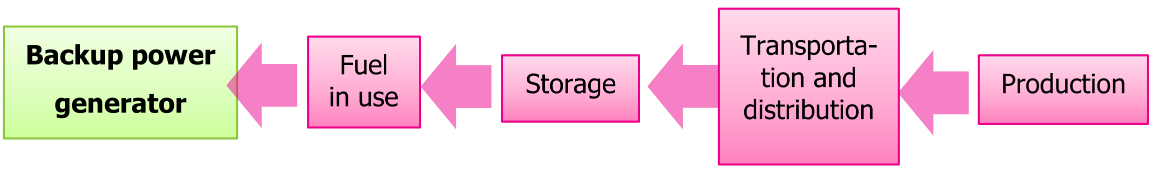

FIGURE 7. The impact of backup engine fuel.

In the production of fuel, it must be taken into account, what raw materials have been used for its production. What kind of equipment is needed to produce these raw materials? Whether the raw material has to be produced by itself or is it a waste of some other product.

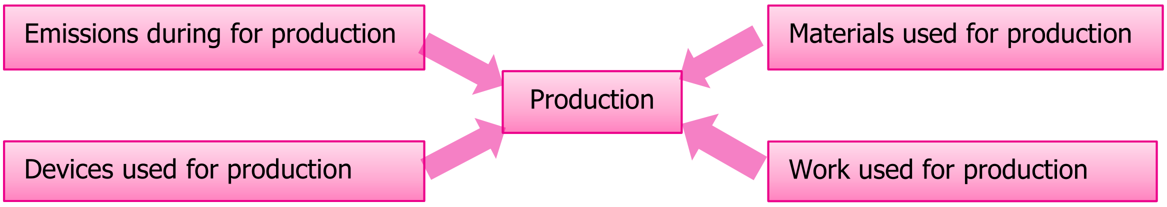

FIGURE 8. Fuel production.

When transporting fuel, the distance to be delivered must be taken into account. What tools and measures are needed to keep the fuel in its own form. Emissions from these can affect the overall picture, as well as possibly availability in exceptional circumstances.

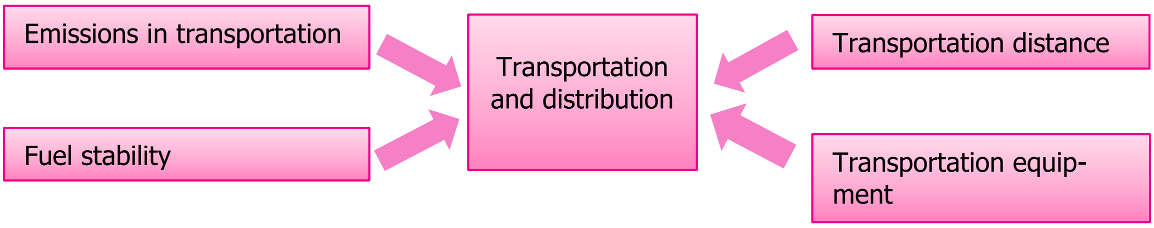

FIGURE 9. Fuel transportation.

When storing fuel, the form in which the fuel needs to be stored must be taken into account. The properties of the fuel create requirements for the technology, how it should be stored, protected and maintained.

FIGURE 10. Fuel storage.

6.1.2 Exhaust gases

Exhaust emissions are affected by the choice of fuel and the technology that is used. Exhaust gas from backup power engines are usually not filtered. The exhaust gases from the backup power machine are very warm, around 400 – 600 °C. Hot exhaust gases should be led out of buildings with their own exhaust pipes. (Sähkötieto ry, 2019) Long exhaust pipes are challenging to build and possibly also very expensive in underground solutions. In underground applications, the exhaust outlet requires excavation, pressure bushings and heavy structures. Figure 11 shows the impact of backup power exhaust on the enviroment.

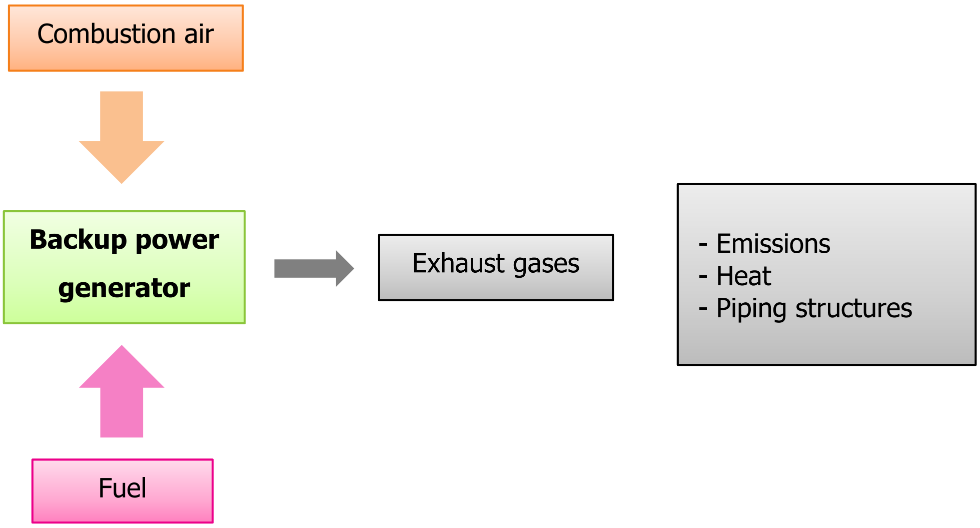

FIGURE 11. The impact of backup power exhaust gases on the environment.

6.1.3 Combustion air

The backup power plant usually takes the combustion air next to the machine. In caverns, there may be a need to bring combustion air to the backup power plant through a separate pipelines. (Sähkötieto ry, 2019) Figure 12 shows the effect of combustion air on the backup power machine.

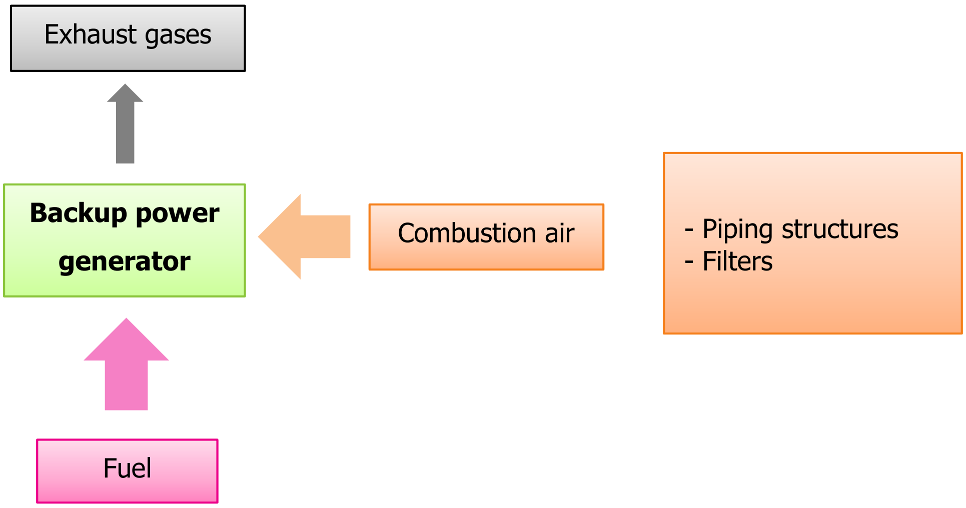

FIGURE 12. The impact of backup power combustion air on the environment.

6.1.4 Heating and cooling

The backup engine generates heat during an operation, that heats the backup engine, and the space around the backup engine, and fuel. This generated heat, must be removed to keep the equipment in working and an operating condition for a long time. The size of the backup power unit determines how much cooling power should be reserved. This cooling capacity must also be taken into account in the production of electrical power for the backup power plant. For cooling, there are different techniques for how to cool a backup power machine and room. (Sähkötieto ry, 2019) Figure 13 shows the challenges and emissions of cooling the backup power plant and space.

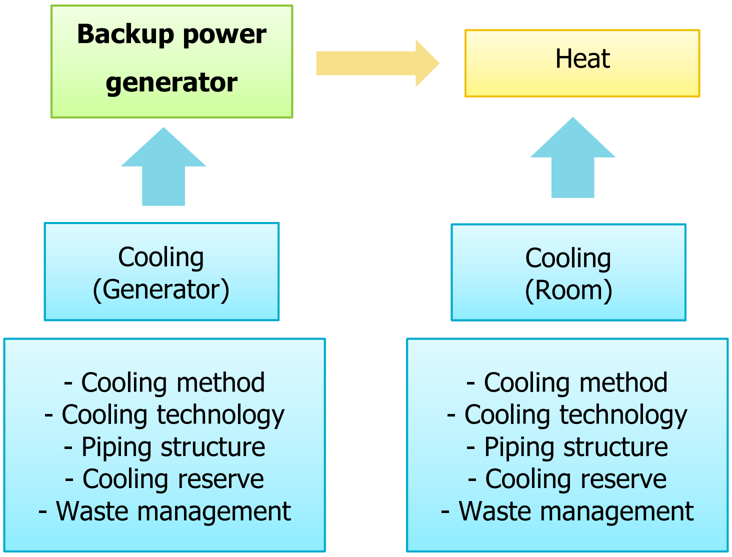

FIGURE 13. The impact of backup power cooling systems on the environment.

6.1.5 Auxiliary systems

Auxiliary systems are greatly influenced by the technology used in the backup power plant. Auxiliary systems could include the following extinguishing system, fuel leakage monitoring, Scada system, management system, building automation, and maintenance procedures. (Sähkötieto ry, 2019) Auxiliary systems aim to ensure the long-term operation of the backup power plant. Figure 14 shows the backup power machine and space-based auxiliary systems.

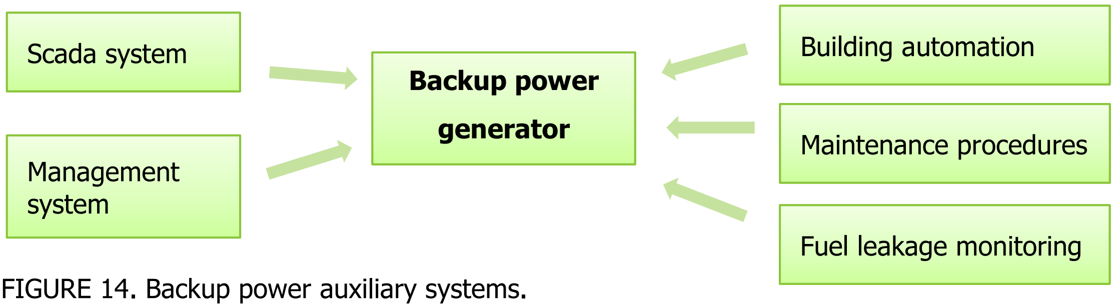

FIGURE 14. Backup power auxiliary systems.

7 ENERGY SOURCES

In this section, the thesis goes through different energy sources. The basic information on energy sources is briefly described. The current applications of energy sources, future prospects and the situation in Finland are also described. Current applications and future prospects are sought from the internet, from various energy companies and from various studies. Some of these energy sources are producing electricity directly for the target and some are producing indirectly.

7.1 Natural gas energy

Natural gas is a fossil fuel that has been used extensively to heat houses and generate electricity. Liquefied natural gas is methane, and it reaches a liquid state at -160 ° C. At the point of use, liquid methane is converted to gas. LNG is also relatively safe to use if a leak occurs in this system. After leaking LNG evaporates immediately and in gas form it is lighter than air. LNG does not explode so easily, because of its higher ignition temperature than oil-based fuels. Compressed natural gas is used as a fuel in gas cars in a pressure of 200-250 bar. Natural gas can also be used to produce hydrogen gas and can also be used in fuel cell installations.

Natural gas systems are developing in Finland all the time. At present, Gasum is one of the largest companies in Finland that owns natural gas filling stations. LNG is delivered by ships from partners in Norway and Europe. (Gasum Oy, 2021) In figure 15 there is Gasum OY's 28,500 m3 LNG terminal in Pori. According to the Automotive Information Center, there will be 52 CNG stations and 7 LNG stations in Finland in 2021 (Autoalan Tiedotuskeskus, 2021). LNG equipment for backup power generation exists and could be used in fixed and mobile solutions. Appendices 28 - 29 shows a backup power plant that operating on LNG.

FIGURE 15. Gasum OY's LNG terminal in Pori, Finland. (Gasum Oy, 2021)

7.2 Biofuel energy

To produce biogas, biodegradable raw materials are needed: inedible bio-waste from trade, garden waste from gardens or, for example, mash from brewing. These biodegradable raw materials are delivered to biogas plant, where they produce environmentally friendly renewable energy biogas.

In Finland, biogas is mainly used for the production of heat and electricity in 2017, about 500 GWh of heat and electricity were produced with gas from biogas plants. The demand for low-emission fuels increased in transportation in 2017. The use of biogas as a transport fuel increased to 31 GWh of energy. There are currently 36 biogas filling stations in Finland. (Gasum Oy, 2021) Neste has over 120 filling stations in Finland, where Neste MY biodiesel is available. Neste MY biodiesel is 100 % produced from waste and residues. (Neste, 2021) Figure 16 shows the Neste demonstration of the combustion of biodiesel, which appears to burn with brighter flame and create less smoke. Biogas equipment for backup power generation exists and could be used in fixed and mobile solutions. Appendix 29 shows a backup power plant running on many fuels, such as biogas.

FIGURE 16. Neste MY biodiesel. (Neste, 2021)

7.3 Hydrogen energy

Hydrogen gas is not stored in nature, but should be produced from natural gas, biogas, or electrolysis of water. The most common way to produce hydrogen has been to use methane. Hydrogen produced through methane is an expensive process. More direct alternatives are being developed, but their operation in the use of backup power can be a challenge. Cummins is one of the leading companies manufacturing modular fuel cells, one example of which is shown in Figure 17. More direct alternatives are to use photovoltaics and wind power, to generate electricity to carry out electrolysis of water. Hydrogen technology is evolving and there are truck solutions that can reach distances of up to 400 km (Newatlas, 2020), as well as passenger car solutions that can reach distances of up to 650 km (Toyota, 2021).

FIGURE 17. Fuel Cell Module. (Cummins Inc., 2021)

7.4 Photovoltaics energy

The photovoltaic system captures solar energy, utilizing single-crystal and multi-crystal panels. The panels of the photovoltaic system are evolving into more energy-efficient solutions for the collector. Photovoltaic systems are becoming more common in Finland. Photovoltaics could be used, for example, in the electrolysis of water to make hydrogen and that hydrogen could be stored, in a separate storage container. Solar panels are not directly the best solution for a backup power generation, because energy is also needed on dark and cloudy days. The solar panel system can be used to generate electricity, which is then converted to another form of energy. Solar panels can be used with battery storage, but it doesn't give as long standby time as fuel based a generator. Solar energy could be better utilized in different structures, as the University of Lappeenranta has utilized in the figure 18.

FIGURE 18. A carport power plant at the University of Lappeenranta. (LUT University, 2021)

7.5 Wind energy

Wind energy utilizes the mechanical energy brought by the wind to rotate the generator and thereby generate electricity. Wind energy production is growing a lot in Finland and this brings to the market, clean energy produced from the wind, as shown in the figure 19 (Tuulivoimayhdistys, 2021). A wind farm is not the best possible source of backup power, because there may be times when the wind power does not rotate due to lack of wind. Wind power can be used to produce hydrogen in the electrolysis of water. Wind energy can also be stored in an electrical energy storage. Appendix 36 contains information on the coverage of Finnish wind power.

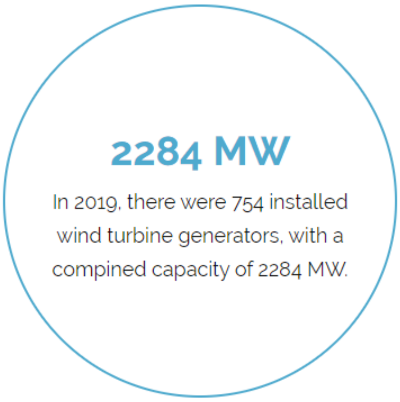

FIGURE 19. Finland is building wind power. (Tuulivoimayhdistys, 2021)

7.6 Nuclear energy

Electricity generated by nuclear power has mainly been produced in large quantities, but there are projects in the world that produce nuclear power in 1-10 MW power plants. Nuclear power generation has been a dreaded subject for some time, but has begun to gain a foothold in the modern world. Sources of low nuclear power generation are called micro or small nuclear power sources. Nuclear power has been producing energy in space for some time. Systems in the Appendices 13 - 15 had a life cycle of 30-40 years. (IAEA, 2020)

The U.S. military has had many experiments and successful solutions on a variety of nuclear-powered targets. Examples can be found in remote radar stations, ships, submarines and other military equipment. In 2019, the U.S. Department of Defence decided to launch Project Pele, which will resort to potentially large power outages. The project will be building many different size of small nuclear power plants from 1 MW to 10 MW. (World Nuclear Association, 2021)

One of the nuclear power plants generating electricity for the Finnish grid is Olkiluoto 3, which is scheduled to start commercial production in 2022. In figure 20 is shown Olkiluoto 3, wich is owned by Teollisuus Voima Oyj (TVO). (STUK, 2021)

FIGURE 20. Finnish nuclear power plant Olkiluoto 3 has a size of 1600 MW. (STUK, 2021)

7.7 Fusion energy

Fusion energy is meant to create energy by combining deuterium and tritium, which are combined at 150 million degrees celsius using strong magnetic fields. During the collision, an electrically charged plasma is formed that can be utilized for energy production. For now the implementation uses more energy than generates. This fusion project has been done through a joint project of many countries (Fusion for Energy, 2021).

As fusion energy technology advances, it can bring in new innovations, such as superconducting materials, that can very strongly shape the electricity distribution of the future if they become commercialized. (Fusion for Energy, 2020) Fusion energy solutions are unlikely to change into smaller solution entities, at least in the near future.

7.8 Hydro energy

Hydropower utilizes the potential energy of water, which is converted into electricity by a mechanical movement by a generator. Hydropower is 100% pure renewable energy. Hydropower production does not generate carbon dioxide. Hydropower can produce large amounts of electricity and this is a very stable production method. Rainfall strongly affects the size of water reservoirs. In Finland, hydropower generates about 15% of electricity, of which Vattenfall's production, for example, accounts for around 3%. (Vattenfall, 2021) In figure 21 there is Vattenfall dam and water pool.

Hydropower could be one form of renewable energy that could be used, for example, as a source of hydrogen energy production. The combination on the side of hydropower could be an electrolysis plant that produces hydrogen from water and electricity from a turbine. So, the water could serve as a reservoir pool for both hydropower and for hydrogen power.

FIGURE 21. Vattenfall's hydropower plant in Joensuu. (Vattenfall, 2021)

7.9 Tidal energy

Tidal energy utilizes the kinetic energy produced by the sea, a lake, a river, or any flowing water. There are already very different solutions that utilize wave energy in the market. Energy production can consist of a sea waves or from the currents at the bottom of the sea. There are also companies pro-ducing wave energy equipment in Finland (Figure 22). Wave energy is also one source of renewable energy that can be used for many purposes. One such means of recovery could also be hydrogen production.

FIGURE 22. Wave power plant produced by the Finnish company Wello. (Wello, 2021)

7.10 Thermoelectric energy

The Thermoelectric Generator generates electricity from heat, utilizing a thermocouple. Thermoelectric Generator technology has been used in space. Combining Thermoelectric Generator technology with other technologies can potentially improve existing technologies, such as photovoltaics, which currently only recover solar energy, but not solar thermal energy. (SFR, 2021) Space technology has utilized the heat generated by nuclear power, together with a thermoelectric generator. (Spacenews, 2017) RTG is used in space technology in equipment with an electrical power requirement of less than 100 kW. (World Nuclear Association, 2021) RTG has also been used in cars as well as in wristwatches that have taken heat from the human body. (G. Jeffrey Snyder, 2008) Over the years Nasa has developed various energy sources for future space flight, one example is shown in Figure 23. (Nasa, 2015) Appendix 27 shows the basic principle of TEG operation.

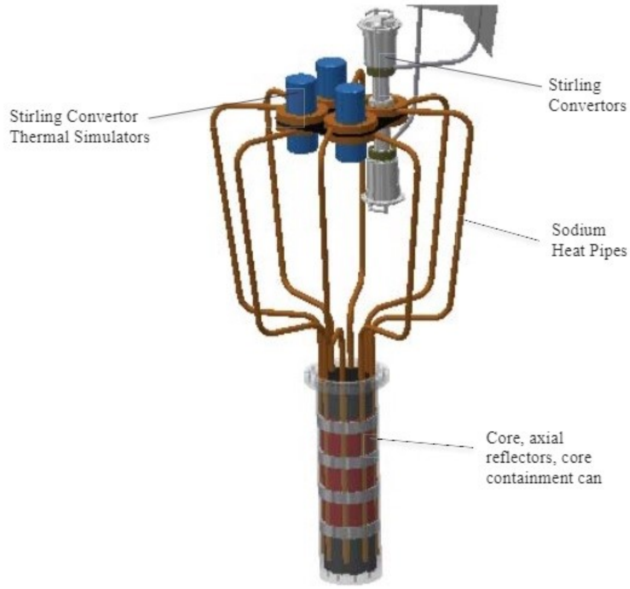

FIGURE 23. Kilopower Assembly Test with a core, sodium heat pipes, hot end conduction plate, Stirling convertors, and Stirling thermal simulators. (Nasa, 2015)

7.11 Geothermal energy

Geothermal energy is the renewable energy that the earth produces over time. Geothermal energy is usually used to heat or cool buildings. Geothermal could also use the TEG technology of the previous title, which utilizes heat to generate electricity. Heat stream coming from underground, could be utilized with a turbine to generate electricity. In Finland, ST1 has a geothermal project in Otaniemi, where renewable energy is developed through geothermal energy (St1, 2020). The St1 technology produces heat, but the equivalent could also utilize it for an electricity generation through turbines. In figure 24 is shown basic principle how geothermal heat is working.

FIGURE 24. The principle of using geothermal heat for a house.

7.12 Neutrinovoltaic energy

Neutrino electricity utilizes neutrinos that fly freely in space or possibly man-made neutrinos. In 2015, two separate scientists found that a neutrino has mass and it has resulted in this being able to be used to generate electricity. Neutrinos are very small and fly through different materials and this allows for energy production almost anywhere. For this, neutrino collection equipment must be developed, just like as solar energy had it own panels. (Neutrinovoltaic, 2021)

Neutrinovoltaic energy is a technology that is still in its development stage, but will have a very promising energy source in the future. If that technology gets into commercial production, it will really shape the distribution and management of energy a lot.

8 ENERGY STORAGE

The stored energy can take very different forms, and they may require different structures and devices to maintain this form. Fuel storaging should take into account the environment and chemical safety.

8.1 Liquid storage

Liquid fuel is commonly stored in steel tanks, but there are also other means of storage. In principle, the fuels of existing backup power plants are stored in liquid form. As fuel properties change, consideration should be given to whether existing storage facilities, piping, and ancillary equipment can be utilized with the new fuel. After all, the best option would be that storage, as usual, would not require major changes when a new backup power plant is put into operation. However, any changes made on fuel storage, there is need to check the laws, guidelines and regulations. In figure 25 there is an example of a fuel tank above the ground.

FIGURE 25. Liquid fuel storage in Pietarsaari. (Asennusliike Lahtinen Oy, 2021)

8.2 Gaseous storage

Gas-powered backup power engines are not much used, at least in the scope of this thesis. So even these storages aren’t much in current installations, if at all in backup power generation. Gas storage facilities are used in separate extinguishing systems. Gas storage facilities must comply with the pressure regulations and other laws and regulations required by it. Gas storage can be, for example; natural gas, compressed air and hydrogen storage. In figure 26 there is installed gaseous storage.

FIGURE 26. Gaseous storage. (Asennusliike Lahtinen Oy, 2021)

8.3 Battery storage

Battery technology is evolving all the time as new materials are invented to store electricity. Currently, lithium batteries are one of the most efficient ways to store electricity. By storing electricity and using it directly from the battery, the efficiency of electricity remains very high, at almost 90%. Battery storage alone is not enough when comparing the energy and duration produced by diesel backup power machine. The situation may, of course, be different in the future if invented products at the nanoscale that get electricity stored in a smaller space. Today, battery storage is used for uninterrupted electricity and to improve the quality of electricity, which is a good combination for backup power. Battery storage will probably be used a lot in storage of renewable energy, but only temporarily. In figure 27 there is one solution from battery storage.

FIGURE 27. A battery storage in a container. (Eaton Oy, 2021)

8.4 Mechanical storage

There are different types of mechanical storage, for example, a water pool can be thought of as a kind of potential energy storage, where water is pumped into the tank with renewable energy and used when there is no renewable energy in use. Similar mechanical stocks may be that heavy materials are lifted up into a container and the lifting is performed with renewable energy and lowered when energy is needed, when renewables do not produce. When the material falls, electricity is produced. (Balkan Green Energy News, 2019) Diesel Rotatory UPS system, DRUPS has a flywheel that works like an UPS and creates uninterruptible backup power. The flywheel acts as a mechanical energy generator. (Kwset, 2021) In figure 28 there is DRUPS installation.

FIGURE 28. DRUPS installation. (Kwset, 2021)

8.5 Thermal energy storage

Many different technologies can act as thermal energy storage. One way is, for example, geothermal energy. In geothermal implementation, heat is produced with renewable energy and that heat is pumped underground to storage. A material that could bind heat well and release it could also be used as a heat store. Renewable energy could produce heat, that is bound in a resource. When there is no renewable energy, this heat could be released to produce electricity. In figure 29 there is one example of thermal energy storage. (International Renewable Energy Agency, 2020)

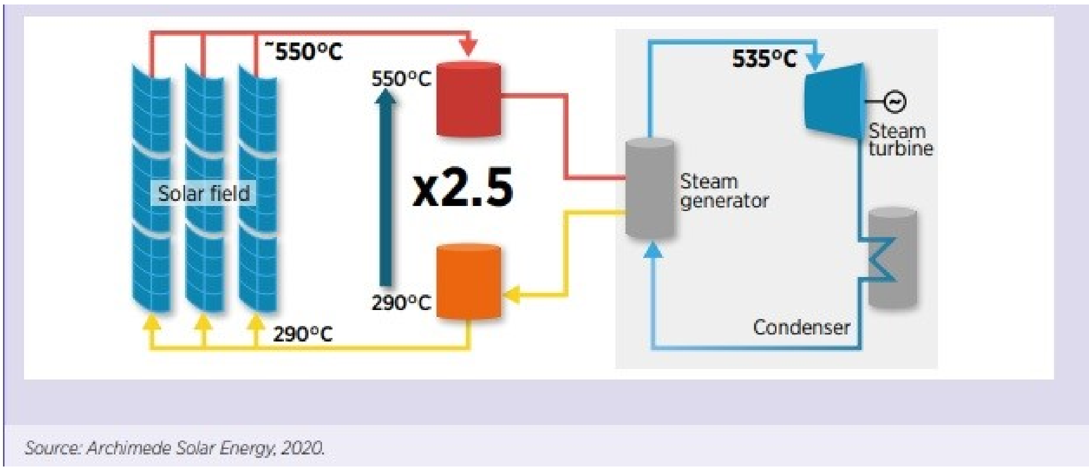

FIGURE 29. Thermal energy storage with a direct molten-salt storage system. (International Renewable Energy Agency, 2020)

8.6 SMES

Superconducting magnetic energy storage is one way to store electrical energy. The SMES system achieves an electrical efficiency of 90 – 95 %. The power size of the system varies from 100 kW to 10 MW. The SMES system has a long service life that can reach about 30 years. In the SMES system, energy is stored in a magnetic field formed by frozen superconducting coils. (EERA, 2019) Figure 30 shows the principle of the SMES system.

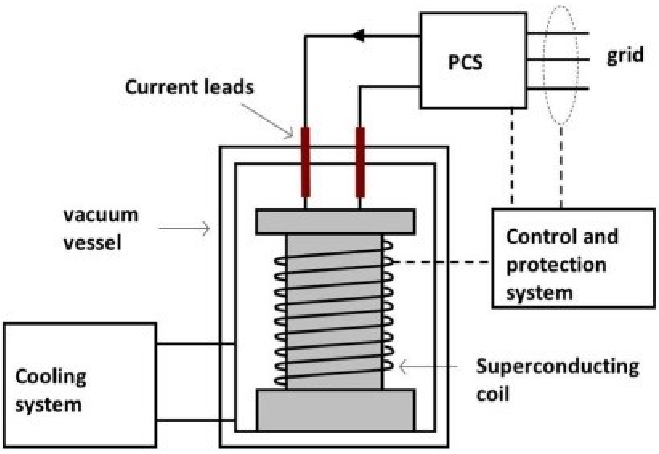

FIGURE 30. The principle of superconducting magnetic energy storage unit. (EERA, 2019)

9 COMBINATIONS OF DIFFERENT FORMS OF ENERGY

It would be a good idea for the backup power plant to be very simple. In a military use with an underground location, the backup power should be easy to maintain. It should be, possible to maintain and repair it with the help of our own personnel. Backup engine components should also be well available, ideally for domestic delivery. This is emphasized in exceptional circumstances and exceptional situations. However, this section outlines the combinations and combinations of different forms of energy and technologies to get the most out of them. The end product desired from the backup power plant is electricity. Figure 31 shows the principle of combining different fuels.

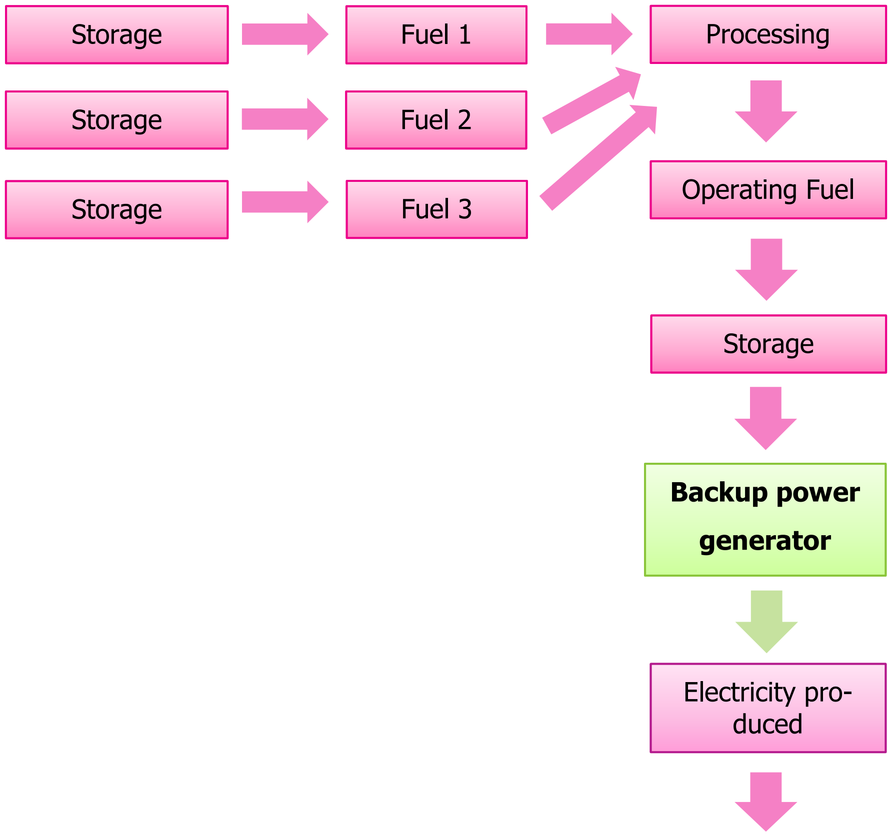

FIGURE 31. The principle of combining energy.

In this section, fuel is defined as all possible raw material needed to produce the operating fuel that is fed to the backup power generator and that produces electricity. The fuel here can also be considered to be electricity produced by solar electricity, wind power or hydropower. The storage here can be listed as a storage tank, ground heat or battery storage. The backup power generator can also be a combination of different technologies.

9.1 Power to X

Power to X means changing the form of energy to another form. For example, renewable electrical energy is converted and stored in a liquid form where it lasts longer after which it can be converted back again. P2X applications emphasize the efficiency of the conversion situation when energy is converted from one form to another.

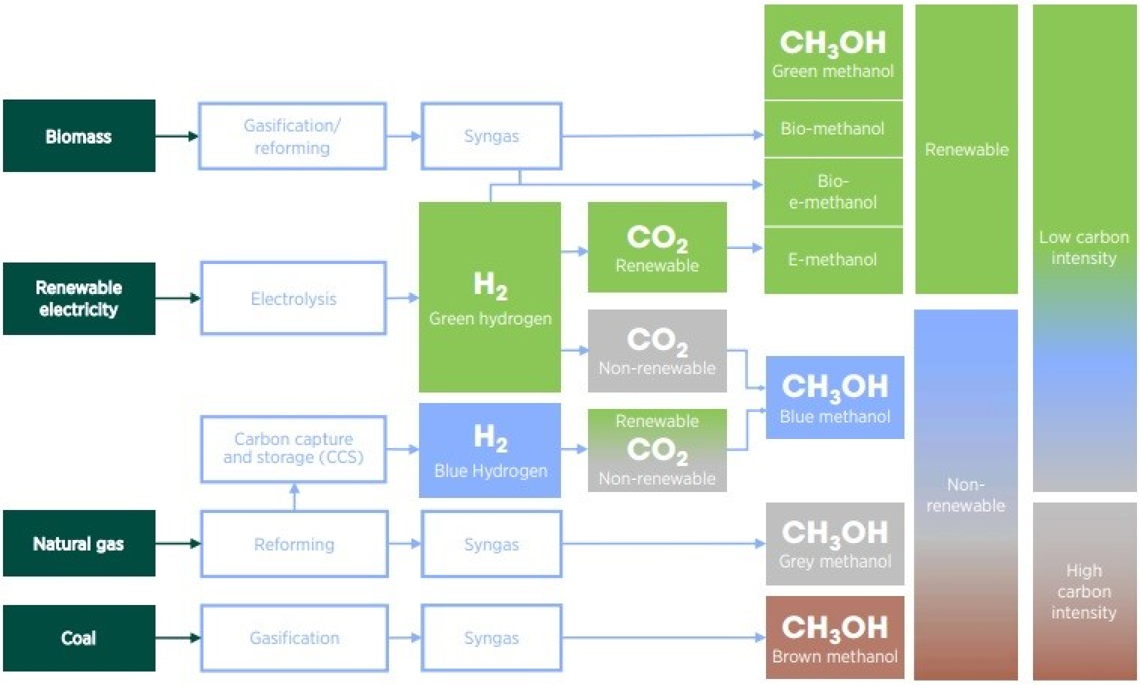

FIGURE 32. One example of Power to X solution. (IRENA, 2021)

The figure 32 shows one example of how P2X is applied when creating different methanol end products from different energy sources. The picture also shows how renewable this product is in the end.

9.2 Power to gas to power

This section considers the production of hydrogen gas from different liquids, using renewable energy sources as an electricity source. Hydrogen can be produced from water by electrolysis. There are some applications of hydrogen that achieve 60% efficiency, which is already better than internal combustion engines. Combustion engines achieve efficiency around 33 – 35 %. (The U.S. Department of Energy, 2015)

The renewable solar electricity is used to produce hydrogen by electrolysis. This electrolysis drops energy efficiency by about 20 – 30 % (Siemens, 2019). After electrolysis, hydrogen compaction and storage and transport further reduce energy efficiency by about 20 – 25 %. At this point, the initial energy source is already half used. This is then used to produce electricity from hydrogen, with efficiency of about 50 – 60 % with current technology (The U.S. Department of Energy, 2015). After this whole process, there was at start 100 %, and after about 30 % remaining available. In other words, in terms of electrical power, you produce 100 kW with solar electricity and after the process, only 30 kW is available. Figure 33 shows the principle of how energy efficiency decreases during the process.

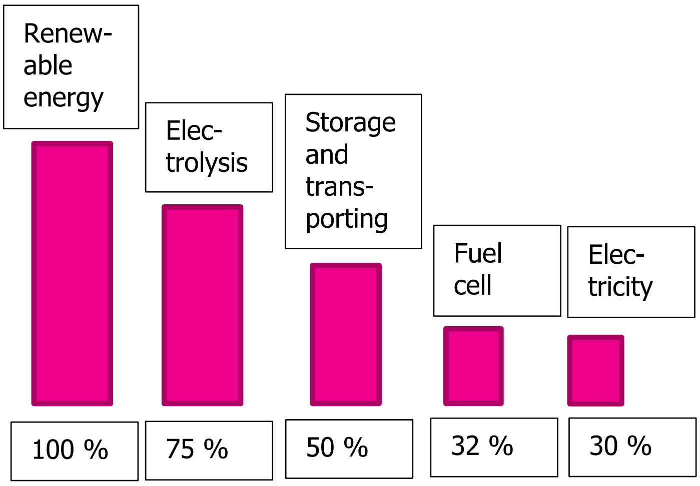

FIGURE 33. The principle of hydrogen efficiency rate.

In a situation where the system produces more renewable energy than it is consumed. In that situation, for example, hydrogen can be produced into storage by electrolysis. Electrolysis should be thought of as fuel production. By using renewable energy to produce hydrogen, which is used as fuel, the fossil fuels and emissions can be eliminated. Of course, emissions are generated when these different systems are built, but as a rule, it is only in the foundation phase. In the future, by improving energy efficiency of energy conversion steps, this could raise the efficiency of hydrogen technology. Figure 34 shows the principle of how energy efficiency decreases closer to the end-use.

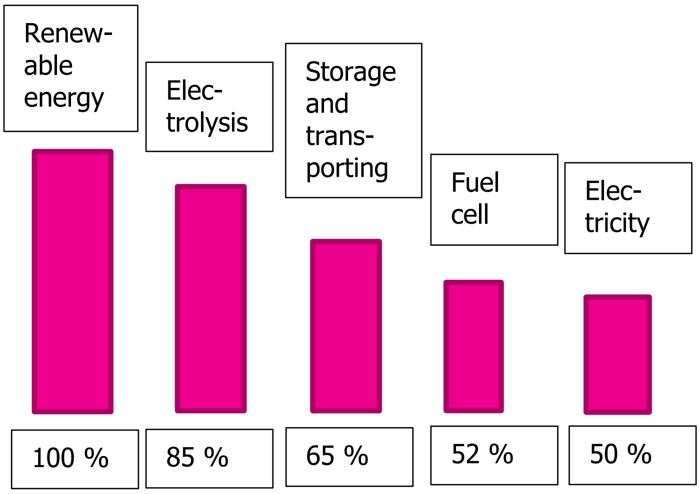

FIGURE 34. The principle of hydrogen efficiency rate, if every conversion part is little developed in the future.

In the future, domestic fuel production, could also be one direction of sustainable development. Therefore, it is extremely important to consider how the systems supporting the infrastructure should be built, if some form of energy is abandoned, such as fossil fuels.

9.3 Power to heat to power 1

This section looks at converting renewable energy to heat and back to electricity. Thermoelectric generator (TEG) can turn heat to electricity. However, the efficiency of this is relatively poor, still with current technology, but in the future this technology may also evolve when suitable materials

and the right compounds for the technology are found. With current technology, the efficiency of TEG is about 5-10 %, which is low in comparison with other forms of production. In figure 35 is shown how low TEG efficiency is.

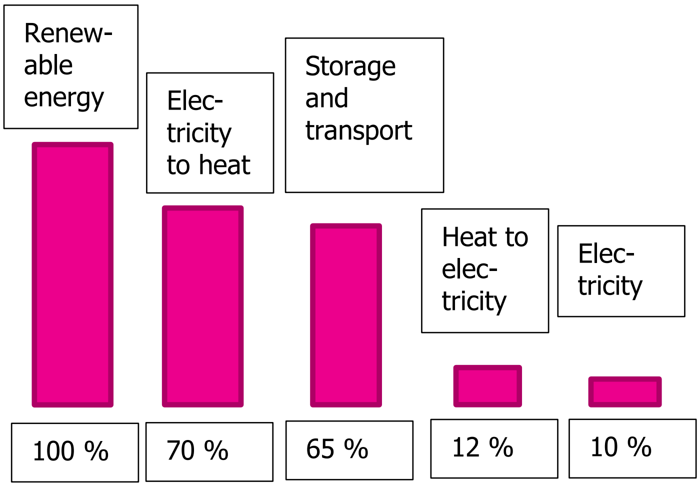

FIGURE 35. The comparison of TEG efficiency rate.

9.4 Power to heat to power 2

This section utilizes renewable energy and converts it into heat and back into electricity. In this version, renewable energy is converted into heat and stored in the ground. When electricity is needed, heat is released up from the soil and a mechanical flow of heat is taken and electricity is produced by a turbine. In figure 36 is shown, that using turbine technology is better than TEG tehchology.

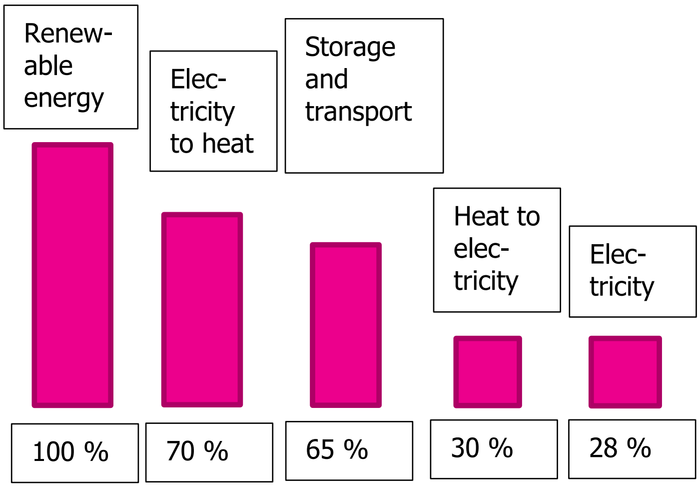

FIGURE 36. Principle of steam turbine energy efficiency.

10 COMPARABLE ENERGY SOURCES

The easiest way to improve carbon neutrality is to switch to bio fuels. This thesis considers the differences between biofuels and fuel cell installations and solution options. After all, it might make sense to move through biofuel to hydrogen solutions. Appendices 9 - 11 shows the basic components that make up the hydrogen system, this information is formed from different sources of the thesis. Appendices 9 - 11 also show different fuel options in the hydrogen system. Appendix 18 presents various hydrogen storages and Appendices 19 and 20 provide basic information related to hydrogen fuel cell technology, and Appendices 21 - 24 present workable hydrogen solutions. Appendix 29 shows a multi-fuel backup power plant in which, for example, biogas can be utilized.

10.1 Compatibility with buildings

Hydrogen and biofuel options work well, both in underground and in above ground installations. Hydrogen tanks have been tested by shooting them with rifle by Toyota (Toyota, 2016) and they have survived extreme testing, during the development phase (The U.S. Department of Energy, 2021). In case of possible hydrogen leaks, it should be taken into account that hydrogen is lighter than air and rises up. This can be accentuated in underground sites (SFS-käsikirja 604-1, 2018). Larger hydrogen solutions begin to have more temperature demands.

10.2 Utilization of technologies

Hydrogen and biofuel options can take advantage of existing storage. Hydrogen installation will need hydrogen storage, and if there is an electrolysis system, it also need own space. Biofuel can be used directly in existing backup power plants. It is the quickest and simplest solution, when it comes to reducing emissions. In figure 37 is shown what installation can be used in different solutions and what is needed to replace.

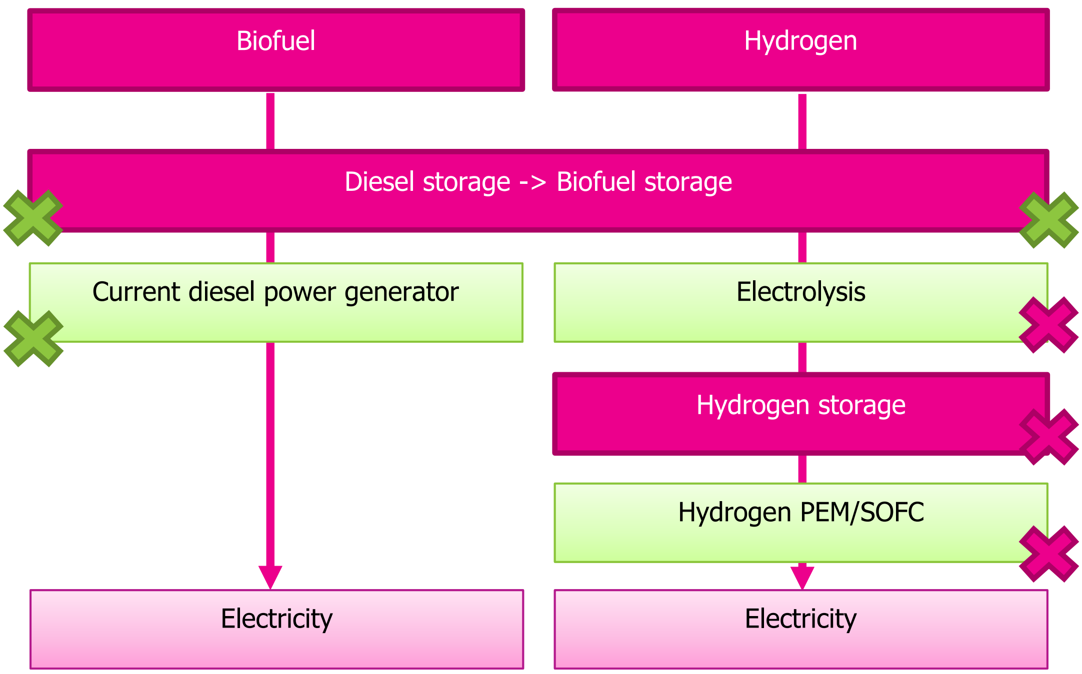

FIGURE 37. The difference in the usability of existing equipment.

10.3 Safety

Both technologies can be made sufficiently safe in the scope of this thesis. The hydrogen storage method has been developed and has become a very robust. Efforts must also be made to take into account possible hydrogen leakage and the measures that result from it. Hydrogen forms an explosive mixture with air at concentrations between 4% and 77%. The self-ignition temperature of hydrogen is about 560 degrees celsius. A mixture of hydrogen and air is a highly flammable gas that can ignite very easily. Hydrogen also displaces air, which can lead to a lack of oxygen. (SFS-käsikirja 604-1, 2018)

10.4 Cost effectiveness

A biofuel solution, especially a biodiesel solution is the most cost-effective solution. Biodiesel can be used directly in existing diesel generators. When switching from diesel to biodiesel, there is no need to make large investments. Biofuel can be used in hydrogen production. If the energy economy is turning to a hydrogen economy, then it is possible to switch from biofuels. Currently, the economy does not fully support the hydrogen economy, but this change can happen very quickly. The easiest and cheapest way to drop your own carbon footprint in backup power drives, is to switch from diesel to biodiesel.

10.5 Suitability for a fixed solution

Both applications are well suited for fixed installations. The use of biodiesel will not change the current installation, so it goes directly to fixed installations. A fixed hydrogen backup power plant works well. In fixed indoor installations with hydrogen more attention must be paid to the safety measures. The safety of hydrogen is mentioned in section 10.3.

10.6 Suitability for a portable solution

Both applications are well suited mobile energy production. Biodiesel also works well in mobile installations. However, the quality of biodiesel should take into account that the fuel can also withstand winter conditions. Hydrogen implementations are suitable for transmission at both low and high powers.

10.7 Risk assessment

Both solutions have their own risks. A few risks are highlighted in this section in Table 3. The table goes through the different colored sections, that can be challenging when choosing this implementation. The different colors on the board mean the following; Green has no challenges, orange can have some challenges and red means challenges (Table 2). The risk assessment has been prepared on the basis of the sources collected during the thesis. In Table 1 show explanations of the points on the risk assessment table 3.

TABLE 1 Explanation of the risk assessment table.

Explanation of the risk assessment table			
Risk	**Effect**	**Fuel 1**	**Fuel 2**
Identified risk that should be considered.	Effect from cause.	The text indicates the current situation. When looking at thesis sources. The color indicates the severity.	The text indicates the current situation. When looking at thesis sources. The color indicates the severity.

TABLE 2 Explanation of the colors in risk assessment table.

Explanation of the colors in risk assessment table.		
Color green	**Color orange**	**Color red**
No challenges identified or it is already well known.	Some challenges identified.	Major challenges identified.

TABLE 3 Risk assessment for biofuels and hydrogen.

Risk	Effect	Biodiesel	Hydrogen
Backup power service life	The need for system renewal and awareness of this.	Relatively well known.	Different implementation ways have different lifespans.
System operation	Using the system in normal mode.	Relatively well known.	Relatively well known.
System safety	Safe use of the system.	Relatively well known.	Relatively well known.
Acquisition costs	System cost, there are potential cost changes known.	Relatively well known.	Different implementation ways have different costs.
Backup power construction	Availability of system builders and repairers.	Relatively well known.	New technology that is evolving all the time.
Infrastructure serving the backup power plant.	Infrastructure supporting the system and its functionality, as well as the impact on the system.	Relatively well known.	Relatively well known.
The ability and speed of the backup power machine to take loads.	System start-up awareness, and standby times of an-	Relatively well known.	The different implementation methods have variability in load taking speed.

	other load-supporting system, such as a UPS.		
Standards and guidelines on storage	System standards and guidelines that can be relied upon during the design, construction, and operation phases.	Is available.	Is available.
Standards and guidelines on backup power	System standards and guidelines that can be relied upon during the design, construction, and operation phases.	Is available.	It is under development.
Spare parts availability.	System spare part available as soon as possible, so that the fault can be corrected. And action at the site will be made to continue.	Spare parts available.	The direct availability of spare parts is not certain.
Service personnel competence.	The experience and competence of the personnel using the system in normal and fault situations.	Relatively well known.	The staff does not have any new technology skills.
Outsourcing of maintenance.	Securing system maintenance in operation to ensure long system life.	External expertise can be found.	There can be challenges in finding outside expertise.
Design expertise in Finland.	System design expertise. Affects in many design fields.	Relatively well known.	There is not much new technology know-how.
Adherence to the backup power plant procurement schedule.	Outlining the system construction schedule in advance. There may be schedule delays.	Relatively well known.	The acquisition schedule may change if technology evolves and certain components are not yet sufficiently on the market.
Extinguishing the fire	System fire response and measures. How to act in this situation.	Relatively well known. Powder, foam or carbon dioxide can be used for extinguishing. Water is not suitable for extinguishing.	Relatively well known. If it is necessary to extinguish a hydrogen fire, direct the powder or carbon dioxide jet at the flame; in large fire

			use a water jet to cool down.

The hydrogen backup power solution has more variable factors, that make it a slightly more risk prone solution. As hydrogen technology develops and becomes more common, the points mentioned in the table 3 will be solved.

10.8 Comparative result

The most sensible solution in this situation is to choose biofuel and use an existing backup power engines for as long as they work and get spare parts for them. In this thesis, however, I want to select hydrogen as a backup power to produce energy. Hydrogen technology has taken a leap forward and amount of installations can rise quickly.

11 NEEDS ASSESSMENT

Needs assessment part gives the basic knowledge and input in order to build the selected energy source. Needs assessment is showing the costs and a draft of the backup power system and shelter. This section reviews what needs to be considered in needs assessment. In this thesis, there is attached needs assessment, which is classified. The needs assessment is not public. The needs assessment goes through the points mentioned here below and the cost estimate thoroughly. The needs assessment is presented in Appendix 41.

11.1 Basic information about the project

The needs assessment reviews all the basic information about the future project that the customer has presented as necessary. The following basic information is, for example, site information that can be used to formulate follow-up measures more clearly and outline the points that are important for this project. The basic information consists of the needs of the project to be implemented, which are related to building services systems. Connections serving the project, such as electricity, telecommunications, water, and sewer connections will be highlighted.

11.2 Objective

The needs assessment reviews why this project is to be implemented, as well as possible options that could be implemented. Different options are studied as well as, different location options in the area. The needs assessment will go through the area as one entity to which this future project will be linked. The needs assessment highlights the customer's needs and reasons behind them. It also highlights what is the output of this project.

11.3 Cost estimate

At the needs assessment stage, there is no need to make a very accurate financial estimate of the project, but to make an approximate estimate of the costs. Cost estimation makes it easier for the decision makers, and they will get some estimate of the future project. The project will be further specified when moving to the project planning and planning phase, in which the costs will be very close to the cost of implementation. The contractors ultimately determine the cost of the project with their bids. In government projects, costs are monitored very closely, and if approved costs are exceeded, this may require approval from the ministry.

11.4 Schedule estimate

The schedule assessment creates an outline of a future project. The schedule should take into account the different phases of the project. The schedule should take into account the project design phase, the design phase and tendering phase and construction. In government projects, schedules are also closely monitored, and the monitoring and use of funding is carefully timed. So if there are any changes to the schedule you should become aware of this in good time.

12 DISCUSSION

The preparation of the thesis has been interesting. I familiarized myself with the different forms of energy and take a look at possible future energy options. It has also clearly been noticed how long-known technologies have only just begun to be introduced. With the introduction of technologies, it has also opened up space for new innovations and their development. This thesis is focused on fixed and mobile backup power engines and alternatives. In this thesis, there was considered various options and the emissions they produce. In minimizing emissions, the whole system should be considered. In this case the whole system is related to the backup power, which consists of fuel, fuel storage, the backup power plant and the emissions of this backup power plant.

Renewable energy

Renewable energy is difficult to use in backup power drives, at least with current technology. Wind power, solar power, wave power, hydropower, and other similar forms of energy production all have their own pros and cons. It would be difficult to use the above-mentioned energies in the objects of this thesis to generate reserve power. But the above forms of energy could be utilized to produce fuel that would sustain the selected forms of energy. As in the case of wind and hydropower, hydrogen fuel production facilities could be built in. Renewable energy could be used to produce biofuels.

The environment must be taken into account when using renewable energy, which could be the best way to produce energy in different areas. The coast could harness the currents of sea waves and water flows to generate electricity, and the empty areas of the coast could harness a wind or solar energy. Of course, nature should be taken into account when a building, to protect its beauty and diversity. There is a lot of strong and good rock in Finland, this could be utilized, for example, for heat production and storage. This heat could also be utilized for potential energy production with turbines.

The use of renewable energy should also be favored regionally, albeit on a village-by-village basis, as some villages could achieve their own self-sufficiency and potentially generate to grid and thus assist other buyers of renewable energy. These would be called micro-producers, however, these micro-producers should hire or elect an electricity manager to manage this entity. The electricity manager is responsible for the equipment and manages the interfaces with the electricity network company. Various innovative projects are underway in Finland that utilize renewable energy. One such project is presented in Appendix 26.

Biofuel

Biofuels could be the fastest way to improve emissions in future. However, biofuel production must be creative so that natural forests are not cut down when creating biofuel production. Biofuels can be produced from a variety of bio products, such as vegetable oils, wastes and residues. So, on a larger scale, such as at EU level, it should be agreed how biofuels will be produced in the future, so that nature does not suffer because of a biofuel economy. One of the best ways to produce biofuel would be to produce it purely from waste and by reusing waste even in construction. The waste would be treated to a point where it could be modified for the desired purpose.

Biofuel runs directly on existing backup power plants and can easily generate even 10 to 2000 kVA electrical energy. Biofuel can use the same fuel storage and pipelines. The behavior of biofuels in long-term storage should still be studied and investigated so that bio-components do not form builds-ups in storage or piping systems. If corps forms in storage or piping, this can block fuel flow and can effect on use of backup power. Appendix 29 presents one solution that can take advantage of different fuel options.

Hydrogen

The hydrogen economy sounds very interesting. The use of hydrogen equipment could greatly improve energy emissions of a few generations. Utilization of renewable energies together with hydrogen equipment could potentially improve the global air pollution that humans produce. I completely can't predict what it might effect in the long run, if water alone is used for hydrogen production and as fuel. Humans should develop various combinations, which can produce hydrogen that is not very harmful in terms of climate. The hydrogen economy should be done in a way that supports all industries. Possibly the state could act completely independently with regard to hydrogen. Independently producing all the hydrogen, it needs, possibly with renewable energy. Different states should look at the different options that their nature offers for renewable energy.

Hydrogen can also be produced from coal, and Finland and other countries also have or probably have had larger carbon storage. Coal in the production of hydrogen can be utilized by oxidizing it, i.e. burning it. Combustion of coal produces heat and carbon dioxide that can be used in synthetic fuels. Synthetic fuel can also be used in hydrogen production. Existing carbon storages could be used for the production of synthetic fuel or further saved for the production of synthetic fuel. Hydrogen produced from coal would be for a while, the only way to produce hydrogen as other means develop or are built for use. However, coal use should be guided by regulations and legislation, even from the EU level.

Hydrogen reserve power in production, could already operate on a smaller scale, such as 10 to 100 kVA. Fuel of this size would be relatively easy to store or even produce locally. Water, methane or ammonia could be used as fuel. Previously mentioned fuels would be converted by electrolysis into hydrogen, which could still be stored separately in the vicinity of the backup power plant.

In hydrogen solutions, SOFC is one of the most promising forms, generating electricity as a backup power. Appendix 24 presents a workable solution for the SOFC system. Appendix 25 shows the chemical reactions of different fuels related to the SOFC system. Hydrogen solutions, which want to produce hydrogen themselves, require their own equipment for electrolysis. Appendix 16 shows the principle of electrolysis and Appendix 17 shows one functional unit.

Game changer

Game changer refers to a technology that has been developed for a long time or can get an innovation at any time. This potentially new technology could improve the availability of electricity anywhere, and potentially deduce emission generation. One such technology could be neutrino technology, which utilizes neutrinos and produces electricity with a kind of panels.

Game changer can also be, some other technology in the field of innovation change or invention. Such as the development of superconduction and the invention of superconducting cabling will make it possible to do a lot on the power distribution side. As well as the first wireless power transmission electricity distribution products (Emrod, 2021). Offshore installations electricity generated by a wind farm and wave power farm, can potentially be transmitted to the mainland wirelessly. Figure 38 shows the principle of this wireless energy transfer. As well as separate energy stores, and their development helps the whole. These inventions can be formed, for example, by developing fusion and accelerator devices. These technologies should be highlighted and supported in order to evolve human technology as a whole.

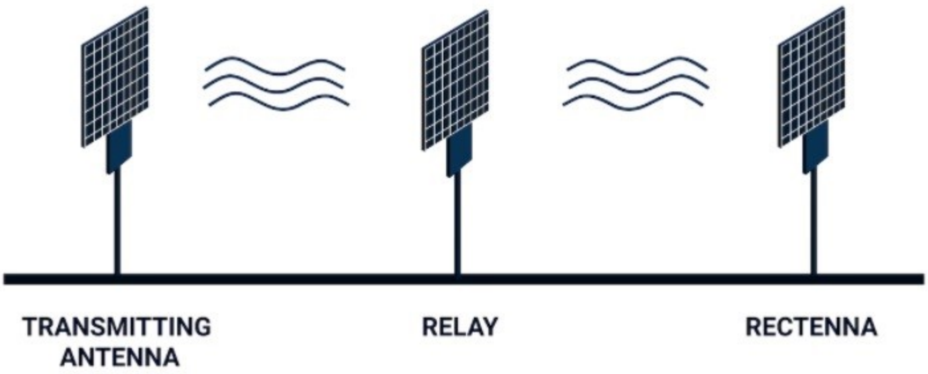

Figure 38 The principle of wireless energy transfer. (Emrod, 2021)

Strategy for the future

In backup power applications, this thesis proposes the following (FIGURE 39) approach to the forward development of fuel for a backup power generation. The current fuel, diesel, would be replaced by biodiesel, thus rapidly changing emissions from production and use. The production and distribution of biofuels must be developed, and supported at the state level. Hydrogen can be produced from many different products, possibly even from biofuels, making this continuum natural for a less emission-free entity. As the above technologies evolve and society's emissions decrease, some game changer technology could evolve on the same time in the background. One potential game changer could be neutrino technology, which would really shape energy management and distribution. Other similar technologies could be neutrinovoltaic or fusion energy.

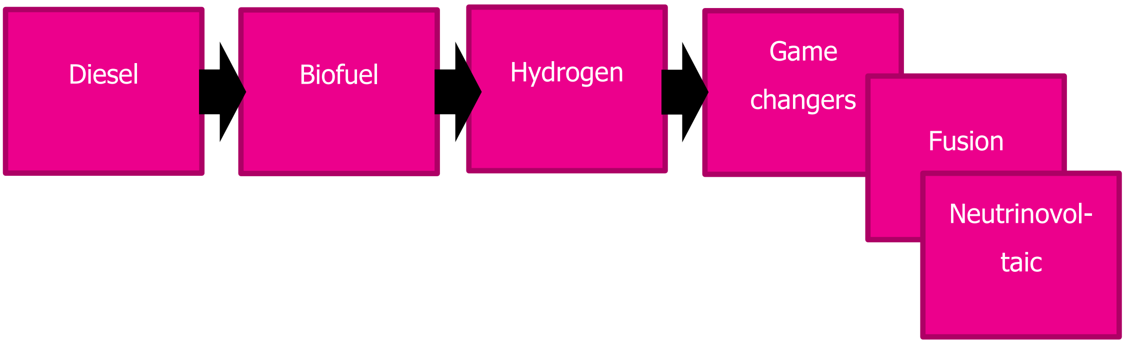

FIGURE 39. Fuel strategy for the future.

Figure 41 shows an alternative time period for how these technologies could be utilized. Figure 41 also shows the phasing of the fuel in relation to the biofuel and hydrogen in backup power. It might be a good idea to get acquainted with hydrogen technology through a portable implementation. This portable hydrogen backup power would build the structures and test its operation in peace. After testing mobile hydrogen solution, testing could move forward and fixed solutions could be tested. Figure 39 show basic principle of strategy for energy source development. The points in Figure 40, consist of a process that goes through innovation, development and testing. Appendices 30 - 35 show a few strategic options for how hydrogen power could be produced and utilized in defence force targets.

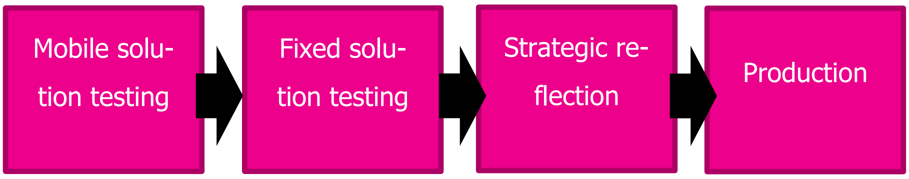

FIGURE 40 Strategy for energy source development.

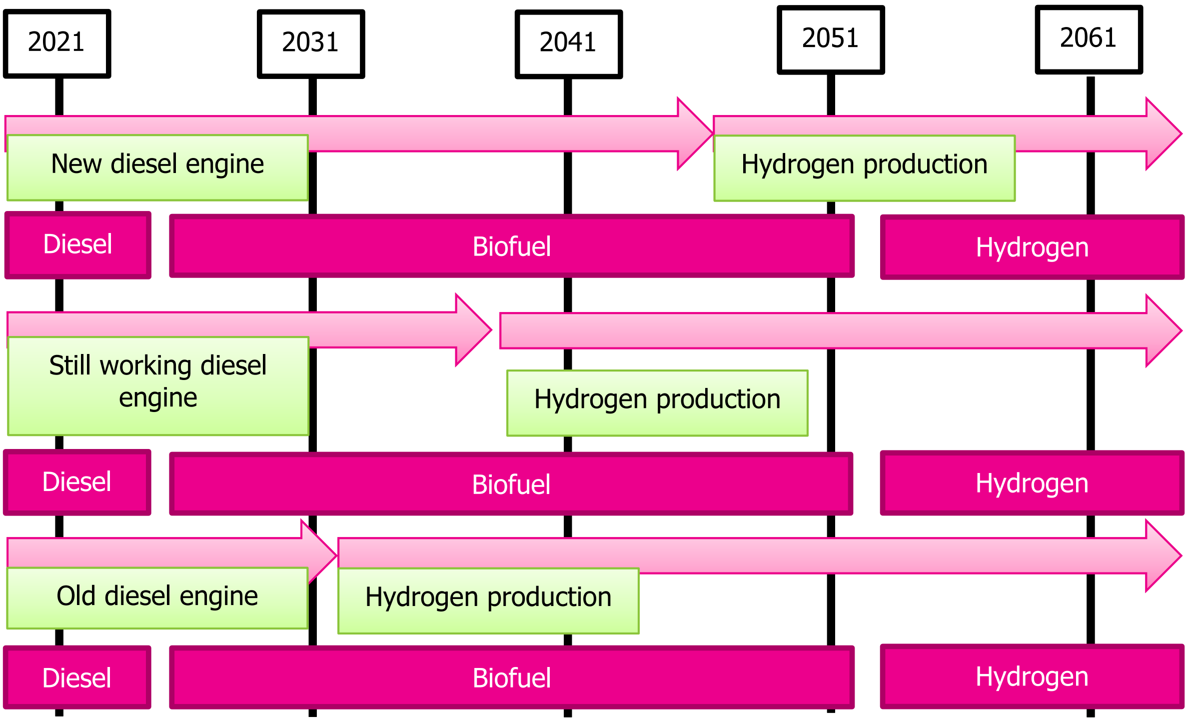

FIGURE 41 Engine strategy for the future.

Hydrogen strategy 1

In my opinion, a separate hydrogen production entity should be created, in which renewable energy is purely utilized, so that self-produced fuel would be available, even if commercial distribution were to falter. The following figure shows the progression of the steps for this own hydrogen production model. Figure 41 and 42 show progress option in the future.

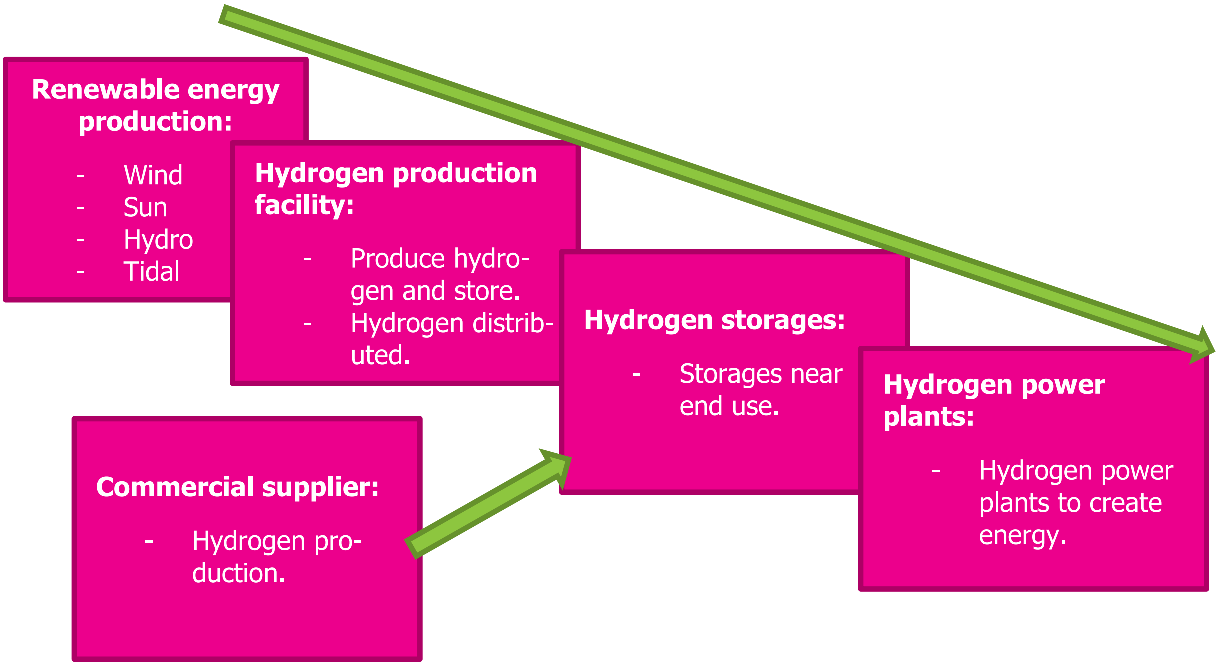

FIGURE 42. Centralized own hydrogen production.

In centralized production, hydrogen is generated with renewable energy and stored, after which it is delivered to destinations where hydrogen is needed. Storage can be produced directly into hydrogen containers for transport. Large hydrogen tanks are used for transport. Hydrogen tanks are left at the site and connected to the site's hydrogen production and consumption. Locally, hydrogen can be divided into each size category in smaller hydrogen storage.

Hydrogen strategy 2

Another option is to produce hydrogen energy locally, for example, a lot of solar energy should be built on the roofs of buildings in buildings and possibly on the roofs of car parks. This regionally produced energy would be used to produce hydrogen for which it would be reserved, either in its own building or inside its own hall. This strategy, too, would entirely follow the picture here above, but production capacity is likely to be significantly lower.

13 SUMMARY

While drafting my thesis, I noticed that more and more news items related to renewable energy and P2X applications were released monthly. The subject area is clearly a very topical area of interest to large companies. I also noticed messages from the vehicle industry that they are moving to producing more electric vehicles. Both the EU and the Finnish state have set some policies and direction of the lines in a carbon-neutral society.

This thesis focused on backup power machines, which are very much influenced by the automotive and construction industries. In the thesis, different forms of energy production and their forms of storage were highlighted. Renewable energies are not currently directly suitable as sources of backup energy, but they can be used to produce fuel that can be used for backup power.

In this thesis, it was decided to choose a biofuel solution, but needs study on the hydrogen entity was prepared for the interest. The biofuel solution was chosen because it can easily convert existing diesel reserve forces into bio diesel reserve forces. In this case, you only need to change the fuel. Based on the interest in hydrogen technology the hydrogen was selected and a need's assessment was carried out to review the various measures that need to be taken to make the plant operational.

In the future, hydrogen may be the next step towards a low-carbon society. Based on personal interst, I reflected on other future innovations and inventions that I noticed during the preparation of the thesis. One of the most interesting was the neutrinovoltaic system. Technology is now evolving really fast as the so-called new generation enters the era, where humans may get rid of the influence of fossil fuels.

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APPENDIX 1: REGULATION (EU) 2016/1628 - 1

Constant speed engines of category NRG and NRE

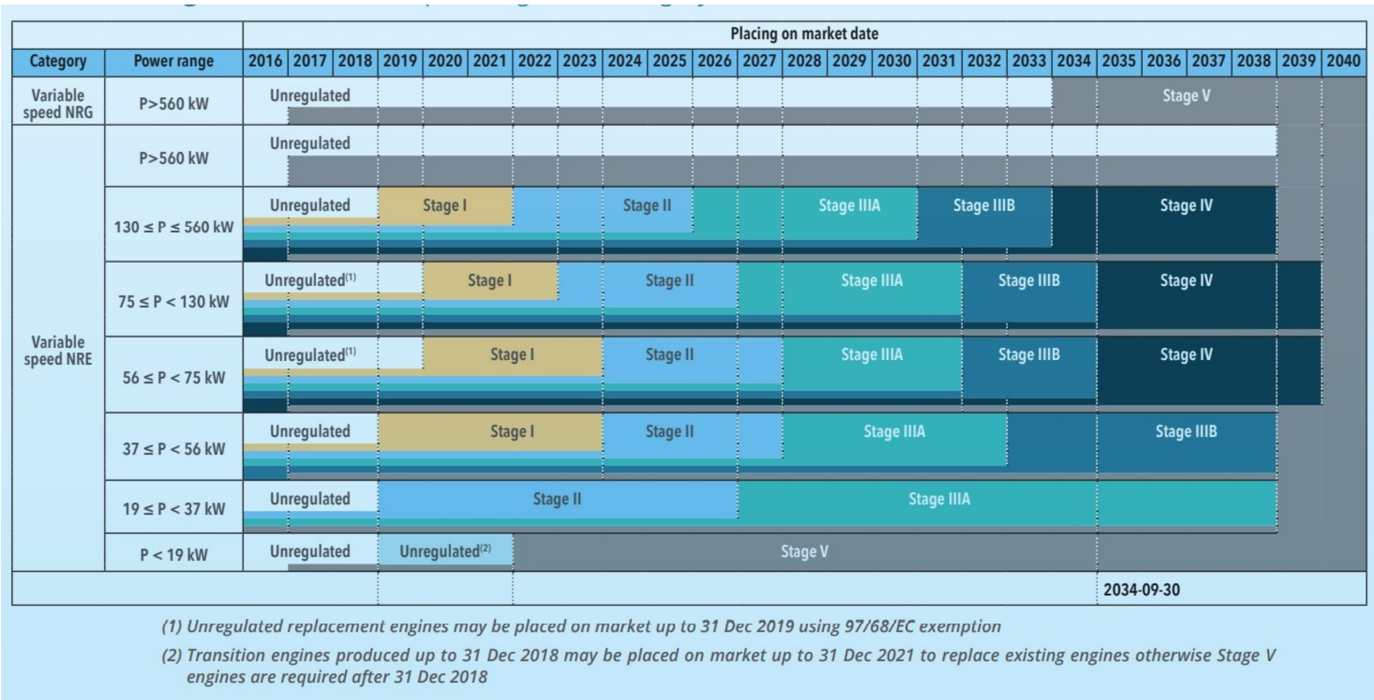
Guide for Identification of non-road mobile machinery and engines compliant with regulation (EU) 2016/1628. (CECE, 2021)

(2) Transition engines produced up to 31 Dec 2018 may be placed on market up to 31 Dec 2021 to replace existing engines otherwise Stage V engines are required after 31 Dec 2018

APPENDIX 2: REGULATION (EU) 2016/1628 - 2

Variable speed engines of category NRG and NRE

Guide for Identification of non-road mobile machinery and engines compliant with regulation (EU) 2016/1628. (CECE, 2021)



APPENDIX 3: REGULATION (EU) 2016/1628 - 3

List of exceptions from regulation (EU) 2016/1628 and corresponding exception.

Guide for Identification of non-road mobile machinery and engines compliant with regulation (EU) 2016/1628. (CECE, 2021)

EXEMPTION	WHICH ENGINES ARE ALLOWED TO BE PLACED ON THE MARKET IN THE EU?	SUPPLEMENTARY INFORMATION	EXEMPTION CODE
Export engines	Engines without a valid EU type-approval for use in non-road mobile machinery intended for export outside the EU for the purpose of installation in that machinery. These engines may also be used in the EU for installation in certain machinery outside of the scope of Regulation (EU) 2016/1628, such as stationary machinery.	ENGINE NOT FOR USE IN EU NON-ROAD MOBILE MACHINERY	EM-EXP
Armed forces engines	Engines without a valid EU type-approval that are to be installed in non-road mobile machinery for use by the armed services for the purpose of installation in that machinery. For the purpose of this exemption, fire services, civil defence services, forces responsible for maintaining public order and emergency medical services are not considered to be part of the armed forces.	ARMED FORCES ENGINE	EM-AFE
Field test [(1)]	This exemption temporarily allows the placing on the market of non-type-approved engines for the purpose of conducting field testing. This field testing may be to evaluate an engine intended for use in the EU, or to test in the EU an engine intended for use in a third country. The manufacturer must inform an EU type-approval authority prior to placing a field test engine on the market and may choose any approval authority irrespective of where the field test will take place. The engine must remain the property of the manufacturer until the field test is completed, which must normally be within two years, but may be extended to a maximum of four years in total.	FIELD TEST	EM-FTE

APPENDIX 4: AUTOMOTIVE INFORMATION CENTER - 1

EU target for car manufacturers to reduce CO_2 emissions.

Automotive propulsion map 2021. (Autoalan Tiedotuskeskus, 2021)

This Appendix has been modified from its original form. The change has been made by converting the Finnish language into English.

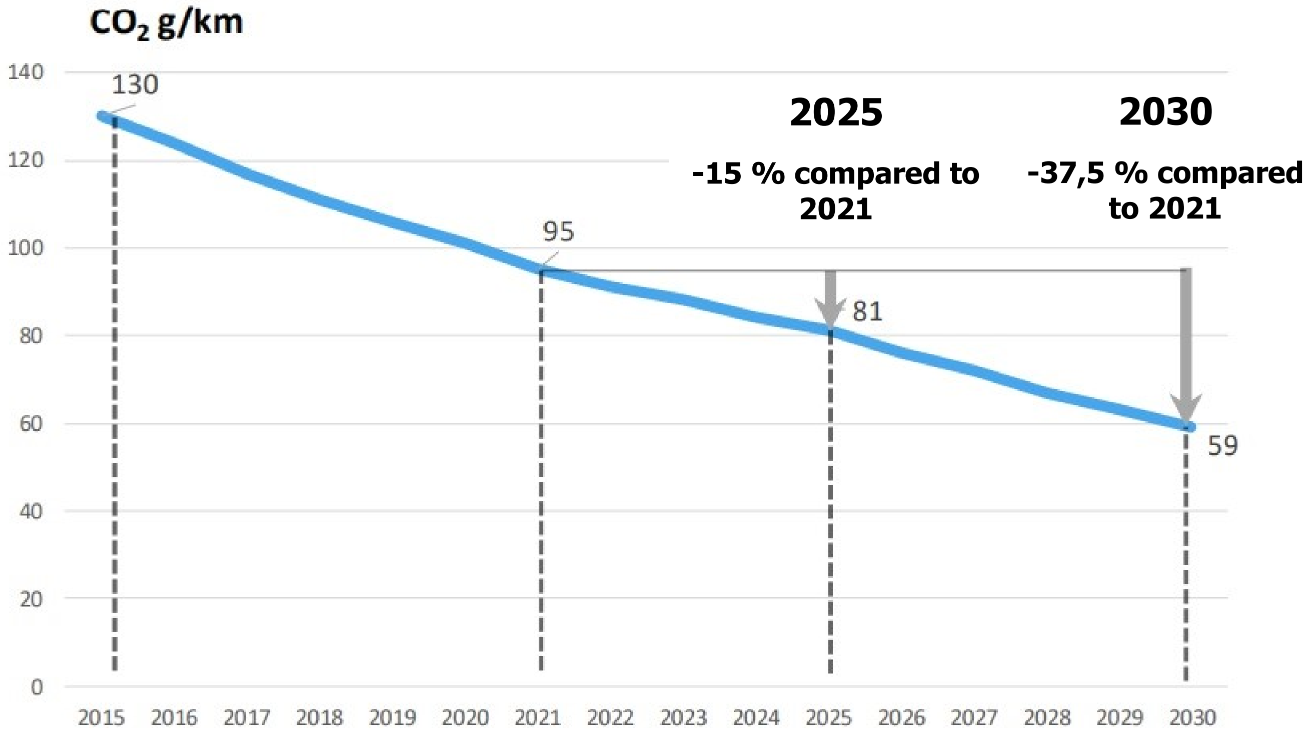


FIGURE 2.1 EU CO2 reduction targets set for car manufacturers at NEDC level. Target values for 2025 and 2030 will be determined per gram over the next few years.

TABLE 2.1 EU CO2 reduction targets for car manufacturers for 2025 and 2030.

	2025	**2030**
Passenger cars	**-15 % compared to 2021**	**-37,5 % compared to 2021**
Van	**-15 % compared to 2021**	**-31 % compared to 2021**
Truck *)	**-15 % compared to 2020**	**-30 % compared to 2020**

***) The truck limit value applies to the most common vehicle size classes defined in the VECTO calculation system.**

APPENDIX 5: AUTOMOTIVE INFORMATION CENTER - 2

Proportion of different driving forces of newly registered delivery trucks in the base forecast.

Automotive propulsion map 2021. (Autoalan Tiedotuskeskus, 2021)

This Appendix has been modified from its original form. The change has been made by converting the Finnish language into English.

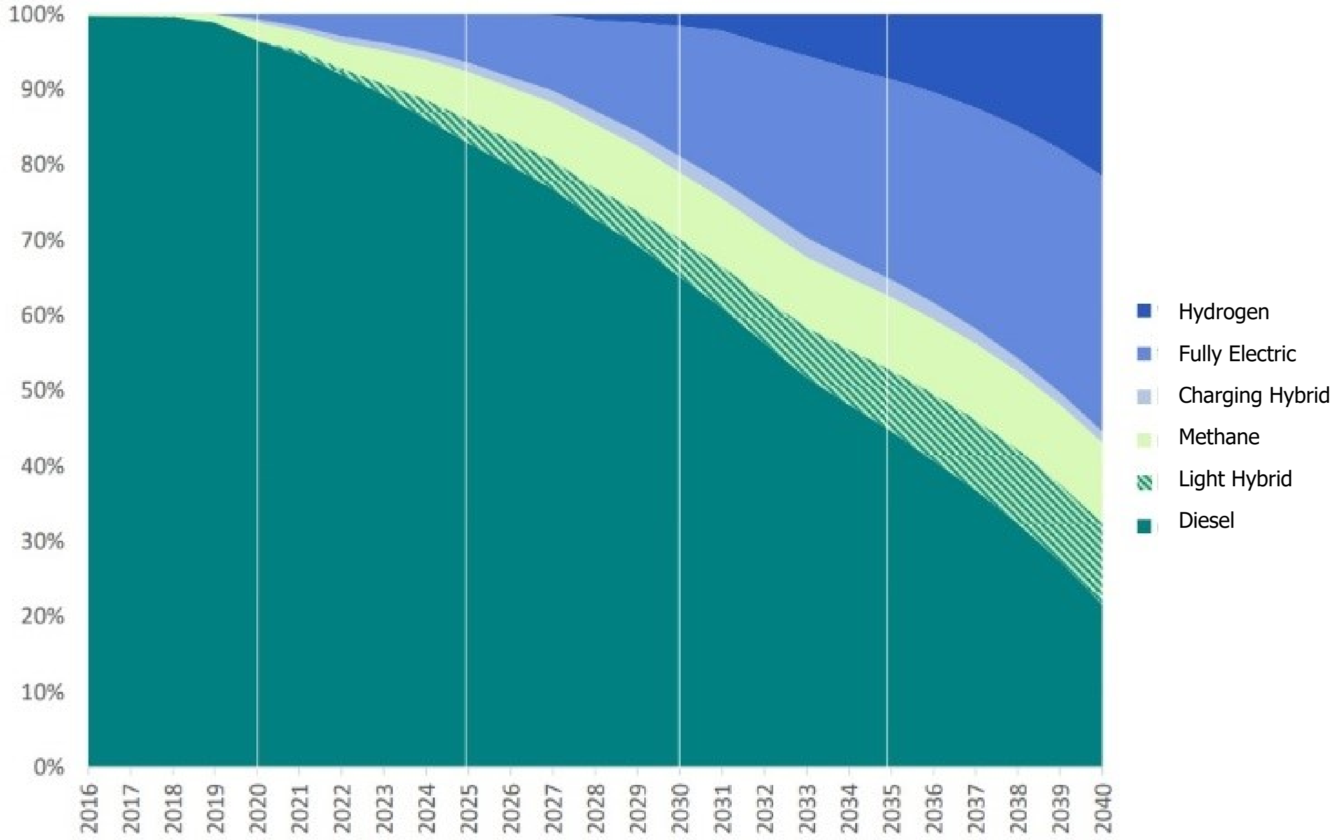


FIGURE 3.6 Proportion of different propulsion trucks in newly registered delivery trucks. The shares for 2016-2019 are based on actual figures.

APPENDIX 6: AUTOMOTIVE INFORMATION CENTER - 3

Proportion of different driving forces of newly registered lorries (i.e., 16 tons) in the base forecast.

Automotive propulsion map 2021. (Autoalan Tiedotuskeskus, 2021)

This Appendix has been modified from its original form. The change has been made by converting the Finnish language into English.

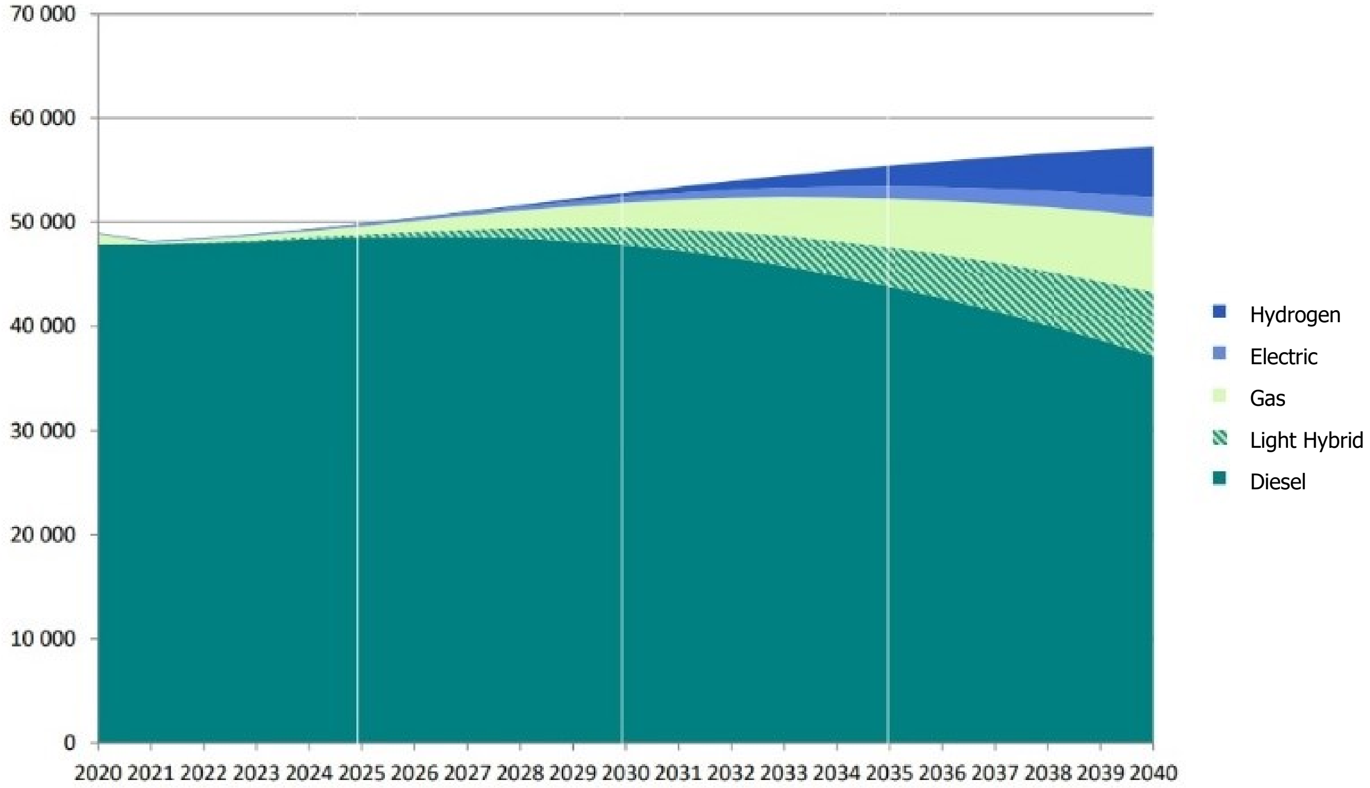


FIGURE 3.8 Share of different propulsion forces in the truck fleet (over 16 tonnes).

APPENDIX 7: AUTOMOTIVE INFORMATION CENTER - 4

Development of the propulsion distribution of the EU truck fleet in different scenarios.

Automotive propulsion map 2021. (Autoalan Tiedotuskeskus, 2021)

This Appendix has been modified from its original form. The change has been made by converting the Finnish language into English.

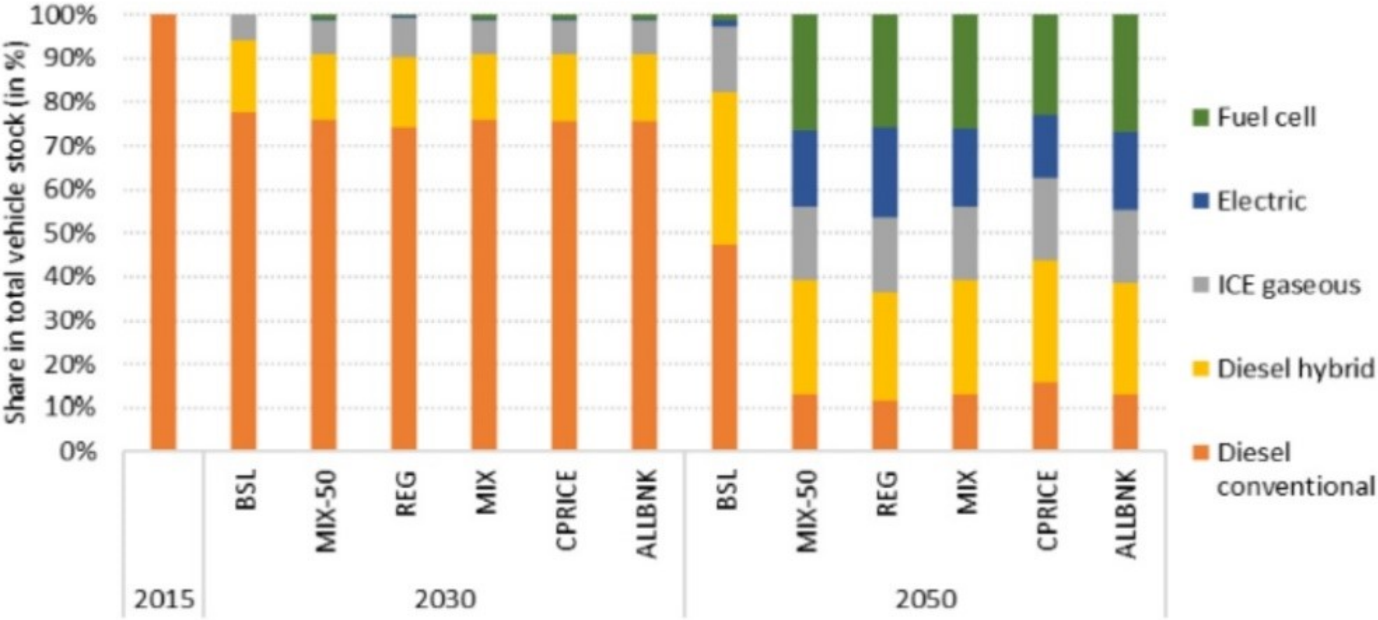


FIGURE 2.9 Development of the propulsion distribution of the EU truck fleet in different scenarios. (European Commission 2020)

APPENDIX 8: AUTOMOTIVE INFORMATION CENTER - 5

Development of the EU passenger car fleet distribution in different scenarios.

Automotive propulsion map 2021. (Autoalan Tiedotuskeskus, 2021)

This Appendix has been modified from its original form. The change has been made by converting the Finnish language into English.

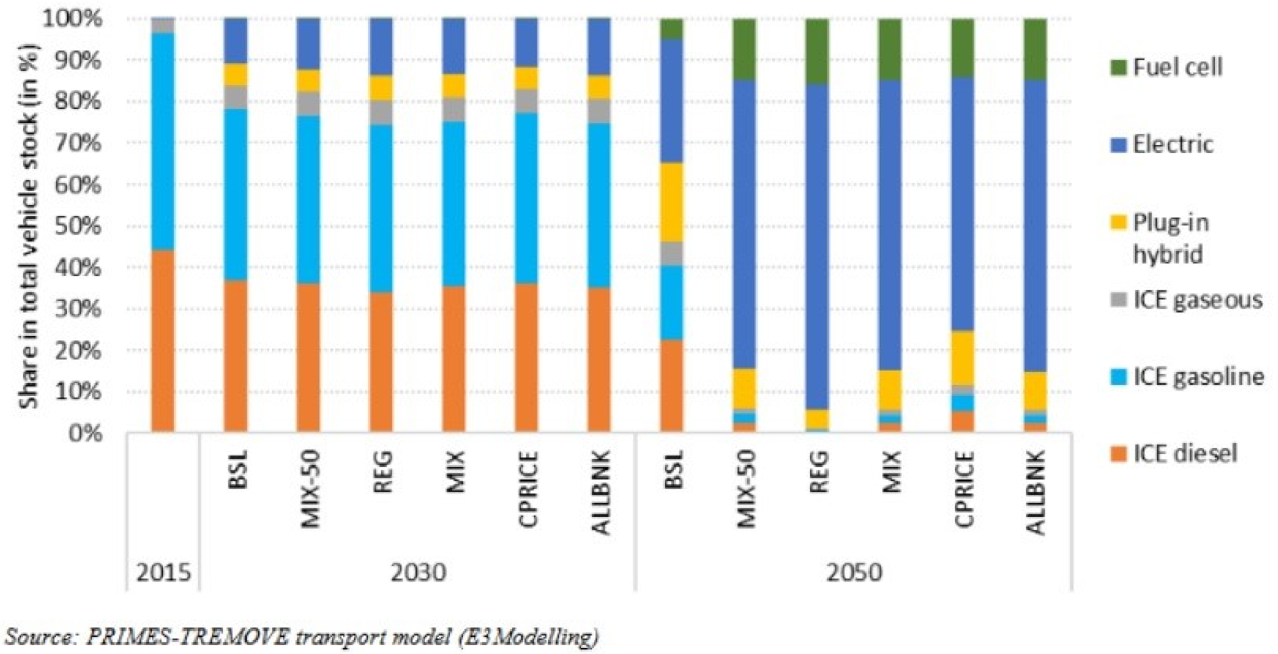
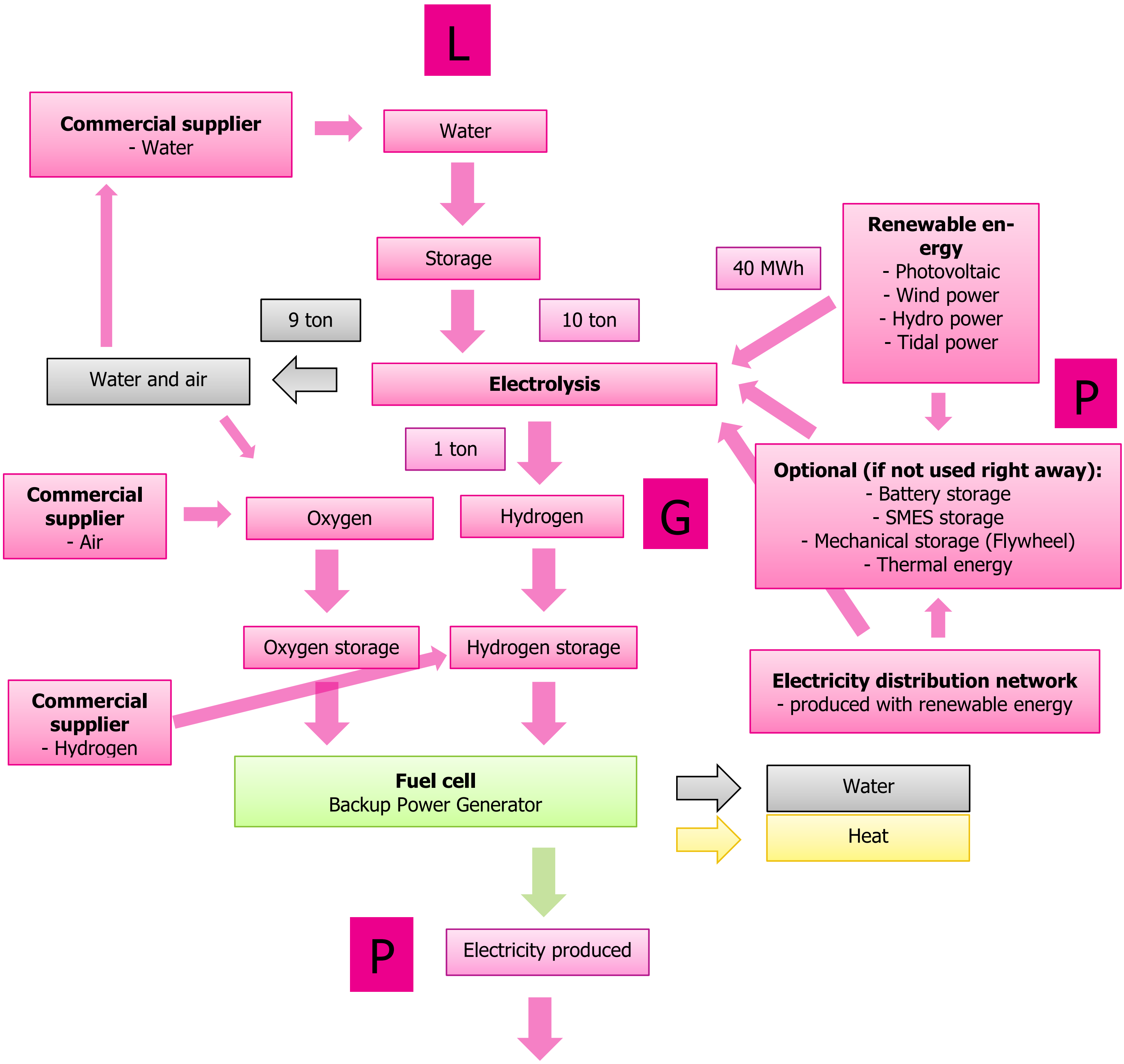


FIGURE 2.9 Development of the EU passenger car fleet distribution in different scenarios. (European Commission 2020)

APPENDIX 9: POWER TO X – L TO G TO P – OPTION 1

L + P to G and G to P

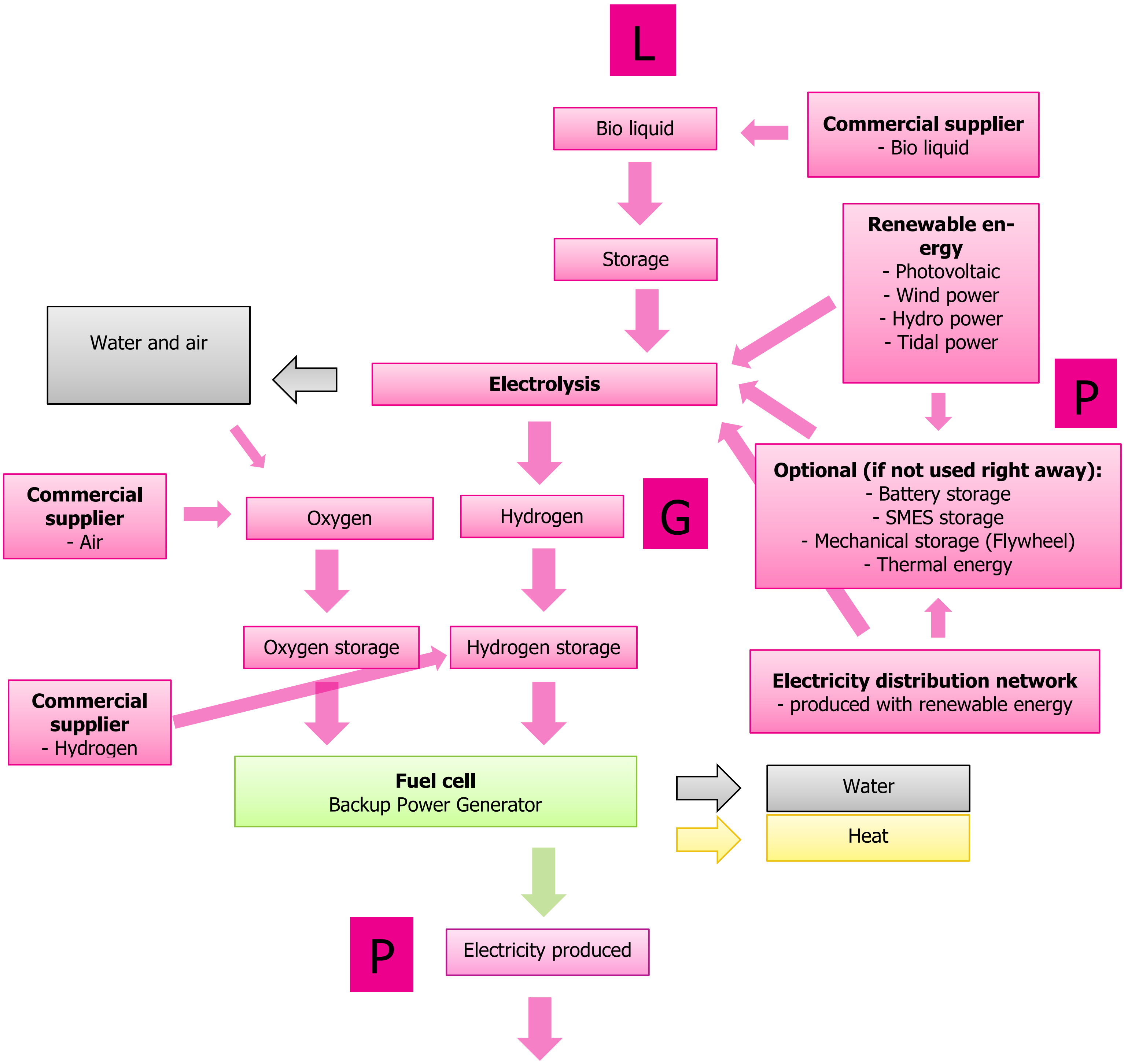
Water fuel-based solution.



APPENDIX 10: POWER TO X – L TO G TO P – OPTION 2

L +P to G and G to P

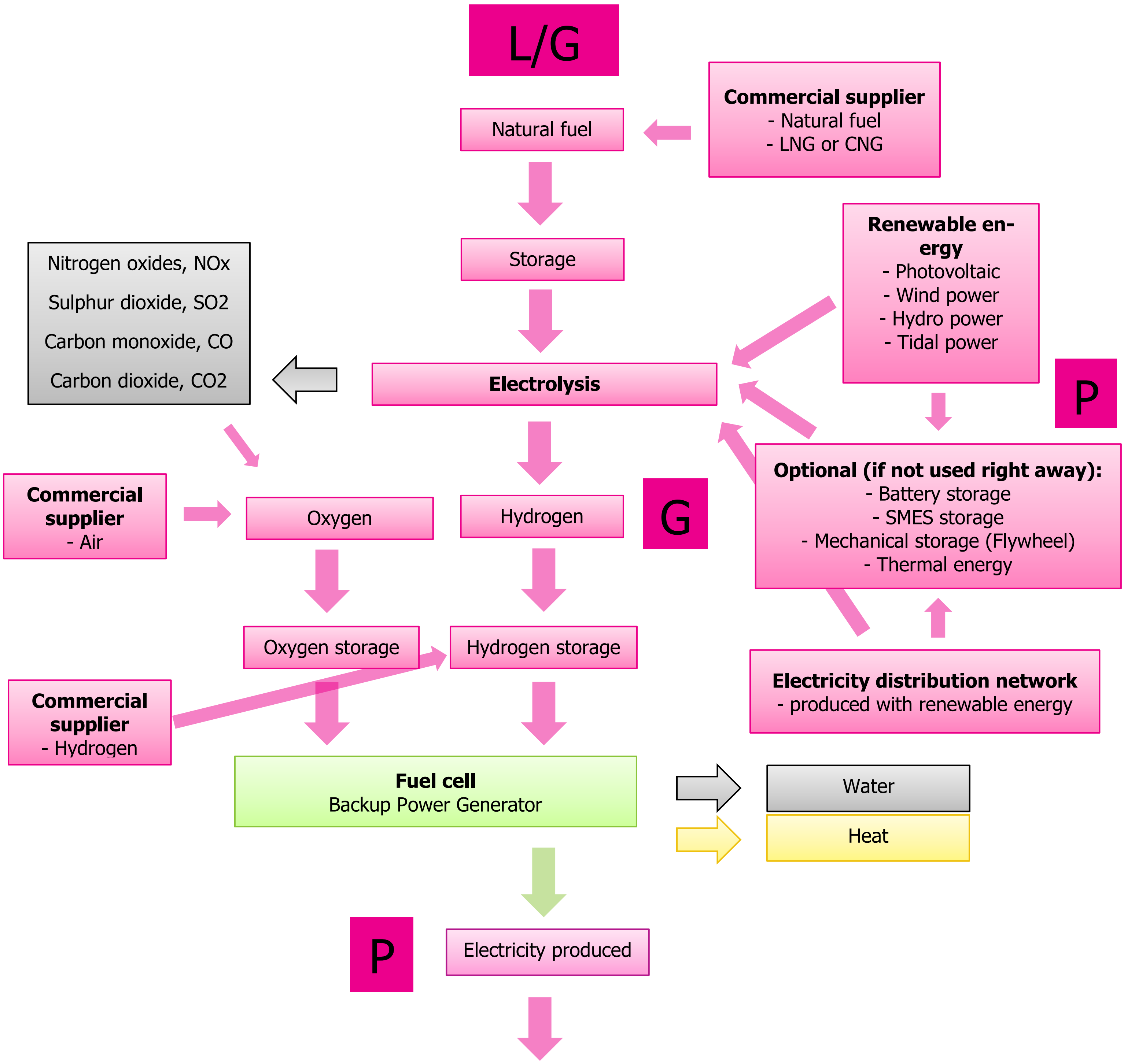
Bio fuel-based solution.



APPENDIX 11: POWER TO X – L/G TO G TO P – OPTION 3

L/G + P to G and G to P

Natural fuel-based solution.



APPENDIX 12: QUESTIONS ON COMPANYS ENG

Hi,

My Thesis is about electrical backup power generators. Stationaries and mobiles, and size range is from 300 to 2000 kVA.

These questions I won't add in my Thesis, but I will use those to get you vision, that I will be delivered to Finnish Defence Forces and Finnish Defence Properties. So, these information's will be kind of background information from bigger picture about future.

In my Thesis I will be taking account on next subjects:

- Earth gas energy
- Bio gas and flued energy
- Hydrogen energy
- Photovoltaic energy
- Wind energy
- Nuclear energy
- Hydro energy
- Tidal energy
- Geothermal energy
- Neutrinovoltaic energy
- betavoltaic energy
- NA-TECC energy
- Battery storage
- SMES storage
- Hydrogen storage
- Other flued and gasses storages
- Mechanical storage (Flywheel)

Thesis will be taking account how to use those energy methods to create electricity and store fuel what is used on that creation.

- Production (Electricity)
- Storage (Fuel, like hydrogen, Methanol, …)

Here is couple question for my Thesis:

- Is there any energy for or mechanism that should be added on that list?
- Finnish government and EU are making some regulations to use more renewables and carbon neutral ideas, so what do you think is next step in energy generation sector and storage. And what is future vision in your company.
- What kind of innovations your companies has been invented to create electricity and how to store that systems fuel and in what for to store that?
- Do you have any co partners what I should ask or what you prefer to ask, those same question?

This Thesis could be working as ”advertise channel” in direction Finnish Defence Forces and Finnish Defence Properties.

Best regards,

Joni Kolehmainen

Electrical Engineer

APPENDIX 13: MOBILE NUCLEAR ENERGY 2-3,5 MW (RESTRICTED TO USE)

APPENDIX 14: FIXED NUCLEAR ENERGY 1,5 MW (RESTRICTED TO USE)

APPENDIX 15: FIXED NUCLEAR ENERGY 4 MW (RESTRICTED TO USE)

APPENDIX 16: HYDROGEN ELECTROLYSIS 1 (RESTRICTED TO USE)

APPENDIX 17: HYDROGEN ELECTROLYSIS 2 (RESTRICTED TO USE)

APPENDIX 18: HYDROGEN STORAGE (RESTRICTED TO USE)

APPENDIX 19: HYDROGEN FUEL CELL 1 (RESTRICTED TO USE)

APPENDIX 20: HYDROGEN FUEL CELL 2 (RESTRICTED TO USE)

APPENDIX 21: HYDROGEN TO ELECTRICITY SOLUTIONS 1 (RESTRICTED TO USE)

APPENDIX 22: HYDROGEN TO ELECTRICITY SOLUTIONS 2 (RESTRICTED TO USE)

APPENDIX 23: HYDROGEN TO ELECTRICITY SOLUTIONS 3 (RESTRICTED TO USE)

APPENDIX 24: HYDROGEN TO ELECTRICITY SOLUTIONS 4 (RESTRICTED TO USE)

APPENDIX 25: SOFC (RESTRICTED TO USE)

APPENDIX 26: RENEWABLE PROJECT (RESTRICTED TO USE)

APPENDIX 27: THERMOELECTRIC GENERATOR (RESTRICTED TO USE)

APPENDIX 28: FIXED NATURAL GAS SOLUTION 1,6 - 2 MW (RESTRICTED TO USE)

APPENDIX 29: FIXED MULTIFUEL SOLUTIONS 0,5 – 1,35 MW (RESTRICTED TO USE)

APPENDIX 30: HYDROGEN STRATEGY – PRINCIPLE (RESTRICTED TO USE)

APPENDIX 31: HYDROGEN STRATEGY – MOBILE SOLUTION 1 (RESTRICTED TO USE)

APPENDIX 32: HYDROGEN STRATEGY – MOBILE SOLUTION 2 (RESTRICTED TO USE)

APPENDIX 33: HYDROGEN STRATEGY – MOBILE SOLUTION 3 (RESTRICTED TO USE)

APPENDIX 34: HYDROGEN STRATEGY – STATIONARY SOLUTION 1 (RESTRICTED TO USE)

APPENDIX 35: HYDROGEN STRATEGY – STATIONARY SOLUTION 2 (RESTRICTED TO USE)

APPENDIX 36: WIND POWER (RESTRICTED TO USE)

APPENDIX 37: COMPANY X ANSWER (RESTRICTED TO USE)

APPENDIX 38: COMPANY X ANSWER (RESTRICTED TO USE)

APPENDIX 39: COMPANY X ANSWER (RESTRICTED TO USE)

APPENDIX 40: COMPANY X ANSWER (RESTRICTED TO USE)

APPENDIX 41: NEEDS ASSESSMENT (RESTRICTED TO USE)