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School of Industrial Engineering and Management
Department of Industrial Management

Master's Thesis

TESTING FCM TECHNIQUE FOR THE WIND ENERGY SCENARIOS IN FINLAND

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ABSTRACT

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In the latter days, human activities constantly increase greenhouse gases emissions in the atmosphere, which has a direct impact on a global climate warming. Finland as European Union member, developed national structural plan to promote renewable energy generation, pursuing the aspects of Directive 2009/28/EC and put it on the sharepoint. Finland is on a way of enhancing national security of energy supply, increasing diversity of the energy mix. There are plenty significant objectives to develop onshore and offshore wind energy generation in country for a next few decades, as well as another renewable energy sources. To predict the future changes, there are a lot of scenario methods developed and adapted to energy industry.

The Master’s thesis explored “Fuzzy cognitive maps” approach in scenarios developing, which captures expert’s knowledge in a graphical manner and using these captures for a raw scenarios testing and refinement. There were prospects of Finnish wind energy development for the year of 2030 considered, with aid of FCM technique. Five positive raw scenarios were developed and three of them tested against integrated expert’s map of knowledge, using graphical simulation. The study provides robust scenarios out of the preliminary defined, as outcome, assuming the impact of results, taken after simulation. The thesis was conducted in such way, that there will be possibilities to use existing knowledge captures from expert panel, to test and deploy different sets of scenarios regarding to Finnish wind energy development.

ACKNOWLEDGEMENTS

I am not chasing originality for this paragraph, I just want to highlight people and circumstances which really made my studying happened.

I would like to express heartful gratitude to my parents and younger sister. In spite of they live so far away from me, they still believe in me and keep their feelings on, even I made a lot of failures in my life.

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Lappeenranta, October 2014

Andrey Ivanov

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LIST OF ABBREVIATIONS

FCM – Fuzzy Cognitive Maps

CHP – Combined heat and power

PMT – Probabilistic modified trends

STEEP – Acronym for: social, technological, economic, environmental and political

SMIC – Study of Man's Impact on Climate

R&D – Research and development

EU – European Union

O&M – Operations and maintenance

SME – Small and medium enterprises

ETS – Emissions trading scheme

LUT – Lappeenranta University of Technology

IEA – International Energy Agency

RES – Renewable energy sources

EC – European Commission

GWEC – Global Wind Energy Council

EWEA – European Wind Energy Association

DC – Direct current

TWh – Terawatt-hours

MW – Megawatt

MVA – Megavolt ampere

GWh – Gigawatt-hour

kV – Kilovolt

TSO – Transmission system operator

CO2 – Carbon dioxide

1. INTRODUCTION

1.1 Research background

The energy is one of the key contemporary basis for sustainable and long-term economic development, either on a national or global level. Environment and energy production are very dependent to each other in terms of impact. The strongest consequent effect can be found in greenhouse gas emission, which can harm global climate stability. Global energy policy should somehow correlate with the objectives of production less emission as it possible.

All energy production related processes can be implicated in regional or global environmental impact, which may lead to biodiversity reduction, waste increasing or direct climate changing. Population growth, economic extension, consumption trends will affect the future energy utilization. From the way back, energy production and consumption impacts, was a highlight focus for a significant time period. Constantly, corporate responsibility is increasing in power generation sector and takes very important role on a multinational basis (Durance and Godet 2010).

Reducing the environmental impacts is time taking process, but effectiveness of production and energy usage plays a crucial role in environmentally friendly methods adaption. A bulk of laws and directives are aimed to control and enhance these methods, mitigating climate change and reasonable spending of natural resources in order to apply the most advanced technologies and energy solutions.

Regarding to (Finnish Energy Industries 2014) the vision for energy is carbon-neutral electricity and district heating in 2050. According to the vision, direct emissions from electricity and district heat production will be considerably reduced. Moreover, low-emission electricity and district heat are exploited for reducing the use of fossil fuels in transport, industry and heating. The key operating factor is the price signal from the trading of emission allowances, attracting investment in low-carbon production. Nevertheless, human activities have increased the concentration of greenhouse gases in the atmosphere. This consolidates the greenhouse effect and warms the climate. This warming and the resulting climate disruption are called the climate change.

There are variety methods of electricity producing in Finland, from those, the high importance given to nuclear power, hydropower, coal, natural gas, wood fuels, and peat. The current share of wind power is relatively low, but rapidly growing. Regarding to hydropower accumulated from Norway and Sweden for the common Nordic electricity market, the share of fossil fuels involved in energy generation, varies considerably. This fact entailed since Finland is part of the joint Nordic electricity market with a free competition.

In Finland, there are approximately 120 companies producing electricity and about 400 power plants, more than half of which are hydroelectric power plants. Finland’s electricity generation is fairly distributed compared with many other European countries. The diversity and the heterogeneous structure of electricity generation enhance the security of electricity supply (Finnish Energy Industries 2014). Almost one-third of electricity is produced in combined heat and power generation, in which case the energy content of the fuel is utilized to its full potential. Up to 90% of the energy of the fuel can be converted into electricity and heat.

Scenarios, as a forefront technique for future studies, have already been used by government planners, corporate managers and military analysts as powerful tools to aid in decision making facing uncertainty. In fact, scenarios bear a resemblance as a set of stories around choicely constructed plots. Such plots can provide a few distinguished perspectives on forecasted events (Mietzner and Reger 2005).

Only few different scenarios can be explored extensively, otherwise the procedure risks to be dissipated. Regarding to logical manner, the most fundamental question is how to figure out approach, which will capture core issues and dynamics of staminal baseline. According to Wilson (1998) the golden rule concerning the number of scenarios is no fewer than two, and no more than four.

Scenario planning technique is a widely used approach to analyze either the entire energy system, or a sufficient part of it. It facilitates in current issues defining and forecasting future prospects thoroughly.

During the last years, caused by increase of deregulated energy markets, it can be supposed that market oriented short-term actions have significantly increased (Varum and Melo 2012). Majority of structural changes raised on international level. Based on that, long-term strategic thinking becomes obsolete, even left behind, and there is a crucial need to modify general approach emerging.

Fuzzy Cognitive Maps (FCM) based scenarios can be applied for the scenarios composing and it generates explicit content as distinct from quantitative scenarios approach. This technique is recently adopted and urged to build a bridge between quantitative and qualitative scenarios approach, eliminating the weaknesses brought by these classical approaches.

The researchers emphasize the suitability of utilize imagination, facilitated by a causal analysis for the scenario building process (Wilkinson 2010). FCM uses the fuzzy logic and it can integrate qualitative knowledge with quantitative analysis. Thus, the FCM-based scenario development approach has the capable potential to combine qualitative approach with quantitative models (Vliet et al. 2010). Researchers also indicate that integration of multi-dimensional approaches in the scenario composing process, results in robust scenarios.

Previous studies about scenarios planning have shown development of Finnish energy sector within the foreseeable future. These are benefited and limited from the techniques involved in scenarios forecasting. It made a set of prerequisites for the topic Master’s thesis work, aiming to introduce novelty in a highly challenging issue. Those strategic and practical scenarios, and not sufficient investigations in this field, formed the main research idea of applying FCM-based technique in the paper.

1.2 Research gaps

Analyzing a contemporary literature abundance related to scenarios planning in energy sector, it turns out that a lot of modern researchers have boundless interest to this concept. Ultimately, scenarios planning entail appropriate political involvement and business support activity. The vision of future enables to manage a plenty of strategic tools and leverages, which flows into fundamental strategy establishment. The more modern and admitted method in forecasting taken, the more insight in further it can provide. Consequently, there is research gap to be fulfilled found.

There was a variety of national energy sectors tested against FCM-based technique, either in developing or developed countries, which brings clarity only on a local level and consider a research valuable for the certain country. It allows bringing originality in case of Finnish energy system, due to common Nordic electricity market existence. There is an emphasis in political driver’s development for the energy prospects to be tested. Moreover, this examination makes a backbone for the rest of Nordic countries, exploring regional scenarios to be fitted into future of energy alliance.

The majority of research papers, which provide mature roadmaps for action, more often, based on qualitative methods, lacked of historical data sets and causality to form expectable future trends. While quantitative approaches should be evolved due to the changes in the future research paradigm, towards a more qualitative and process-oriented method (Mietzner and Reger 2005).

The literature, regarding scenarios usage techniques figures out a weak linkage between qualitative and quantitative scenarios, which has been mentioned as a major disturbance in integrated scenarios development (Kok and Delden 2009).

Since the fast growing and potential capacity importance, wind energy sector is chosen for further scrutiny. The reason to separate wind energy based on fact that Finland has significant share of combined heat and power sources (CHP), in addition to nuclear and hydro sources (Eurelectric 2012). That enables to distinct factors which have potential influence on a different renewable energy sources in terms of plausible future forecasting.

Therefore, in spite of widely explored topic of scenarios planning for renewables, within this concept, there are many uncovered areas, and this thesis is aimed to fill research gaps described above, and to contribute in a research data set accordingly.

1.3 Research objectives

Taking into account wind energy, its variability and uncertainty, in a long-term development it requires structural changes in power grid and transmission facilities, to enhance intermittent generation adaptation for consumption needs. The research will cover challenges toward the integration of wind power capacities in developed country within the Nordic electricity market community.

However, the development of fruitful scenario to action is quite a complicated issue. There are a lot of internal and external factors which drive the energy sector performance. Some of them have much impact on a wind energy development, whereas the rest drivers only bring causality to the entire strategy. At the same time, deployment requires a clear and transparent investigation of key drivers involved in potential impact.

The foremost objective of this research is to develop wind energy scenario on a national level and a set of recommendations to look closer, resulted from the conducted research. Fuzzy Cognitive Maps technique is applied and certain set of graphical causality links are given to the expert group. This paper used the wind energy sector of Finland as a case study.

The main research question to examine whether FCM-based approach on the qualitative scenarios in Wind energy sector in case of Finland, will have salutary effect on robust scenarios development or not. In pursuit of constructive work, the research baseline can be divided into several sub-questions for the potential readers' convenience:

1) How FCM technique can be applied to develop plausible scenarios for the wind energy sector?
2) What are the drivers, favoring and impeding the development of wind energy in Finland?
3) How causality links, developed by experts, affect to the raw plausible scenarios?

There will be three probable scenarios tested to meet a most suitable compatibility with the input vectors deployed. As final result, one of scenarios will be considered like most credible, and enable expectation of a wide array of possible future outcomes.

Besides this, the research will develop integrated FCM scheme which may be useful tool to examine new scenarios proposed by researches involved in Finnish wind energy exploration as well as Wilson matrix for concept prioritizing will be developed for possible further iterations.

The scope of the study is restricted by the modern trends gathered regarding to scenarios formation in Finnish energy sector, which formed a key drivers to be supported. The research is conducted with a few experts assistance, who considered having a strong awareness about regional features.

The research contributes to managerial practice more than theoretical knowledge. It brings value to existing papers about energy scenarios in Finland, as it was based on recently granted method. Moreover, the research can be handled as a strategic roadmap, when managerial decisions are in consideration by determinative parties. The most plausible scenario can be taken further into robust map developing for all energy practices on a national level or be treated solely.

1.4 Research methodology

The research started by using a deductive approach, since the theoretical framework about scenarios forecasting was provided, which leads to the specific technique observed and empirically tested in the study. The main statement, which leaded to discussions about future of wind energy in Finland, is that extension of wind power capacities and integration in current energy system is a challengeable and complex process.

The hypothesis about the salutary effect of FCM-based approach on the qualitative scenarios in Wind energy sector in case of Finland, and the potential of cognitive maps are tested. It is supposed that FCM technique have a transitional property between qualitative and quantitative scenario methods, and play a pivot role in refinement raw plausible scenarios. This research used the wind energy sector of Finland as a case study.

For the FCM development, expert panel was formed from the participants who have the knowledge and experience in energy sector in Finland. The credibility of information obtained from the expert panel significantly depends upon their topic awareness, that’s why the selection was careful.

The data for the raw scenarios development was collected from the research papers and databases, while the data, collected from the experts was primary. There were two rounds of data gathering launched, using graphical workshops initially, and email semi-structured survey approach to increase validity, afterwards. The participants were informed about topic beforehand, and FCM technique details, as well as paper description, were explained during the personal meetings. Since the workshops were implemented through the graphical maps, their reliability can be affirmed.

Collected data was utilized for empirical part of research, when the mathematical computing was carried out with the aid of Microsoft Excel software. Therefore, the results of simulation were adapted to the research undertaking and performed in appropriate qualitative manner. Finally, results were performed in a way of robust scenarios with causality linkages given by expert panel, theoretical and practical contributions of the research, limitations and directions for further research were given.

2. FINNISH ENERGY SECTOR BACKGROUND

2.1 Overview of the national energy sector

From the way back, the solid milestone in energy system development, Finland started after the first oil crisis happened in 1970s. Since that, government leveraged the proper and carefully planned occurrence toward the development of external driver forces, which will be reasonably balanced in terms of economic and possible implementation. Since the 1980s, the nuclear power gained high priority, the energy independency is highly raised, and the fact of bilateral trade with Russia was remitted in 1990s, Finland lengthened its self-sufficiency throughout.

Being aimed to enhance competition and trading facilities in the electricity market, Finland established deregulated market as a part of Nordic electricity market in 1995. Growing awareness of climate change and other environmental problems related to energy production and use had and will have a significant impact on the whole energy sector (Finnish energy industries 2013).

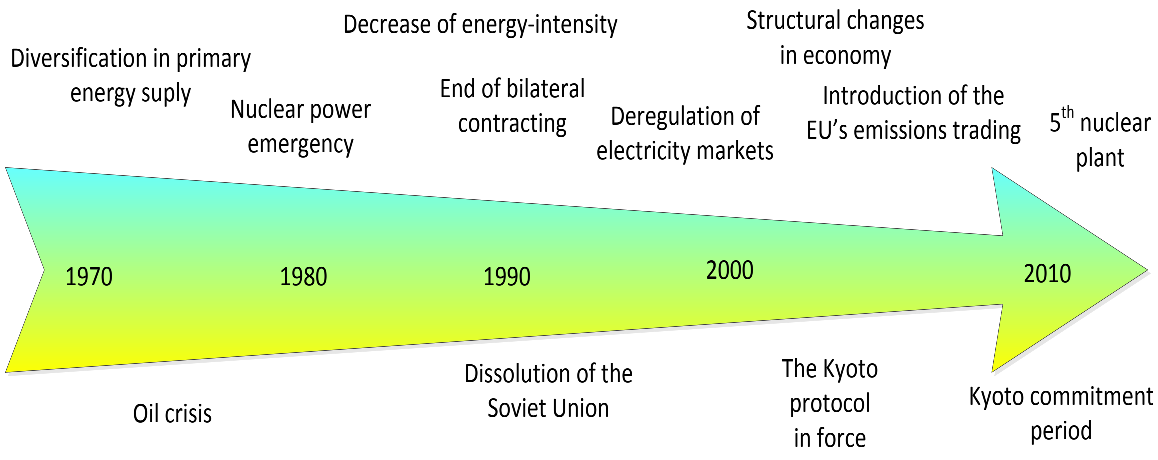


Figure 1: Important changes in the Finnish energy economy (VTT 2009)

Energy, environmental, economic and technological developments are all inseparably connected with each other (Oktay and Dincer 2009). Energy is a vital ingredient in socio-economic development and in economic growth nowadays.

In this modern era, the majority of global energy is generated and consumed in a way that cannot be compatible by using current technologies with the stable increase in overall consumption. From the national point of view, countries should focus on enhancing effectiveness of energy generation, distribution and final consumption.

As general, Finnish electricity consumption is mostly represented by energy-intensive industries with a strong emphasis in lighting and heating demand in a long winter period. The national electricity supply is primary based on distribution system, which relies on a variety of energy sources, due to the prior role of combined heat and power generation. The country's economy is mostly industrialized, including significant share of high-technology manufacturing, paper and forestry industry. The country is sizably rural, rarely populated, except of southern part. Due to its cold climate and energy-intensive industries, Finland has one of the highest energy consumption per capita among the European countries (IEA Report 2013).

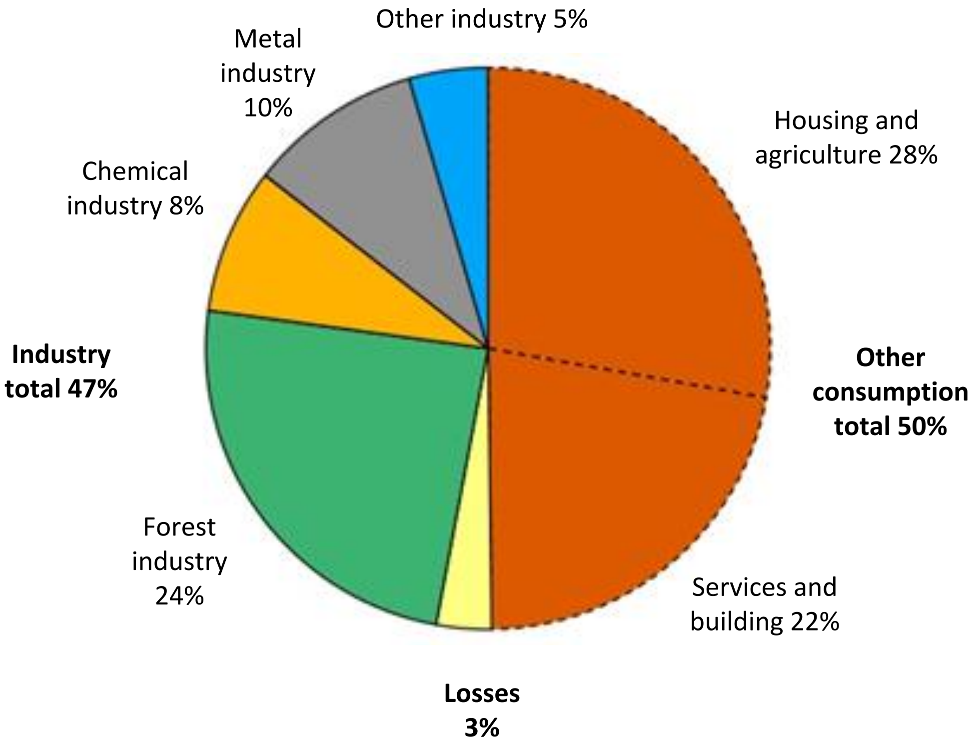


Figure 2: Electricity consumption in 2013 (Finnish energy industries 2013)

In the last year, Finland consumed 83.9 terawatt-hours (TWh) of electricity. Net electricity imports covered 18.7 per cent and Finland's own production 81.3 per cent of the consumption. The electricity consumption from industries accounted to just under 40 TWh in 2013 year, 47 per cent of consumption in total that was just 9 TWh less than in the 2007 peak year when industry amounted 53 per cent of total consumption. The forest industry alone accounts more than a half of industrial consumption. The use of district heat with increasing amount of new buildings led to increase in space heating over the last 15 years in Finland.

Finland strives for developing diversified electricity production mix, produces almost three equal thirds from the renewables, nuclear power and hydrocarbon energies respectively.

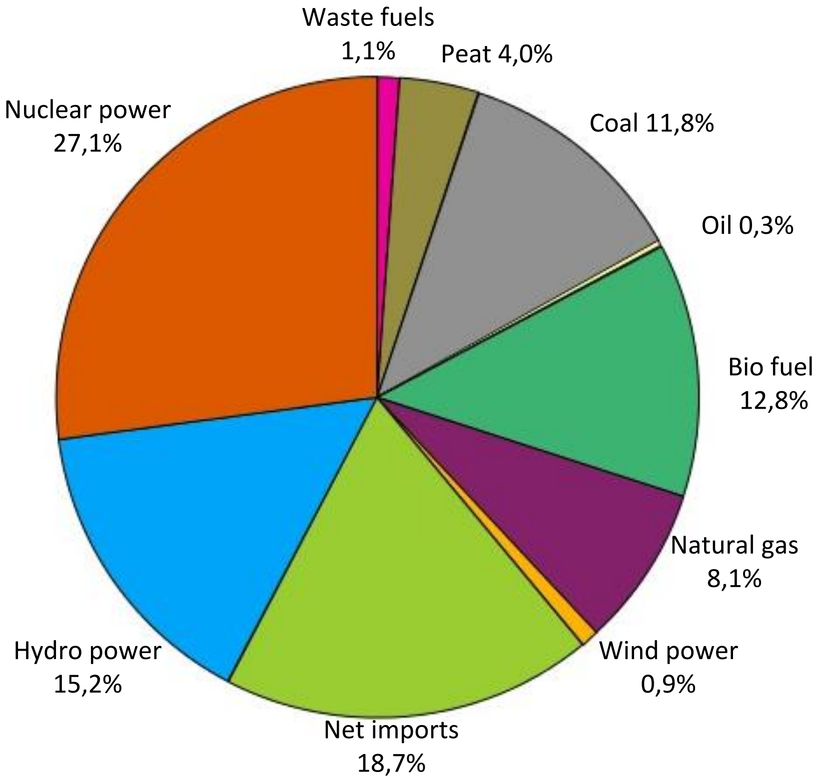


Figure 3: Electricity supply by energy sources 83.9 Twh in 2013 (Finnish energy industries 2013)

The import figure is still very high, though the share of imports fell to 18.7 per cent from the previous year’s 20.5 per cent. Therefore, last year ranks among the biggest in terms of electricity imports. This reminds to the need future of domestic investments in electricity generation, especially in carbon-free.

Wind power production raised significantly by 57 per cent from previous year and hit 0.9 per cent in share and reached 771 GWh in 2013 year.

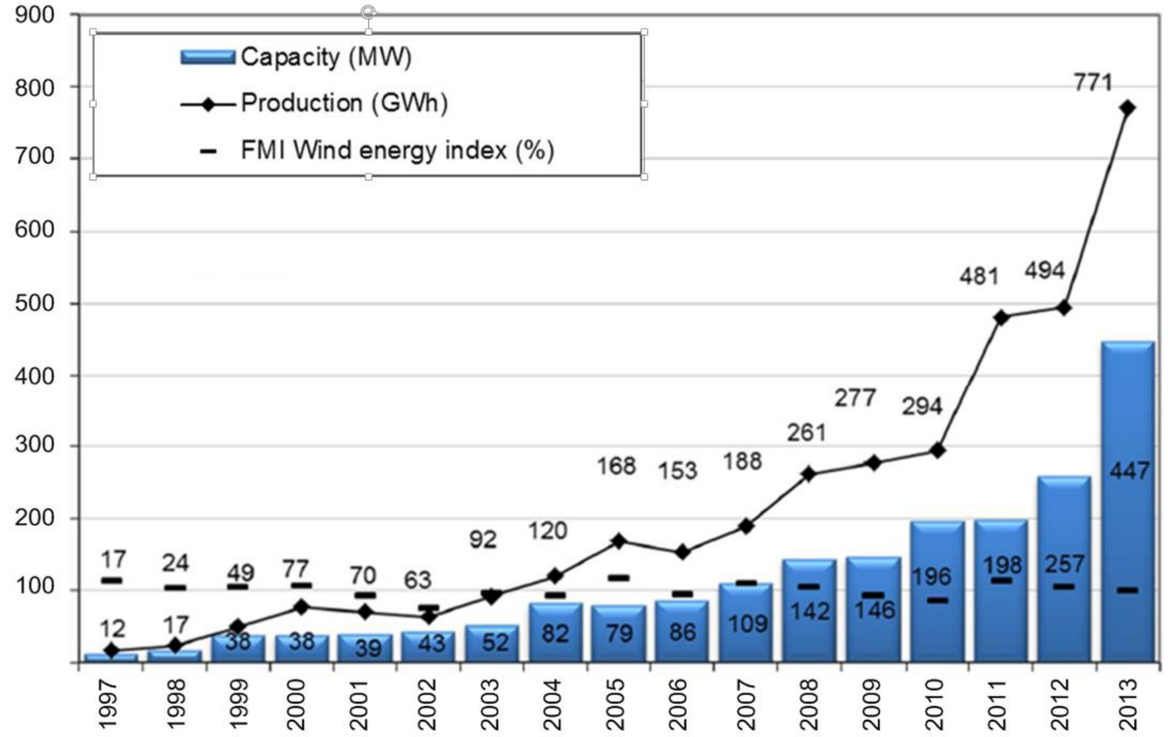


Figure 4: Development of wind power capacity and production in Finland (VTT 2013)

The overall emissions are increased in 2013 for a quarter, compared to 2012, due to recession in local hydropower production. Despite of that, 69 per cent of domestically generated electricity was carbon-free.

One of specific feature of the Finnish energy system is the high efficiency in energy generation, whereas combined heat and power plants cover almost one third of total electricity production. In crowded cities, almost 70% of household heating energy is district heating systems.

Finland is poorly endowed with indigenous hydrocarbon energy resources, thus placing energy policy, and particularly energy security, at the heart of the government’s policy concerns. The energy strategy addressed to enhance the energy security, to transfer national energy sector into decarbonized and to develop high integration with the European market (IEA 2013).

Chasing the low greenhouse gas objectives, Finland adopted the relevant nuclear programme to develop diversity in the energy production mix, naming one of the few

European members to expand nuclear activity in the country. It might be the wild card, due to the top-of-the-league ranking in terms of transparency and low corruption level to contribute in national economy and energy security.

In 2010, in accordance with its Climate and Energy Strategy, the Finnish Parliament ratified favorable decisions-in-principle for two more nuclear power plants, in addition to Olkiluoto 3, which is already under construction (IEA 2013). It’s planned to enhance share of nuclear energy in total electricity production from 28% in 2010 to over 30% in 2020 and correspondingly up to 60% in 2025. For a successful implementation, the surplus of radioactive waste should be taken into account in terms of facilities available to bury the waste left.

Currently, the market situation around gas supplying remains partly constrained, due to the sole source of import, which based only on a pipeline entry point from Russian part and insufficient infrastructure to supply arrangements. But Finland explores alternative opportunities to succeed with that issue.

The country’s transmission and distribution are organized with grids: 110,220 and 400 kV; while a distribution is below 110 kV generally. The key future of transmission system is belonged to common Nordic power system, including Sweden, Denmark and Norway. There is likewise, the interconnection with Russian power system as back-to-back DC link. The most significant surplus in generation is in south-western and northern Finland, when the rest parts are lack of required production.

2.2 EU 2020 policy

The challenge with the energy future, is considered to be the most important that Europe has ever faced. It takes a few decades to find and follow the sustainable path, and as it goes forward, the cost of failure is increased, otherwise it can raise Europe’s competitiveness at risk.

For the next ten years, energy investments over € 1 trillion are needed, in order to renovate existing equipment and diversify the generation mix, concerning the brand new and challenging energy requirements. Structural changes in energy supply, partly resulting from changes in indigenous production, oblige European economies to choose among energy products and infrastructures. These choices will be felt over the next 30 years and more. These decisions should be taken urgently as well as policy framework defined. Postponing these decisions may have indescribable aftermath on society as regards both longer-term and costs of security (European commission 2009).

The 2009 Renewables Directive (2009/28/EC) determines a new objective in terms of EU policy, concerning renewable energy sources (RES), compelling the EU members to consume at least 20% by RES in total on a national level. It is supposed to face a great challenge in renewable policy modification rather than extend the current trends and policies in existing manner.

The 20% target for renewable energy is calculated as a percentage of total final energy consumption, including all energy use - electricity, heating & cooling and transport. There are no sectorial targets for electricity or heating/cooling, but a separate 10% target has been set for use of renewable energy in transport (Directive 2009/28/EC). In the meantime, the mandatory targets were to reduce greenhouse gas emissions by 20%, and to deploy energy efficiency to 20%, replacing the existing facilities. There was also set achievement by 2020 a 6% reduction in the greenhouse gas pollution of fuel using in the road transport and non-road mobile machinery as an objective.

The European Parliament supported these goals as paramount. In spite of that, the promoted strategy is currently unlikely to achieve all the 2020 targets by all member states, and it is entirely hard-hitting in long terms. There are five priorities to European energy strategy (European commission 2009):

1. Achieving an energy efficient Europe;
2. Building a truly pan-European integrated energy market;
3. Empowering consumers and achieving the highest level of safety and security;
4. Extending Europe's leadership in energy technology and innovation;
5. Strengthening the external dimension of the EU energy market.

European Union is just starts stepping in renewables promotion, set up a 20% goal for achievement in 2020 and introduced the compatible legislative framework. It is vital to assure the entire implementation of the legislation, and to break the way for scalable renewable energy adaptation in the years beyond 2020. From the investment’s point of view, it should guarantee the confidence to recoup the money injection in the new sector and properly enforce the industry to accept challenges.

The lack of grid infrastructure also challengeable for renewables development, as distinct from traditional sources to compete on an equal basis. There is large scale of power lines in need to transmit the power between the wind capacities in the North and solar in the South projected to the high consumption places. The current grid is unable to succeed in absorption planned volumes, which 2020 targets enable. That's why a concurrent infrastructure deployment is consistent path.

The EU Emissions Trading System (ETS) is another important side of ambitions to decarbonize the State members, whereas collaborative way within the EU countries entails quick and economical advantage in energy market.

Finland as a state member, developed national structural plan to promote renewable energy generation, pursuing the aspects of Directive 2009/28/EC and put it on the sharepoint. It is preliminary estimated to gather 56 TWh available in fuels, while renewable energy sources will yield 77 TWh in accordance, and overall consumption as 327 TWh.

The national targets and measures concerning climate and energy packages were set in 2008 to steer both EU and national level:

Targets for 2020	The EU	Finland
Reduction of greenhouse gas emissions (base year 1990)	-20%	EU-level target
ETS emissions (base year 2005)	-21%	EU-level target
Non-ETS emissions (base year 2005)	-10%	-16%
Share of renewable energy sources in final energy consumption	20%	38%
Share of biofuel in transport fuels	10%	20%
Improving energy efficiency (in comparison to development as estimated in 2007)	+20%	EU-level target

Table 1: The EU's and Finland's energy targets for 2020 (National Energy and Climate Strategy 2013)

There are enough decisions, made beforehand to meet renewable targets for 2020, aiming to cover 38% of total consumption, and it is most likely expected to meet EU goal to the end of planned period well-off.

Since the EU set 10% share of renewables for transportation, Finland lifted a national level to 20%, supported this aim legislatively, by allocating biofuel obligations for liquid fuel suppliers. It is anticipated to enhance national self-sufficiency, when granted nuclear power units become operational and decentralized energy generation exaggerates in scale. There will be scalable replacement implemented, intended to change majority of coal plants for heating and power generation to emission-free production, as biomass. The small-scale generation for local district needs will be intensively promoted. The share of decentralized energy production in the production of renewable energy will be increased. When planning national energy and regional policy, as well as the related promotion measures, account will be taken of the development of the use and distribution of decentralized energy production and innovative local solutions (National Energy and Climate Strategy 2013).

Regarding to the biofuels production in Finland, it is considered as the cheapest and valuable way to increase forest-based bioenergy generation simultaneously, since the forestry took a noticeable place in national industry division.

There are some significant obstacles to achieve predetermined goal for 6 TWh wind generation. To promote large-scale wind farm commissioning is rather forceful than rely on local groups of wind turbines. There was additional EUR 20 million devoted from the governmental budget to launch large-scale offshore project by 2015. Likewise, promoting leverages to obtain large scale wind capacities will be investigated. Regarding inshore capacities, there are limited areas with considerable wind conditions to produce energy, therefore public authorities are in charge to maintain legislative atmosphere and take account about environmental welfare.

Implementing of new waste legislation will leverage waste generation, promote recycling and usage of recycled material, as well as promoting the energy use from the waste not suitable for recycling and material recovery through an increase in incineration and the production of biogas (National Energy and Climate Strategy 2013).

The national Finnish grid is now divided into several price areas, as well as bidding areas reflected at Nord Pool trading operations, which entails congestion situations inside country and may lead to contradictory impacts. In its turn, the Ministry of Employment and the Economy is obliged itself monitoring and possible cancellation of price area division, due to inexpediency.

In terms of Finland, small-scale generation is limited by can reduce purchased electricity consumption, in summer daylight hours. The market for companies, operated in this sector is rather homogeneous and can be quite competitive. Since Finland has a huge potential in smart-grid solutions, this advantage could be promoted through the domestic capacity opportunities.

Consumers are also involved personally in energy saving processes, as end users of electricity and potential users of small-scale renewable sources. That's why the need of developing online services and tools for comparing and estimating final impact of own choice should be promoted and organized. The search of customized decisions should be appropriate and easy to implement.

There are approximately 40% not considered by the emissions trading system, which is based on road traffic emissions. The alternative facilities for transportation as cycling, walking and public transport can reduce these sectoral greenhouse gas emissions. Moreover, promoting these means of transport in urban regions also reduces other environmental impacts caused by traffic, facilitates the smooth flow of traffic and improves traffic safety. Taking a long term, influencing choices in terms of transport, and consequently, transport performance, will become necessary in order to meet emission reduction targets (Ministry of Transport and Communications 2013).

The great and unprecedented changes for European energy market are coming, since the energy prices will be corrected by the huge amount of castor investments, as well as carbon pricing and international energy prices increasing. Through the entire energy chain, the facilities should be moderated and replaced by competitive and efficient ones. The overall scale of the challenges should be estimated properly (Böhringer et al. 2010). It fosters contemporary and competitive power market, which, besides, enables enhancing security and sustainability of energy systems, grid management, and energy market regulation monitoring. The extensive efforts are required to refit local and international consumers into energy order changes for ultimately saving energy, reducing wastages and adapting low-carbon technologies.

Investments in renewable energy production will be sooner covered by market-based instruments as taxation and trading of emission quotes. This strategy is called to help EU countries be ready for global challenges, which is coming by 2020 already, and to provoke coordination and instigation internally.

2.3 Importance of wind energy

Wind energy is now considered as a mainstream electricity generation source worldwide, and takes a middlemost role in an increasing number of countries' short and longer term power plans. After 15 years of average cumulative growth rates of about 28%, the commercial wind power installations in about 80 countries at the end of 2012 year had in summed in total 240 GW, increased by more than 40 times over that same period. Twenty two countries have more than 1,000 MW installed and adapted to central grid (GWEC 2012). In basic terms, wind energy benefits from the totally free source as wind, required no any other fossil fuels to be maintained. Apart from, the turbines can be placed almost everywhere including onshore and offshore locations, placing remotely. Likewise, in combination with a conventionally generated power can be considered as highly reliable power source.

In Europe, the total wind energy production took a 3% from all generated electricity. Its contribution in cumulative electricity generation is considered to be doubled every 3-4 years in the nearest future. The overall wind potential in European Union countries is far enough to fulfill primary energy demand even taking in account high European density and ensuing land-use restrictions. Therefore the energy grid facilities determine the ability of system to accept produced amount of renewable energy (Energy visions 2050).

In general, wind behavior is rather changeable and not stable, because of the earth's surface nature, required a permanent driving motion for heating and cooling processes. The motion of air flow in parallel to the earth's surface is a wind's direction and magnitude scale, which is randomly changing. Therefore, to forecast speed and direction of wind in a certain part of the land is quite unpredictable pursuit. This factor adds the most descriptive feature to wind's originality.

Mostly, wind power farms only imply visibility of industrial equipment as an environmental impact. It is taken as a not significant consequence, in comparison to conventional generation footages as radioactivity, acid rains or climate change (Sahin 2004).

Currently, the larger wind farms are required economically viable technologies for massive deployment and construction, becoming key drivers for industrial development. Modern technologies and research findings enable to lower marginal costs of turbines and construct larger-sized units in offshore sites far from the adjusted grids.

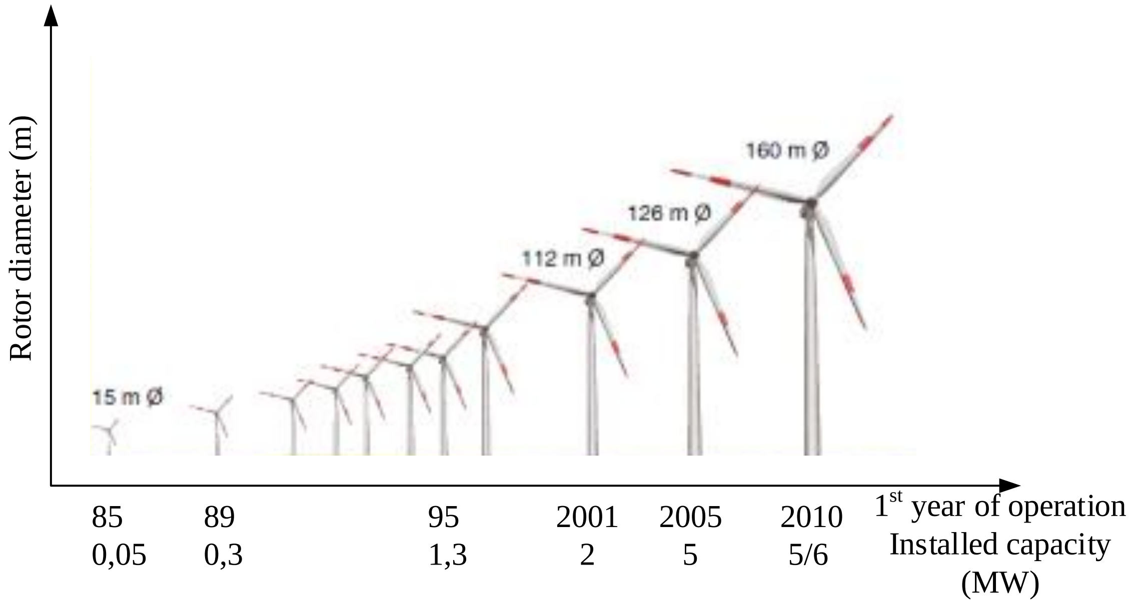


Figure 5: Development of wind turbine technology from 1980's to 2010 (Energy visions 2050)

The innovation design in wind turbine keeps evolving, and it enables to cut costs and increase productivity noticeably. Moreover, those developments enlarge the machine yield, making the blades longer and thinner, capacity greater and hub base higher. It results in technology shifts toward multiple regime usage, different operation conditions and remoteness in maintenance.

Renewable energy production inevitably impacts the global labour market, creating a bulk of jobs, spreading alongside with the value creation and comes to the forefront in policy negotiating. There are approximately 6.5 million people working partly or directly in renewable energy sector based on surveys from period of 2012 to 2013 (Blanco and Rodrigues 2010).

The groundbreaking moment in wind energy job distribution is supposed from 2012 to 2030, since the amount of installed capacity will grow sequentially. There will be about 50.000 of additional skilled staff in demand for the industry by 2030, whereas, the most popular source will be shifted toward operations and maintenance sector (EWEA 2013).

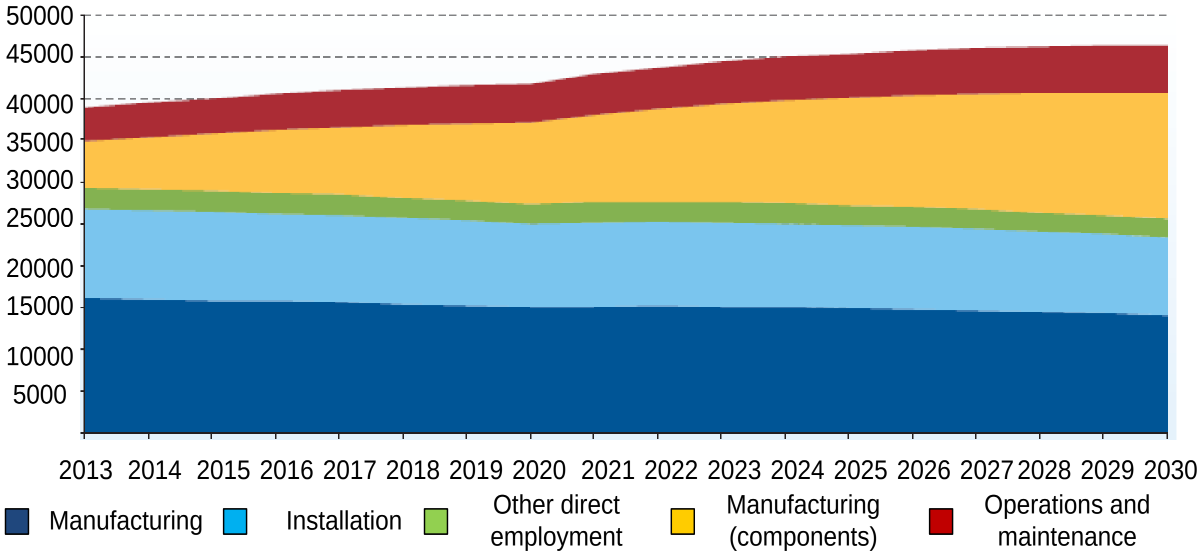


Figure 6: Rate of job creation for trained staff (EWEA 2013)

The large bounce in “Operations and Maintenance” sector caused by overall rise of wind capacity in Europe forecasted.

Producing electricity based on a wind is sensible either in economic or environmental terms. Moreover, wind generation electricity and further selling is quite typical business model worldwide. To prove economical viability, the production costs should be less than distribution prices. Furthermore, there are few market based mechanisms adapted, such as subsidiary leverages or taxation systems. Thus, the wind electricity price varies in different countries much. Since the project has launched, the expenses are sent only for operation and maintenance, when the capital cost is between 75 and 90% of the total.

The cost of electricity, generating from the wind is made up from (Madariaga 2012):

- Investment costs—building the power plant and connecting it to the grid;
- Running costs—operating, fuelling, and maintaining the plant;
- Network connection costs.

Network connection costs in Finland are considered as costs for transmission line facilities to the closest grid, operating by Fingrid, Finnish transmission system operator (TSO). Connection procedures are managed jointly with the Fingrid, but all connection costs, including fault protection should be covered by new power plant operator (Fingrid 2013).

Running costs are divided into normal life cycle operation costs, such as personnel wages, electricity components maintenance, repairing and costs of equipment, and blackouts losses. Investment costs cover all costs between project planning and commissioning of the power plant. In its turn, there is a methodology, including division of costs depends on park structures, distance to shore, tower height. Usually, the cost of turbine is about one of third part for investments. Concerning onshore development, the turbine cost increases much, usually two-thirds or even more. Another investment cost components are foundation and electrical infrastructure. Blanco (2009) estimates rough investment cost structure in her research.

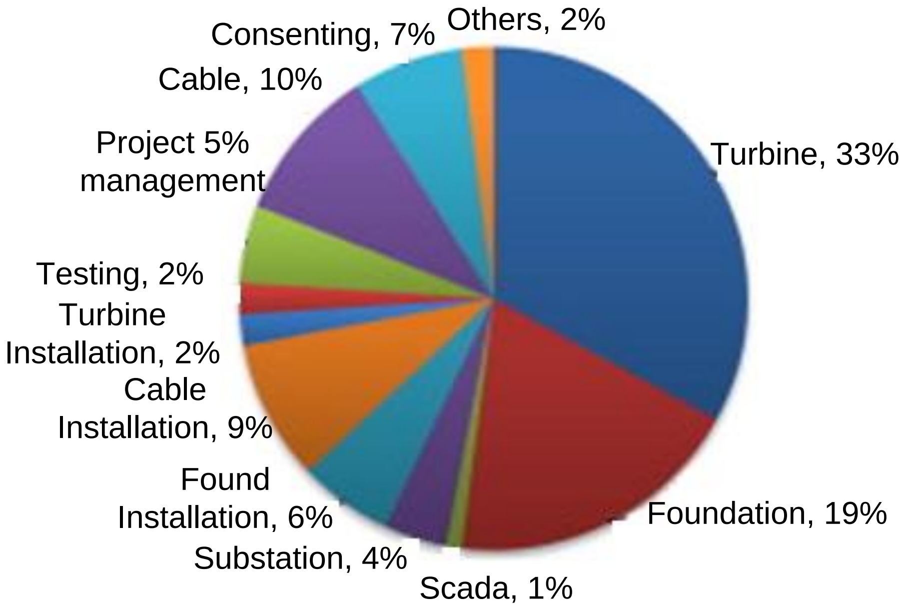


Figure 7: Investment cost structure (Blanco 2009)

Nowadays, wind power becomes competitive with coal and gas plants, even challenging a gas in some locations, which is considered a cheapest option. Wind energy is sequentially reduce generation costs and increase efficiency, while wind projects are relatively cheap and easy to conduct. Land fees and taxes can induce additional revenue for farmers in charge, raising income in rural areas. Building up and construction are mainly completed by local incentives, promoting new jobs.

2.4 Wind energy challenges in Finland

Finland is located in such kind of latitude, that there is an ability to bring good wind resources over the country by polar fronts. But there is significant part of country, covered by forests, which makes restrictions concerning the height level of onshore wind towers, along with that, there is not forested landscape in southern part of country. The onshore farm requires quite high turbines and complex logistics decisions, resulting quite often in unpredictable outcome. Notwithstanding this, the national offshore potential looks very attractive to invest in. Technically, total potential capacity both of onshore and offshore is much greater than energy consumption in Finland. Additional problem raised with icing formation on the blade’s surface, which lead to unpredicted costs concerning to heating and overall self-consumption of the turbine.

There are anticipations about dramatic turbine size growth, as that was previously, due to lack of logistical capabilities, which are very complex to overcome. Whereas, land-based turbines are not expected to have rotors larger than 100 m in diameter, with the total output from 3 to 5 MW as maximum. Offshore turbines are not faced with logistical issues, but relative expensiveness forces larger size, because of the water depth. But difficult load for the turbine emerges when flow conditions are changed due to the rotor size enhancing (Renewables global status report 2014). Moreover, current electrical grids are lack of facilities to incorporate large-scale offshore capacities. There is a strong need to redesign infrastructure of the national grid, systems regulation and grid management to incorporate renewable energy technologies.

Finland participates in Nordic electricity market, which is deregulated and common for all countries included. Due to the diversity of generation resources, this system is well adapted for the participant in terms of collaboration. Norway relies highly on hydropower generation, whereas Sweden has almost 90% of power generated from nuclear and hydro, but Denmark conducts thermal power generation mostly. Thus, in Nordic market, the most efficient technology drives.

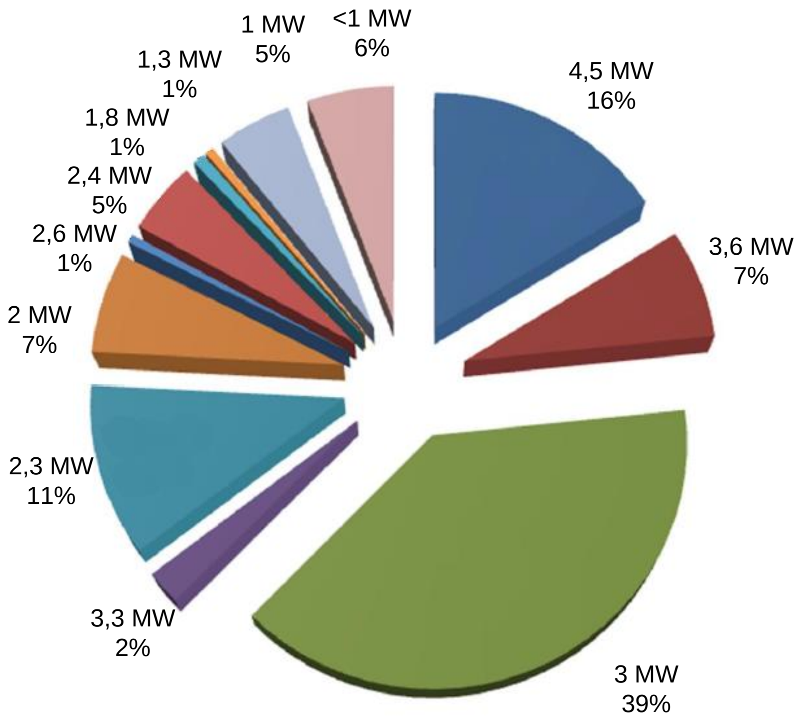


Figure 8: Size of wind power turbines installed in Finland at the end of 2013, 447 MW in total (VTT 2013)

In strong pursuit of greenhouse gas emissions reduction, the Finnish government encourages secured national energy supply, as well as competitive electricity price formation. The level of support is substantially based on generation costs, deploying wind energy where the costs are lower, assuming crawling support incentives from the EU members (Schmalensee 2011). In favor to investment attraction, there was Wind Atlas project devoted by Finnish Meteorological Institute in order to make estimations related to wind flow activities and appropriate turbine size commissioning.

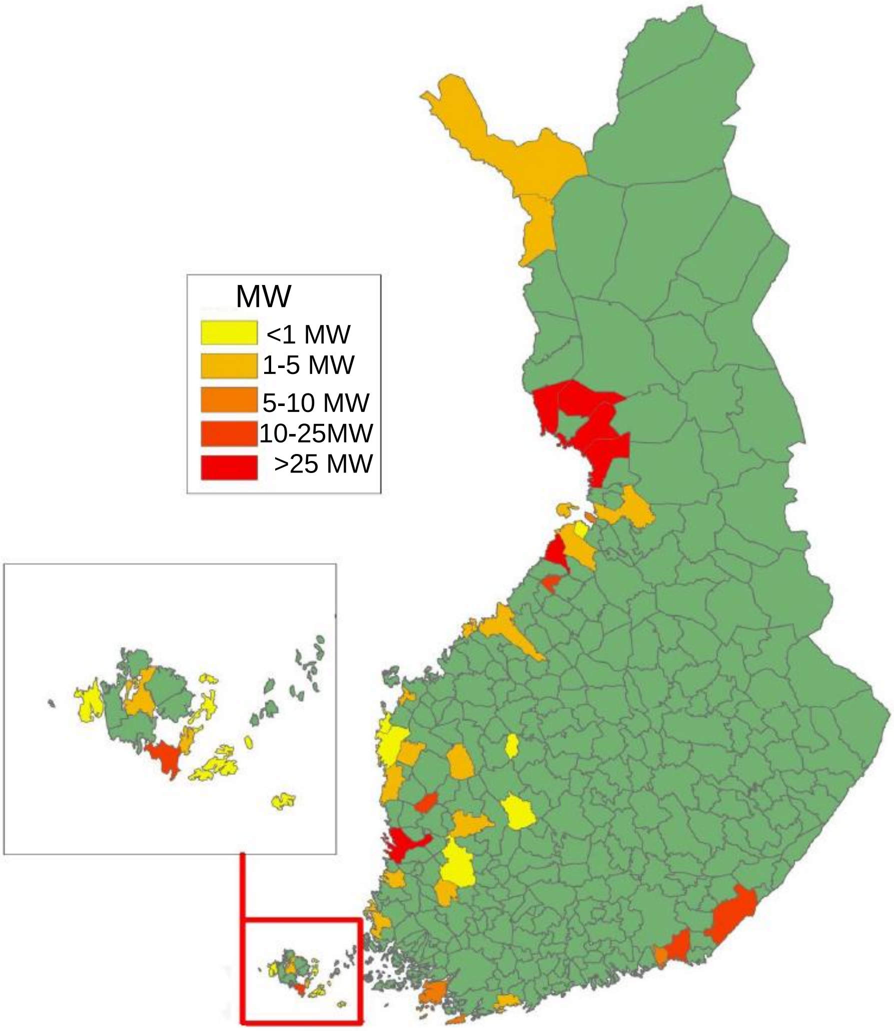


Figure 9: Regional distribution of wind energy capacity in Finland in 2013 (VTT 2013)

Renewable power is supported regarding to EU incentives and RES directive, targeting 20% of total share for renewable by the 2020 year. The governments are in charge for their own deploying ability, which is 38% for Finland and required to consume about 30 TWh annually from the renewable energy sources. The strong interest is predicted to offshore plants besides, aiming to reach 3000 MW in the nearest future (Government of Finland 2011). It is doubtful to succeed those plans by 2020 year, due to lack of additional support for offshore projects comparing to onshore investment costs.

Currently, government support in Finland derivates from the act of production with the renewable sources (Government of Finland 2010):

- The plant is located and connected to the grid in Finland’s territory;
- Target price for wind power is set as 83.5 €/MWh;
- Target price should be reduced to plant’s consumption itself. Support is paid by the TSOs meter reading at the grid’s interconnection point;
- The basis period for market price estimation is 3-month time period as average. If the market price is less than 30 €/MWh for that period, the tariff will be reduced with 30 €/MWh.
- Fast project completion will be granted with the exception price set as target price of 105.3 €/MWh until 31.12.2015, for a three years in maximum with higher target price.
- Target price will be paid to all producers assigned to the programme, till the total capacity will reach 2500 MVA.

Recently, the government placed a 20 M€ reservation for the offshore demonstration project so far, in terms of Energy and climate strategy. That money will be additional base to feed-in tariff, aimed to minimize investor’s risks, covering construction costs with a new offshore experiments. For the end of 2013 year, there were six companies proposed with the offshore projects, ranging from 2 to 9 km to cost (Finnish Ministry of Employment and Economy 2013).

For the previous capacities, the support was 0.69 €cent/kWh paying by consumers in the form of taxes. Since that, tax reductions are replaced for the direct tariff prices to generators. Whilst, current wind energy generation is not covered by taxes, since no fuel consumed (Salo and Syri 2014).

In a short time, developing onshore and offshore projects will be considered as full-scale power plants and should be integrated similarly as fossil fuel power plants. Therefore, there will be cross-border and national grid upgrades required, developing and gathering suitable infrastructure. This will derive large investments, meaning that there is no single cost for wind power electricity.

3. THEORETICAL FRAMEWORK

3.1 Scenarios planning review

Every action becomes senseless when the goal is not adapted, whereas only extend of anticipation, points the path to action and brings the meaning and direction both. As one Roman philosopher mentioned, “there is no favorable wind for the man who knows not where he is going”.

In the last few decades, there is sustainable increase in scenarios formation within the industrial management field, it engaged an array of domains and fields inward. Essentially, the business environment faces uncertainty in a high level, which can be determined by scenario planning studies thoroughly. In the present era, characterized by uncertainty, innovation and change, increasing emphasis is being placed on the use of scenario planning techniques because of its effectiveness in terms of uncertainty and complexity (Schoemaker 1991).

Scenarios composing facilitates to overcome limited thinking and go beyond the blinkered realization of futures. Scenarios can be treated as possible sets of related events to base a sequence of future conjuncture. Due to the definitional complexity, scenarios can be admitted as descriptive vectors of possible future pictures in reflect of variety perspectives on the past, present and future. But due to the breadth of field to utilize, this definition could characterize future forecasts at all. However, scenarios is considered as a tool par excellence of futures forecasts, which reclaim the present, contour the uncertainty, explore alternatives, and better predict (Inayatullah 2008).

As dominant, project managers handle scenarios to disclose their mental preferences about future to mark decisions, eminently they take into account. Scenario planning is becoming dominant tool for improving decision making processes and uncertainty leveraging by considering a possible future environments (Varum and Melo 2012). Thus, scenarios enable to dissipate uncertainty and benefit either from the group or sole decision making processes.

More comprehensive task is to develop strategic culture, which can be more advanced and effective as traditionally taken, long-term planning. In technology planning, forecasting, strategic analysis, and foresight studies, scenarios are used to incorporate and emphasize those aspects of the world that are important to the proposed forecast (Amer et al. 2013). Coates (2000) mentioned that the biggest issue divides among scenario practitioners is whether or not scenarios can be seen as forecasts. In approaches where scenarios are taken as forecasts, the immediate problem is that countless possible scenarios can be created. Selecting from the multitude of scenarios is logical challenge, based on constructor’s abilities regarding chosen field and that number of scenarios should be equaled to manageable amount. This can be implemented by defining boundary conditions to narrow the number of scenarios, avoiding the dullness of a probability approach.

Also, there is a human judgment is taken into account, due to personal abilities to include or not include events, which can entail critical situations occurred. Overly-optimistic thinking may put a pressure to decrease uncertainty in the faced situation, but it does not reduce uncertainty we meet in the real life, which may raise a surprising future development. Scenarios intended to include external trends and in-house decisions, distinguishing the relative impact on decisions both. Schumacher (2012) exemplifies a number of internal factors like decisions, strategies, vision, values, and knowledge as well as external factors like rules, regulations, and influences. Scenarios planning should supremely move away from central-thinking tendency and be based on experts proficiency.

If uncertainty is low, then small number of highly related scenarios can cover the majority of probabilities, one could favor for either: a risky strategy (by betting on one of the most probable scenarios), or a robust strategy that reflect most probable developments (Godet 2012). But, in the case of high uncertainty, preferably reversible forecasts are recommended to be adopted. However, Godet (2012) accepts refusing to risk in strategy adopting as dangerous, even rejects high risky options that could turn out into profitable ones, and get back on forecasts with profits as low as the risks.

On the basis of perspective, scenarios are classified into descriptive and normative scenarios (Porter 1991). Regarding to author, descriptive scenarios are tended to be extrapolative as natural and present a range of future likely alternative events. In its turn, normative scenarios are directed to presented goal in response to policy planning concerns in order to achieve the desired targets. Mietzner (2005) classified scenarios on the basis of scenario topic chosen (problem specific verses global scenarios), breadth of the scenario scope (one sector verses multi-sector scenarios), focus of action (environmental verses policy scenarios), and level of aggregation (micro verses macro scenarios).

As a forecasting method to be carried out, scenarios planning can be divided into several milestones, containing most of applied stages broadly used in industrial management environment. There are several divisions in academic community to depict a robust implementation timeline. To get familiarity, there is a sequence drawn by highly cited researcher, Michel Godet.

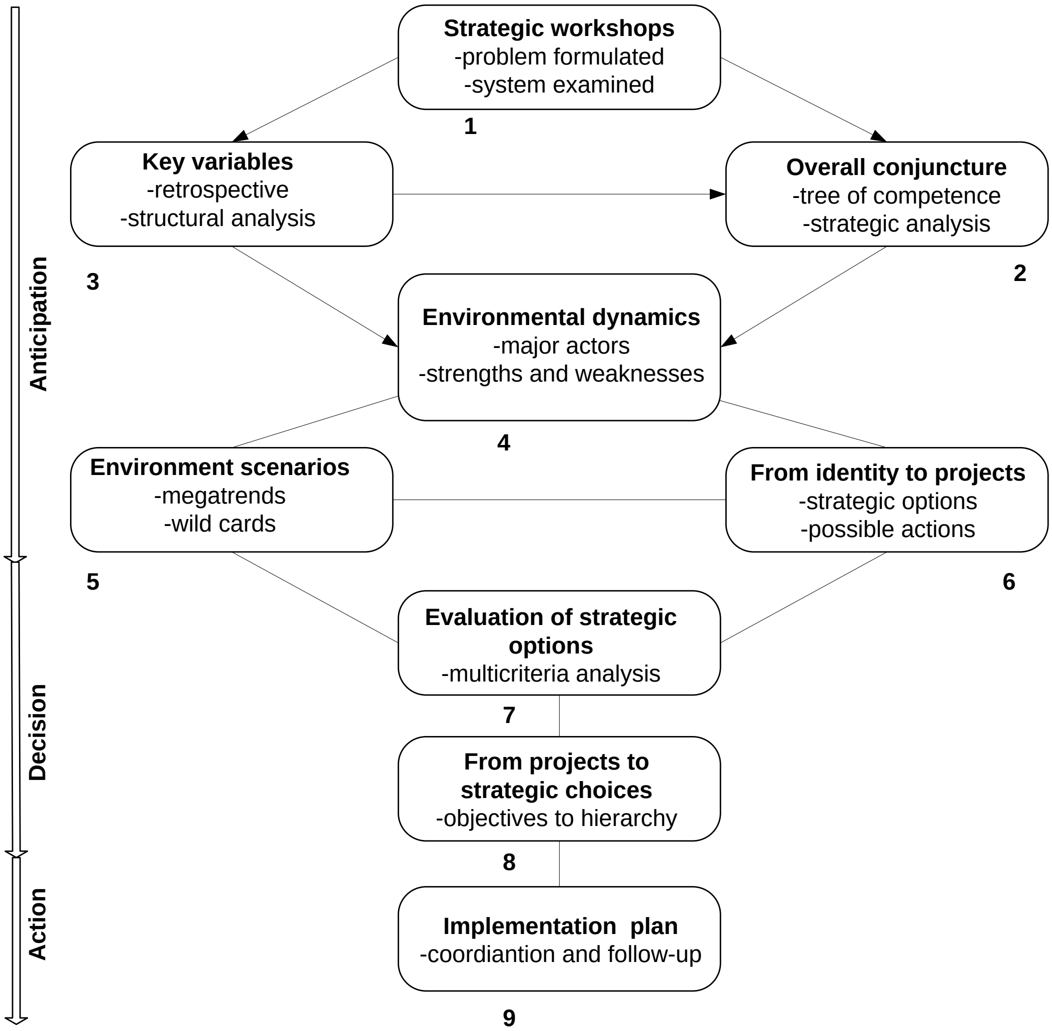


Figure 10: The graphical interpretation of scenarios planning approach (Godet 2012)

The first phase is kick started from the contemporary problem analysis examined the system as happen to be, and to draft strategic prospects of deployment. The second phase involved the analyzed unit in the X-ray proceeding, figuring out the essential competences relatively. In the third phase, the structural analysis identifies the key variables of unit and its environment. Environmental dynamics in unit's retrospective and past development are emphasized in section four, linked with the strengths and weaknesses in relation to the major actors in its strategic environment. In the fifth phase, key future questions are tested against uncertainty, whereas experts can reveal megatrends and wild cards concerning the planning outcomes and draw out the most likely scenarios. In sixth phase, strategic highlights compatible with the analyzed sector identity and environmental scenarios are getting into manageable visions. Seventh phase is wholly concerned with assessing strategic options; a rational approach would encourage the researcher to fall back on a method of multicriteria choices, but this is rarely the case; the reflective phase prior to decision and action ends with this phase. In eighth phase, transition from thinking to strategic decisions are realized, the decision's hierarchy is composed. Ninth phase encourages planned implementation and scenario coordination.

Mostly, the process of scenario planning is not straightly sequenced, it is assumed to use possible feedback loops to ensure quality achievement, in particular, from phase seventh to second phase. Eventually, this scenario planning approach is given on a miscellaneous basis, and introduces an action testimonial either to single company or national sector forecasting. Moreover, scenarios should match in appropriate extend, to the specific needs of the discussed unit and outcomes expected from.

3.2 Comparison of key scenarios planning approaches

Pierre Wack (2003) contends "the single most important aim of scenario planning is to challenge the assumptions of decision makers about how the world works and compel them to change their image of reality – sometimes resulting in revolutionary transformation".

Scenario technique is easily considered as methodological chaos without corresponding definitions across the breadth of their implementations, in spite of its methodological unity to studies in future (Stewart 2008).

Since there were many different approaches in scenarios generation, it's apparent to admit several methodologies used by research community in a miscellaneous manner. Besides the Godet's approach in composing scenario through the vital stages sequentially mentioned in the paper, there is variety of generic prerequisites to unify and elaborate scenarios in academic way.

Inayatullah (2008) in his study divide scenarios methods in five approaches: single variable; double variable; archetypes; organizational; and integrated. The single variable approach identifies future triangle as a core, performing future drivers into scenarios developed and validated. The double variable method, invented originally by Galtung (1998), identifies the two major uncertainties and develops scenarios based on these. The third method combines scenario archetypes, in which the analyzed unit placed and tested to meet similarities with the certain archetype: continued growth, collapse, steady state and transformation. The fourth model of scenario writing is developed by Peter Schwartz (1996). It is organizational focused, when the scenario structure is composed of four variables: best case (where the organization desires to move towards); worst case (where everything goes bad); outlier (a surprise future based on a disruptive emerging issue) and business as usual (no change). In the fifth scenario methodology, Inayatullah (2008) listed four dimensions: the preferred, the world we want; the disowned, the world that we reject or are unable to deal with; the integrated, where owned and disowned are united in a complex fashion. And last is the outlier, the future outside of these categories.

Another interesting methodology based on the suggestion that different worldviews influence on a scenarios composition. One of the comparative analysis, proposed by Peter Hayward (2005) to match up different worldviews in their relationship to foresight with the scenarios development focuses. The diversity of scenario methods, however, can be seen as a different scope within a certain worldview and thus lower degree in variation than those separated by the depth of worldview overtaking them (Hayward 2005). An application of the worldviews of foresight interpretative framework to the development of scenario methods is outlined in Table 2.

Table 2: Scenario method worldviews (Hayward 2005)

Scenario Worldviews	Scenario Characteristics			
	Habermas' Interest	Content Focus	Signature Strength	Signature Weakness
Progressive Foresight Scenarios	Technical	External trends and behaviours	Progress forecasting and prediction	Single point extrapolation with limited view of causality
Political Foresight Scenarios	Technical	External systems and structures	Decision support within a systems based view of operating environment	Worldview assumptions such as those relating to power, and positivist progress and control are opaque
Critical Foresight Scenarios	Emancipatory	Internal structures of meaning and power	Social discourse renewal	Becoming trapped in idealistic normative conceptions and failing to acknowledge practical empirical realities
Consensus Foresight Scenarios	Pragmatic	Collective relations	Participatory Action learning	Extreme relativism resulting in action paralysis, or nihilistic normative outcomes
Integral Foresight Scenarios	Combined based on context and purpose	Based on context and purpose	Integration and easier access to qualitative and quantitative complexity	Forced abstraction

From the analysis conducted, there is insight given that every worldviews-based approach to scenarios elaborating contains exact value, to the extent of what is perceived.

There are three fundamental schools of scenario development, brought much influence in concept evolving and popularizing. Two of these are originated in US, when the third one is initiated from France. The approaches are: Intuitive logics, probabilistic modified trends (PMT) methodology and the French approach of La prospective. The PMT technique is originally quantitative whereas intuitive logics approach is purely qualitative technique. The French approach of La prospective combined qualitative of and quantitative tools inward. The most highlights of these methodologies in comparison, given in the Table 3.

Table 3: Principal scenario development techniques comparison (Bradfield et al. 2005)

Scenario characteristics	Intuitive logics methodology	La prospective methodology	Probabilistic modified trends methodology
Purpose	Multiple, from a one-time activity to make sense of situations and developing strategy	Usually a onetime activity associated with developing more effective policy and strategic decisions	A onetime activity to make extrapolative prediction and policy evaluation
Scenario type/perspective	Descriptive or normative	Generally descriptive	Descriptive
Scope	Can be either broad or narrow, ranging from global, regional, to a specific issue	Generally a narrow scope but examines a broad range of factors within that scope	Scope is narrowly focused on the probability and impact of specific events

Methodology type	Process oriented approach, subjective and qualitative	Outcome oriented approach, analytically relying on complex computer modeling	Outcome oriented very directed, quantitative using simulation models
Nature of scenario team	Usually an internal team from the organization for developing scenarios	Combination of some members from client organization led by an expert	External teams, scenario developed by experts (external consultants)
Tools	Generic tools like brainstorming, STEEP analysis, and stakeholder analysis	Proprietary and structural tools like Micmac, SMIC and Mactor analysis etc.	Proprietary tools like trends impact and cross impact analysis etc.
Identifying key driving forces	Intuition, STEEP analysis, research techniques, expert opinion	Interviews with stakeholders and structural analysis using sophisticated computer tools	Curve fitting to past time series data to identify trends and use expert judgment to create database
Developing scenario set	Defining the scenario logics as organizing themes or principles	Matrices of sets of assumptions based on variables for future	Monte Carlo simulations to envelope uncertainty around base forecasts
Number of scenarios	Generally 2–4	Multiple	Usually 3–6 depends on the no. of simulations
Evaluation criteria	Coherence, internal consistency and novelty	Internal consistency tested by rigorous analysis; plausible and verifiable in retrospect	Plausible and verifiable in retrospect

Based on a future perspective, scenarios can be classified as descriptive and normative (Porter et al. 1991). Descriptive scenarios have extrapolative nature and represented as a set most likely alternative events, meanwhile normative scenarios are driven by objective formularized and aligning by policy planning concerns to meet the desired goal.

Depending on scenario topic, there are problem specific and global scenarios, whereas environmental verses policy scenarios perform classification by focus of action division. The level of aggregation suggests distinguishing micro and macro scenarios.

The variety of scenarios is ranged from simplistic to complex, qualitative to quantitative. A plenty of essential scenario building approaches built on qualitative inputs, when the rest extensively use statistical and computational tools (quantitative techniques) and on this basis scenarios can be based on qualitative data and quantitative data (van Notten et al. 2003).

Due to enormous number of scenarios methodology invented, there is an evidence of methodological disarray, caused by emerging completely weak and ineffective development models, never go beyond the literature and never been tested. Furthermore, complicated software tools oftentimes are required to get familiarized with, just to approach a complex of sub-techniques which are undeservedly hard for implementation.

In sum, there were contemporary worldviews and techniques compared in terms of scenario planning significance. That gave a research ground to deepen into modern insight of energy sector forecasting.

3.3 Scenario planning in Energy Sector

The scenario planning is comprehensively applied in energy sectors from the routine processes to brand new technological solutions being in plan to implementation. Intrinsically, it facilitates to enhance decision-making processes and to identify new challenges to be met in forecasted period. It enables to analyze entire energy systems in their inherent complexity. To use scenarios planning for energy sector forecasting is valuable, due to the lack of accuracy in this field forecasts, as well as it raises imagination, logic discussion and preparation to plausible futures.

The ultimate goal for energy planning is to cover energy demand within certain period of time, taking into account political, social and environmental special aspects, as well as historical data collected for previous energy plans, hence it can foster sustainable development (Cormio 2003). Generally, it is supposed to base energy plan on energy demand and supply statistics, on population growth and social impacts, as well as on a core technology ownership and political leverages in the country. It is crucial to understand high importance of energy planning contribution as robust research findings.

In terms of economic impacts, the energy sector influences the environment, the society at all, market potential, technological field, as well as general electricity demand and supply. All of these parameters are taken into account while the proper energy planning implemented. The economy's sectors affected by energy development include agricultural, industrial, commercial and residential ones. Hence, energy plays a role in production in the industrial sector as well as being established as final product for consumption heating, transportation, cooking, etc. (Devezeaux 1990).

The end-user technology plays an important role in amount of energy utilized per unit to satisfy household needs or amount used for a unit of production. Besides, consumer can choose type of technology for harnessing electricity in terms of economic and technological feasibility. Energy planning should always support the sustainable development of a sector in overall. Neves and Leal (2010) defines three important criteria of successful planning in energy sector: environmental, economic and social. Environmental criterion summons to reduce greenhouse gas emissions, air pollution and exhaustion of natural resources which caused by limited supply chain and inefficient energy utilization. Economic criterion includes reduction in fossil fuel consumption and stimulates local renewable energy incentives and energy efficiency modernization that entails local business activity and welfare. Social criterion is responsible for human health enhancement, employment activity, comfort and the involvement consumers into decision-making processes.

Thery and Zarate (2009) have summarized the three different energy planning terms: short-term (hours, days, months, one year), medium-term (from one year to 10 years) and long-term (beyond 15 years) energy planning. The short-term planning is aimed to meet reliance concerning devices or services, when key decisions were made with existing technologies. The medium term-planning admits emerging new energy technologies as a special case to meet energy demand. The long-term energy planning is conducted when introduction of brand new infrastructure or advanced technologies took a place, when especially energy demand is planned to be changed or correlated. The longer term of energy planning is considered, the less possibility to apply changes in the core structure and further supplements. In this point, scenario planning technique is started, when there is a need to model few related structural changes regarding to chosen pathway. Moreover, those changes lead to significant impaction on the planning itself. Kydes et al. (1995) discusses the results of long-term modeling by explaining how environment and economy are affected by assumptions on costs, rate of technological progress and efficiency improvement proposed in long-term study without reducing the uncertainty.

Scenario planning facilitates in defining key emerging issues in the energy sector thoroughly. There are some of advantageous cases to come up with scenario planning within the energy scope:

- Analysis of the future energy consumption in the transport sector and evaluation of electric vehicles penetration extend (Limanond et al. 2011);
- Analysis of potential energy export capacities and consumption diversity (Kalashnikov et al. 2011);
- Analysis of current energy policy and measurement of environmental consequences from the electricity consumption activity (Browne et al. 2009);
- Analysis of the most leading opportunities to breakthrough changes in the national energy infrastructure as energy efficiency, renewable energy sources or a transportation load (Ghanadan and Koomey 2005);
- Analysis of plausible electricity demand on a national level (Hai-ying et al. 2011);
- Global or regional energy resources assessment (Silberglitt 2003);
- Assessment of energy generation mix and greenhouse gas emissions (Krewitt et al. 2007);
- Commercial energy savings (Zhou et al. 2008);
- Hydrogen energy popularization (Sorensen et al. 2004);
- Renewable energy integration (Weisser 2004);
- Estimation of future renewables share and demand dependency (Keles et al. 2011);
- Renewable energy portfolio planning (Chen et al. 2009);
- Long-term energy planning at national level and roadmap development (Czaplicka-Kolarz et al. 2009).

However, there were just a significant criteria listed in the paper, to guide energy scenario planning, but after all, the people are responsible for a decisions about policy and further development of energy sector, either governmental officials or a implementers. Energy planning is a key pillar to force sustainable development of the country.

3.4 FCM scenarios overview

The FCM approach originated from the “cognitive maps” phenomena, initially introduced and called attention to research community by political scientist Robert Axelrod (1976) for representing set of scientific knowledge. Axelrod depicted cognitive maps as signed graphs, which had variable concepts in nodes, and edges as casual connections represented then.

Afterwards, Californian researcher Bart Kosko (1986) evolved cognitive maps technique to “Fuzzy cognitive maps” approach, representing causal reasoning through fuzzy graph structures. He stated that the fuzzier the knowledge representation, the easier the knowledge acquisition and the greater the knowledge-source concurrence, but the fuzzier the knowledge, the harder the symbolic knowledge processing. As an outcome of his study, he actualized a fuzzy causal algebra to govern causal propagation on FCM.

Based on experts causal knowledge in complex to research topic, cognitive maps used to capture those related knowledge and represent into graphical manner to accept communication and visualization of expert workshop. Cognitive maps encode dynamic behavior ("something happens because and after something else has happened"), but the dynamic properties of the mapped system cannot be easily inferred by decision makers (Jetter 2006).

The FCM approach got relative popularity by researches worldwide in terms of scenario building. This approach filled the gap between qualitative and quantitative scenarios, making the process more integrated than previously. It basically brings imagination to causal analysis, while graphical mapping makes experts involved and to disclose their mental templates and apply their own knowledge. In addition, causal relationships were considered to be weighted in order to enhance or weaken relationships in the chain. Therefore, FCMs can overcome the indeterminacy problems of the causal cognitive maps which occurs when one concept is influenced by an equal number of negative and positive ingoing arrows (Schroder and Jetter 2003).

The FCM plays vital role in decision-making process, leveraging the key concepts and relevant links in order to capture the backbone and causality. It is considered as modeling approach that makes the qualitative causal maps computable (Jetter 2006). But applying the FCM should be covered of minimalism logic, to prevent complexity in final concept integration and analysis. A finite number of FCMs can be combined together to produce a joint effect and capture opinion of multiple experts together in one collective map (Kandasamy and Smarandache 2003). The concepts are not just linear functions for leveraging the path of weighted activation, towards original causes.

The approach brings much credibility in a long-term planning, considering the multi-prospective environment rather than solely raised paradox. The FCMs are usually collected by experts view and get integrated into collective map in order to assess holistic assumption about covered field.

The FCM-based approach is used currently in the variety of applications covering different fields. It’s applied in political forecasting, software development, strategic system evaluation, product planning, electronic logic, in web data mining and many more scopes relatively.

Remarkably, that FCM approach making a powerful support for decision-making processes in technology management and engineering, including product forecasting, R&D activity, alternative business scenarios development and etc. Primarily, it helps to identify sensible variables among the experts and desired target influence on variables. Moreover, many identified problems are too difficult to come up by decision-maker solely, that’s why multiple people affected should be taken into account.

There were some facilities of FCM-based scenario planning highlighted:

- FCMs capture expert knowledge in the networks of simple rules of causality, using comprehensive language. FCMs are easily extendable and thus accumulate a sequential modeling approach where different experts attach their knowledge to an existing model (Jetter 2006);
- Cognitive maps rely on intuitive graphical approach, which fosters system thinking among the experts, when symbolic representing gives a rapid access and

observations without required software tools. The visualization is easy to modify, change weight priority or include more concepts;

- Since the experts formulate their own explicit worldviews, it enables to refine it and validate by other experts communication in order to obtain common problem understanding and dorm decision-making teams;
- FCMs manage qualitative concepts and thus it’s ideal for early project planning, when the lack of quantitative data is dominant framework;
- FCM technique can improve scenarios quality, by calculating plausible alternative models using the predefined ones as inputs for integrated map.

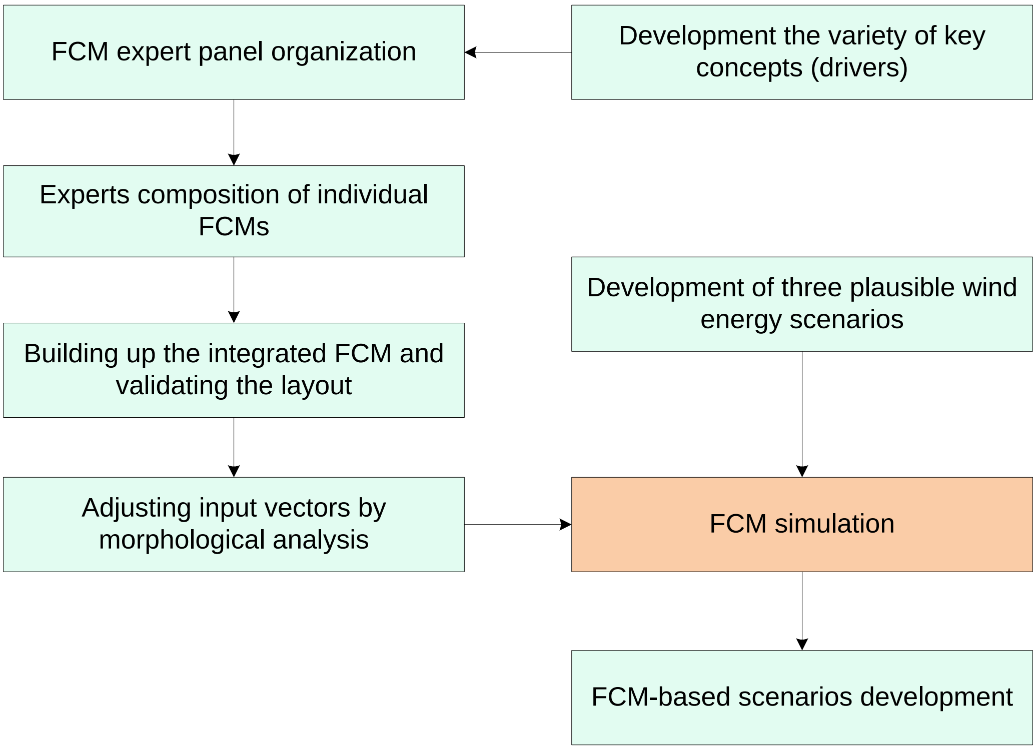


Figure 11: The overview of research framework

To get robust scenario as ultimate, plausible scenarios are developed in order to compute FCM modelling in few steps. The process takes time and can be divided into six milestones (Jetter and Schweinfort 2011).

Step 1: Scenario preparation and concepts formulation

Project starts with developing the framework of researching objective, timeline and important project boundaries took a place in this step. Based on contemporary literature analysis and foresights, the raw cumulative scenarios are developed and proposed. The number of scenarios should be appropriate and manageable, in order to assess dynamic situation and define plausible core futures.

Then, the versatile literature review regarding renewables and national energy sector should be carried out to identify wind energy concepts (drivers), which may reflect a state, variable, event, action, goal, objective, value, or other system component. The amount of concepts is recommended to be reasonable to avoid ambiguity and replication, and their meaning should be clear and easy to get. It is considered to cover the social, technological, economic, environmental, and political aspects in the concepts identifying. It is sensible to cluster concepts to the fields they are devoted to better understanding by experts and to avoid overlapping the similar implications. These drivers will be given to experts as fragments of future map and transformed into manageable FCM. Moreover, experts are asked to provide any possible additions to drivers mentioned, by virtue of their insight, it can be valuable for further data gathering.

Step 2: Knowledge capture

The expert panel is called and founded from the potential insight holders, who have relevant experience or required knowledge. They must be aware of the overall factors affecting the deployment of wind energy on a national level and preferably in Nordic countries. The experts should be taken carefully from the public or commercial organizations, to choose scenario drivers (concepts) that will have influence on wind energy deployment and identify weights (strengths) and causal links diversity. The given figure reflects integrated FCM from experts, aggregating knowledge concerning attractiveness of photovoltaic systems.

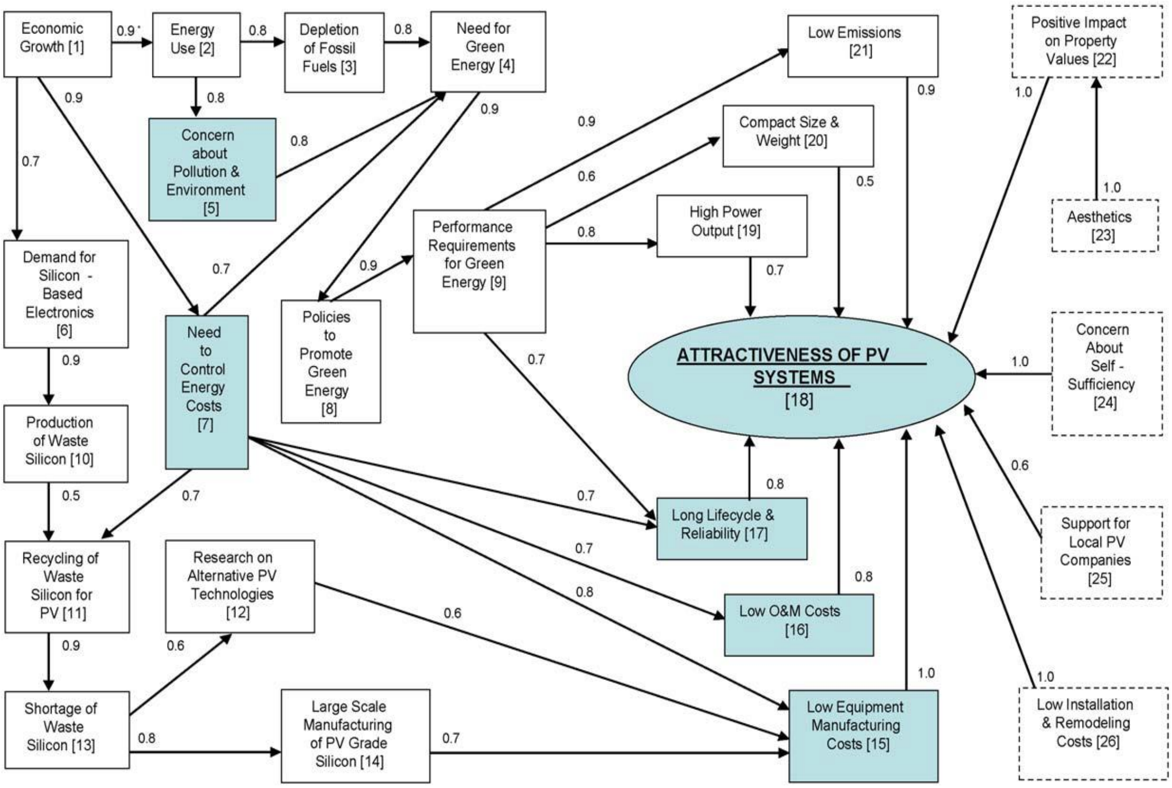


Figure 12: Integrated causal map (Jetter and Schweinfort 2011)

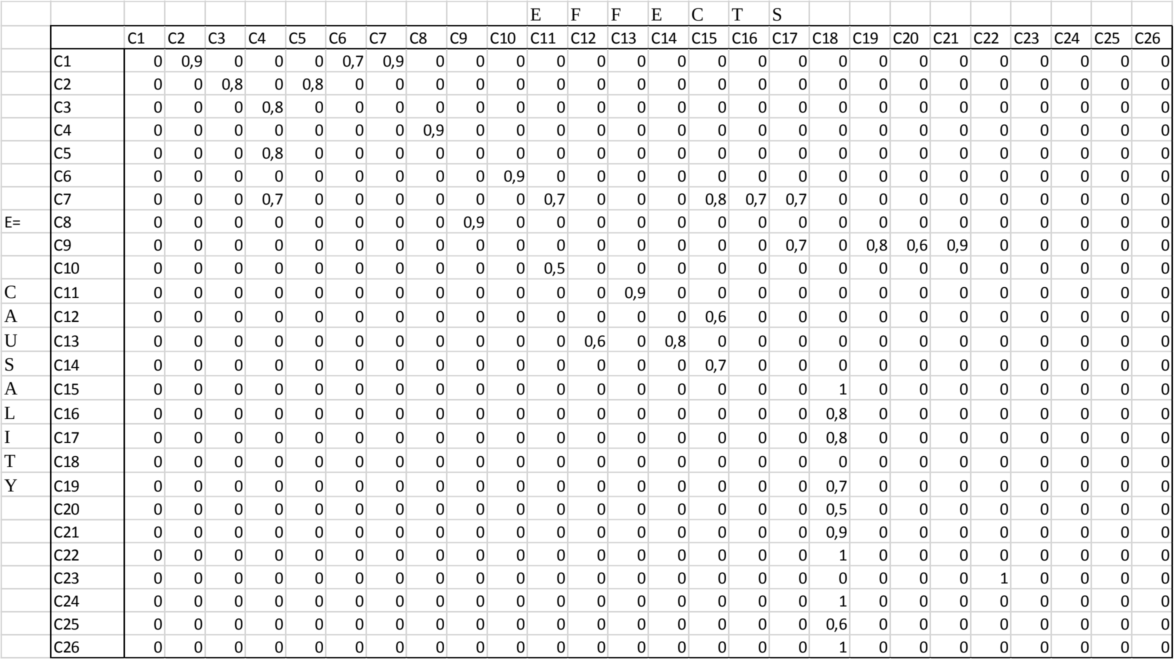
The causality weights are measured with the range of [0; 1.0] numbers, but for a certain studies it is recommended using 5-point Likert-type scale ranging from 1, reflecting a very weak causality, to 5, representing the strongest causal link. Favorably, those FCMs can overcome the indeterminacy problems of the causal cognitive maps which occurs when one concept is influenced by an equal number of negative and positive ingoing arrows (Schroder and Jetter 2003).

The few sets of drivers will be given to the experts, to draw a cognitive map, expressing their mental models and imagination. The map predominantly consists of drivers (nodes), arrows and strength indicators, while the example of required FCM (Technical note) will be given to get apparency of composition logic (Appendix 1).

Afterwards, individual causal maps are refined and collected from each expert with the possible remarks. There is some theoretical background can be given to expert in order to grab better instructions and the list of drivers description.

Subsequently, the integrated FCM is developed. The integrated FCM is supposed to be more useful and conceptual than an individual one because the data is collected from a multiplicity of sources is worth more credibility.

This integrated FCM is created by taking the average of the proposed causal weights from the number of experts relatively and compose to FCM matrices, showing causality of concepts as columns and effects as rows.



												E	F	F	E	C	T	S									
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26
	C1	0	0,9	0	0	0	0,7	0,9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C2	0	0	0,8	0	0,8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C3	0	0	0	0,8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C4	0	0	0	0	0	0	0	0,9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C5	0	0	0	0,8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C6	0	0	0	0	0	0	0	0	0	0,9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C7	0	0	0	0,7	0	0	0	0	0	0	0,7	0	0	0	0,8	0,7	0,7	0	0	0	0	0	0	0	0	0
E=	C8	0	0	0	0	0	0	0	0	0,9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,7	0	0,8	0,6	0,9	0	0	0	0	0
	C10	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C	C11	0	0	0	0	0	0	0	0	0	0	0	0	0,9	0	0	0	0	0	0	0	0	0	0	0	0	0
A	C12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,6	0	0	0	0	0	0	0	0	0	0	0
U	C13	0	0	0	0	0	0	0	0	0	0	0	0,6	0	0,8	0	0	0	0	0	0	0	0	0	0	0	0
S	C14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,7	0	0	0	0	0	0	0	0	0	0	0
A	C15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
L	C16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,8	0	0	0	0	0	0	0	0
I	C17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,8	0	0	0	0	0	0	0	0
T	C18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y	C19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,7	0	0	0	0	0	0	0	0
	C20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0
	C21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,9	0	0	0	0	0	0	0	0
	C22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	C23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	C24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	C25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,6	0	0	0	0	0	0	0	0
	C26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Figure 13: The integrated FCM matrix, transposed for photovoltaic systems attractiveness (Jetter and Schweinfort 2011)

These different FCM matrices are summed and divided by number of experts to obtain the average edge weight, using Microsoft Excel worksheet. The integrated FCM is a union set of nodes and average of the causal weights is taken. If one map is not showing a specific concept or edge weight, then in the FCM matrix “0” effect is considered as the edge weight.

Step 3: Scenario Modelling

The integrated FCM is reviewed and moderated to gain credibility and desirable layout to work with. Since all of the concepts are assigned to their weights and given the causal position with respect to the rest of drivers, there is a need to define and prioritize the most interesting, important and uncertain concepts raised. In pursuit of visibility, it is more comfortable to capture them with the aid of graphic technique.

The Wilson matrix is used to evaluate and classify concepts with the uncertainty/impact scale approach. It ranges drivers against the proposed dimensions: impact potential and uncertainty to turn into proposed trend, followed by causal network. This simulation leads to identifying the most extraordinary concepts in spite of overall causality, by experts’ own vision.

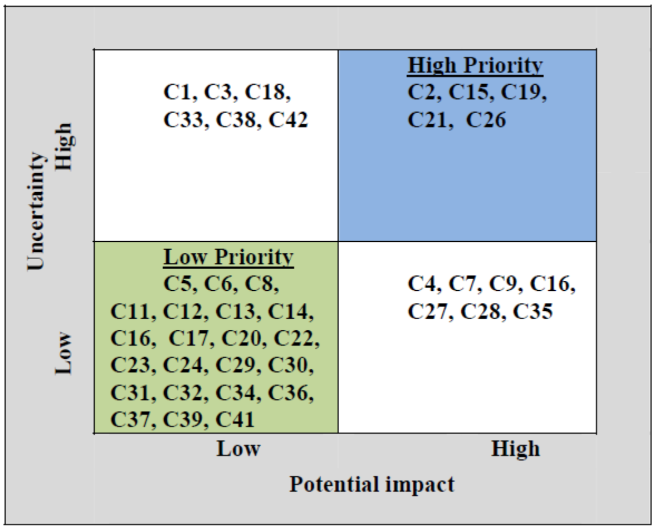


Figure 14: The Wilson matrix (Amer et al. 2013)[1]

Regarding to experts developed individual maps, the Wilson matrix is given to them, in order to highlight concepts for the further input vectors development. The experts are asked to point out five the most extraordinary concepts regarding to the research task. The most highlight concepts are gathered from the number of experts and taken some of them with the most frequent occurrence.

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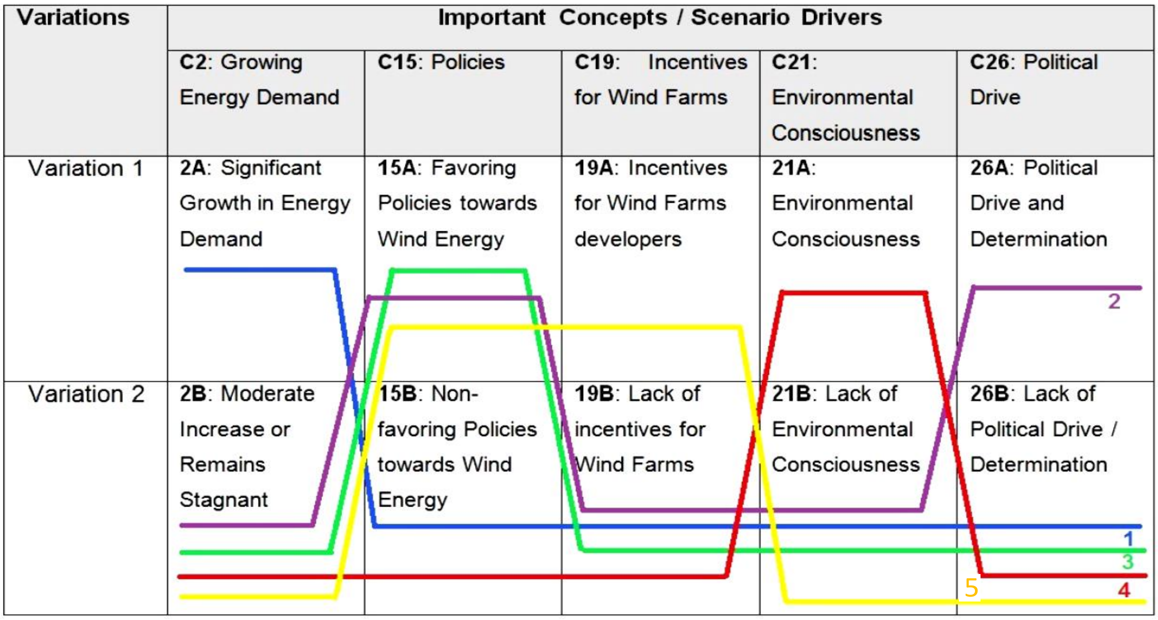
[1] The Wilson matrix was composed from the variety of concepts, developed for the wind energy sector in Pakistan (Amer et al. 2013)

Step 4: Inputs development

After the concepts ranking, the morphological analysis is conducted to develop inputs for a scenarios simulation as a core of scenarios testing procedure. This analysis is applied when the exploration requires different solutions with a multi-dimensional and non-quantifiable approach. This technique facilitates with scenarios refinement and to avoid incompatibility with the plausible combinations (Jenkins 1997).

For the inputs generating, there are important concepts for the certain study taken from the Wilson matrix and at least two numbers of development variation identified. The inputs development goes when experts combine scenarios variations as plausible strands.



Variations	**Important Concepts / Scenario Drivers**				
	C2: Growing Energy Demand	**C15**: Policies	**C19**: Incentives for Wind Farms	**C21**: Environmental Consciousness	**C26**: Political Drive
Variation 1	**2A**: Significant Growth in Energy Demand	**15A**: Favoring Policies towards Wind Energy	**19A**: Incentives for Wind Farms developers	**21A**: Environmental Consciousness	**26A**: Political Drive and Determination
Variation 2	**2B**: Moderate Increase or Remains Stagnant	**15B**: Non-favoring Policies towards Wind Energy	**19B**: Lack of incentives for Wind Farms	**21B**: Lack of Environmental Consciousness	**26B**: Lack of Political Drive / Determination

Figure 15: Morphological analysis for wind energy in Pakistan (Amer et al. 2013)

As an outcome of morphological analysis for the mentioned study, there were five inputs identified and discussed among experts (Amer et al. 2013):

Input 1: 2A – 15B – 19B – 21B – 26B;

Input 2: 2B – 15A – 19B – 21B – 26A;

Input 3: 2B – 15A – 19B – 21B – 26B;

Input 4: 2B – 15B – 19B – 21A – 26B; and

Input 5: 2B – 15A – 19A – 21B – 26B.

Only a few important drivers form the inputs, but when the FCM simulation is implementing, the rest of the scenario drivers are participating to generate refined scenarios. For the FCM simulation, all experts' consideration collected to have different inputs, thus every expert generates his own input.

Step 5: FCM simulation

The integrated FCM is tested against the number of developed inputs. In this stage, the scenarios developed beforehand, are involved in simulation process as a squashing functions trend setters. Structurally, each scenario is decomposed as a related FCM concepts holder, therefore the FCM model is running with binary squashing functions. For this functions, input and output states of concepts are either 0 or 1, which reflects the concept turns into "on" and "off". The simulation is conducted for the all raw scenarios simultaneously, testing each scenario against the FCM matrix and the most compatible input, in terms of certain scenario.

In every scenario from developed, there are concepts from the integrated FCM, which have either 0 or 1 status. For instance, in the study concerning wind energy sector in Pakistan (Amer et al. 2013), one of proposed scenario reflected "Environmental Concerns", therefore few drivers as "Environmental consciousness (C21)" and "Health and safety consciousness (C27)" are clamped always to be "on" (1) and come back to initial state after each iteration, while, and the initial states of all other concepts will be "off" 0 (Jetter and Schweinfort 2011).

Depending on the causal linkage and assigned weights, changing the state of certain concept affects all the concepts involved in integrated FCM. To reach the stable state, activation goes in a non-linear manner, by sequent concept engagement, but it is also possible to meet different vectors in the same final state, due to meta rules. The simulation is conducted with a variety of inputs in order to assess the holistic outcome. It is performed till the inference vector becomes finally stable, by multiplying the input vector with the FCM and applying squashing binary function as a threshold function devoted to inference vector. The Adjacency Matrix (E) of the integrated FCM model is built up by composing a square matrix n by n, where n is a number of concepts developed to form a FCM by experts. Inside the Adjacency Matrix, there will be causal weights placed, ranking from 1 to 5 by Likert scale.

For n number of concepts, the input vector is 1 by n, the FCM adjacency matrix is n by n, and the inference vector is 1 by n. The new inference vector is multiplied with the FCM adjacency matrix and it is repeated till the multiplication results in equilibrium (Dator 1979). As a result, system is settled down and the FCM model is stabilized. Implications of the FCM model are analyzed by squashing different drivers and the vector, adjusting the matrix multiplication procedure, to assess the outcome of these conductions on the developed model. The inputs are transformed into matrix with the size 1 by n for further multiplying, whereas states in matrix is based on 0 or 1 status, clamping the scenarios assumptions given.

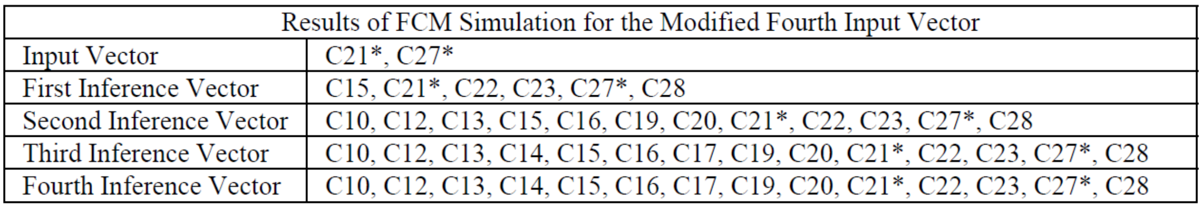
Simulation proceeds by multiplying Input vector (I) and FCM Matrix (E), then applying squashing binary function in Excel (=IF(value>0;1;0)) to get inference vector (S1) is computed using MS Excel worksheet:

$$S1=I\times E, (\mathrm{IF}(\mathrm{value}>0;1;0)$$

Second inference vector (S2) is resulted by multiplying the first inference vector (S1) and FCM Matrix (E), then applying squashing binary function:

$$S2=S1\times E, (\mathrm{IF}(\mathrm{value}>0;1;0)$$

The simulation goes until the inference vector get stable, then the concepts greater than zero, used for further scenario discussions.



Results of FCM Simulation for the Modified Fourth Input Vector	
Input Vector	C21*, C27*
First Inference Vector	C15, C21*, C22, C23, C27*, C28
Second Inference Vector	C10, C12, C13, C15, C16, C19, C20, C21*, C22, C23, C27*, C28
Third Inference Vector	C10, C12, C13, C14, C15, C16, C17, C19, C20, C21*, C22, C23, C27*, C28
Fourth Inference Vector	C10, C12, C13, C14, C15, C16, C17, C19, C20, C21*, C22, C23, C27*, C28

Table 4: Results of the simulation with fourth input vector and "Environmental Concerns" scenario (Amer et al. 2013)

The FCM simulations are used to practice with the discussed input vectors, but the model is still accessible to gather different vectors to test not regular scenarios and holistically evaluate the concepts. The assumptions made around the squashing functions for the developed scenarios, can be negotiated with the experts in order to raise validity.

Step 6: Scenarios analysis and strategic decisions

The FCM simulation should be done accurately, due to the insufficient change in input vector can lead to significant variation of the stable states. All numbers of forecasted futures in the wind energy sector are incurred the simulation and transformed into refined ones in order to make implications about the most plausible futures.

The scenarios obtain consistency and plausibility after the simulation, and go to overall analysis about aptitude and probability for the Finnish wind energy sector. These scenarios can be discussed as a feedback manner with the experts or modified from the stages, the possible fault can happen. The limitations also should be taken into account and correlate with the wind energy sector conjuncture.

4. EMPIRICAL STUDY

4.1. Key drivers for Wind energy development

The project starts with a composition actual concepts (drivers), which will have a potential impact on wind energy development in Finland. It is recommended to get into the nuts and bolts with the contemporary literature analysis regarding to wind energy in Finland solely and as a part of EU integration. The knowledge acquisition should cover social, technological, economic, environmental, and political aspects in process of concepts identification (Jetter and Schweinfort 2011). The driver’s investigation leads to proposing of potentially important factors which will have causal relation on development of wind power in Finland (concept C11). The concepts are composed from the highly discussed topics concerning to national energy sector and from developed drivers for the national wind energy sector in Pakistan, as some of them are referenced as common drivers for a single national wind energy case (Amer 2011). A description of concepts with the robust definitions consolidated and given in the table below:

Table 5: Description of concepts for FCM development

Concept number	Concept title	Concept definition
C1	Increasing cost of energy	Electricity’s cost continues increasing from 2007 year, for industries as well as for households. The prices in electricity production either increase, but with the less intensive (Statistics Finland 2014)
C2	Population growth	The population is increasing with the annual rate of over 0.06% (Index Mundi, Finland 2014)
C3	Energy self-sufficiency	Energy dependence plays quite crucial role, since the net import in power consumed, accounts 18.7 per cent in total volume (Finnish Energy Industries 2013).

C4	Growing in energy demand	Regarding to forecasted economic growth and products and services development, the energy demand is expected to be increased by 2020 and slightly decrease by 2030, due to the overall energy efficiency bounce. The highest increase is expected in demand within metal industry and the service sector (Finnish Energy Industries 2007).
C5	Economic growth	Despite on small drops in 2009, 2012 and 2013 years in the volume of gross domestic product, the overall economic growth is still anticipated next decade, as extension of robust trend from the past 15 years in Finland (Official Statistics of Finland 2013).
C6	Technology innovations	The wind sector is on the stable development path, the investments increasingly devoted to new technology exploration and commercialization in terms of renewable technologies (Renewables global status report 2014).
C7	Local assembling and manufacturing of wind turbine components	From the 2012 year, it is anticipated to face a sequential increase in the wind capacity installed, due to that fact, the growth of manufacturing facilities is expected (EWEA 2013).
C8	Cost reduction of turbines	Due to the all leverages applied, such as EU and national policies, local manufacturing, technology deployment an etc., the worldwide cost of wind turbines will be reduced significantly in the next decade (Chandler et al. 2009).
C9	Favoring government policies	The government supports wind energy deployment by feed-in tariff introduction, as a part of target for 38% consumption from renewables by 2020 year (Government of Finland 2010).

C10	EU 2020 policy	The 20% target for renewable energy usage in final consumption is placed to strive for state members, 10% for use of renewable energy in transport, to deploy energy efficiency to 20% as well (Directive 2009/28/EC).
C11	Deployment of wind energy in Finland (Objective)	Deployment of wind energy on a mass generation in country is an objective for the FCM analysis.
C12	Nuclear energy deployment	There was announced about nuclear energy extension to to over 30% in 2020 and correspondingly up to 60% in 2025, and commission two more nuclear power plants, in addition to Olkiluoto 3 (IEA 2013).
C13	Reduce in O&M Cost	Reduction the costs in operating and maintenance (O&M) sector, caused by technological and economic development in wind energy sector (EWEA 2013).
C14	Wind energy sector incentives	The bunch of favorable tools on a national level, including all kinds of promotional incentives, such as tax reductions, subsidies, low interest loans and demonstration projects (Chandler et al. 2009).
C15	Offshore wind farms development	The strong interest is predicted to offshore plants, aiming to reach 3000 MW in the nearest future, as a basis to large scale development of wind generation (Government of Finland 2010).
C16	National grid modernization	Current electrical grids are lack of facilities to incorporate large-scale offshore capacities and increasing share of onshore turbines. There is a strong need to redesign infrastructure of the national grid, systems regulation and grid management to incorporate renewable energy technologies (Energy visions 2050).

C17	SME involvement in wind power sector	Involvement of small and medium enterprises in wind energy segment is a very important aspect of further development, since the SME have crucial commercial drivers, which require strong project implementing skills.
C18	Wind projects transparency	Transparency and clarity of wind related procedures of planning, permissions, connections works and etc. will be favorable to investments attraction (Schmalensee 2011).
C19	Environmental consciousness	Growing awareness of climate change and other environmental problems related to energy production and use had will have a significant impact on the whole energy sector (Finnish Energy Industries 2013).
C20	EU Emission trading scheme (ETS)	The extra costs are placed on a generator, which has a fossil fuel production processes lead to carbon emissions. Due to that, there is an obligation to cover required emissions with allowances, spending extra funds to maintain operation processes (Sijm et al. 2005).
C21	Regional awareness to accept wind energy	The awareness of green energy technologies foster the local incentives to adapt wind energy as a source of job creation, clean climate and CO_2 avoidance.
C22	Increasing electricity import	There was a slight leap reproved in the electricity import trend from the Nordic countries and Russia mostly since 2006 to present time (Finnish Energy Industries 2013).
C23	CHP plants deployment	There is uprising trend noted in CHP development in district electricity and heat consumption in country, since almost 70% of household heating energy is district heating systems in crowded cities (Finnish energy industries 2013).

C24	Road traffic emissions increase	There are approximately 40% not considered by the emissions trading system, which is based on road traffic emissions. Since the population growth and lack of considerable changes in public transportation systems, road traffic emissions can reduce renewable targets meeting (Ministry of Transport and Communications 2013).
C25	Nordic hydropower development	The hydro power is considered as lowest marginal cost energy, and in a case of its large deployment in Nordic countries, the price for common electricity market participants will be reduced (Partanen et al. 2010).
C26	Availability of Wind Resource	Technically, total potential capacity both of onshore and offshore is much greater than energy consumption in Finland (Renewables global status report 2014).
C27	Oil price increasing	Currently, the market situation around gas supplying remains partly constrained, due to the sole source of import, which based only on a pipeline entry point from Russian part and insufficient infrastructure to supply arrangements.
C28	International collaboration	The capabilities to collaborate with lead countries in terms of wind power development, in order to share and incorporate successful drivers and attract foreign investments.
C29	Bottlenecks in the transmission networks	The establishing of a common transmission network’s operator for European countries is considered as reasonable for electricity markets deployment, but probability of its development remains low (Vision for European Electricity Markets in 2030).

C30	European power exchange establishment	The establishment of common power exchange for European countries, such as Nordic power exchange but with the more consolidated market structure (Vision for European Electricity Markets in 2030).

4.2. Raw scenarios development

For this part of paper, there is a necessity of developing raw scenarios for wind energy development, which will be tested by FCM technique and refined into manageable and credible scenarios afterwards. The time horizon of the scenarios is set at the year of 2030, while the reference year is 2014, as current.

There was decided to develop five plausible scenarios based on assumption of inevitable wind energy development, according to current research experience and methodology available (Amer 2013). All of five scenarios are considered broadly positive, having different drivers to facilitate national wind energy sector. It is considered to compose five scenarios, in order to have opportunity for choosing the most appropriate three scenarios for simulation, due to the probable contradiction among the experts. For the scenarios extraction, there was a bulk of academic papers and industries' researches observed, while major studies which have given robust insights are follows:

- Energy Visions 2050 (VTT 2009);
- Renewable electricity in Europe (Ruska and Kiviluoma, 2011)
- Finnish energy industries – energy scenarios and visions for the future (Värttö and Ahoniemi 2009);
- Extending Technology Roadmap through Fuzzy Cognitive Map-based Scenarios: The Case of the Wind Energy Sector of Pakistan (Amer 2013)
- Challenges for Nordic power (Pöyry 2010);
- Wind power in Finland up to the year 2025 (Varho and Tapio, 2005).

Presently, there are five raw scenarios, which are formulated and filled in obedience to listed bank of sources.

Scenario 1(SME)

The first scenario places involvement of small and medium enterprises in wind energy generation and related niches as a key factor influencing on development of wind energy and accompanied renewables. In this case, supporting from the business has grounds in long-term projects profitability, which attracts foreign direct investments and local based funds. The market structure will be under the modern transformation in this scenario, which leads to clear market-based approaches emergence, and competitive conditions formation in the field of wind energy. This scenario drives the incentives toward deployment all available renewable sources of energy, increasing efficiency of existing industrial appliances and promoting biofuel as alternative to petroleum based fuel in transport sector with the aid of SME involvement.

The economic situation in this scenario is considered to follow the current slight increase and doesn't impact much on energy trends. The scenario relies on a market based instruments in promotion renewable energy, demanding high industry party involvement and social consciousness about global resource limitation and harmful effect of conventional generation technology. Finns are expected to buy wind electricity voluntarily on a large scale, as a part of public support.

The suggested roadmap for this scenario, is based on assumption of eternal wind resource availability, which is a core prerequisite for the stable and long-term investors' interest toward the sector. The governmental incentives should be consolidated into set of comprehensive and efficient mechanisms to facilitate a rapid wind projects estimations and launching. The prices for emission allowances are anticipated to increase and the European level support in terms of green technologies will play important role.

Scenario 2 (Offshore)

The second plausible scenario determine pivotal roles for the wind energy incentives and other favorable factors which will largely steered to force national wind energy development until it becomes gradually competitive. This scenario remains fossil fuel generation as negligible in the country, promoting the locally generated energy, with the aid of available instruments: tax reductions, subsidies, low interest loans and demonstration projects. The favoring policies will be basis for the wind industry thorough development, including the feed-in tariffs and direct investments in large offshore projects, as well as conducive basis for technologies adaption support. It is implied that those governmental leverages will lead to wind energy's costs decreasing and high interests from private sector involvement. Finding more suitable wind sites will be expectably less difficult, while bureaucratic constraints will be abolished and lead to attractive atmosphere among the offshore projects investments. The nuclear power energy will continue to follow predefined trends. The availability of bioenergy resources will be dependent on the future production of the forest industry, which generates side products suitable for energy production, and this will have a stable growth.

It is assumed that offshore demonstration project from Finnish Ministry will have positive response in regard of new findings allocation to Energy and climate strategy. The international cooperation is planned to be deployed and emphasized, in pursuit to reach 3000 MW in the nearest future, as a basis to large scale development of wind generation. The financial support for these arrangements is required different sides incentives and national capability to promote wind energy intensively.

Scenario 3 (Economic growth)

For the third proposed scenario, it was considered that country's economic breakthrough factors will lead to the strong need of cheap energy produced in large volume to cover consumer's needs. It is expected expect wind power to be competitive without subsidies. Striving for the diversity in energy consumption mix, the situation around gas supplying will be considered as minor, since the national industries development and urgent need of energy security, while the nuclear power plants will have increasing impact on national energy's mix development. The increasing demand will increase average costs of electricity which will enable to develop large scale offshore wind farms, even assuming the lack of additional favorable support toward. The technological concerns will play a crucial role in development of innovative and smart solutions in-house or from the global. The GHG emissions will have a slight increase due to industry development mostly.

This scenario describes the intensive development of wind energy despite on lack of favoring policies and supporting investments. In this case, the national grid should be capable to incorporate additional capacities and be able to get modified easily with required scalability. The level of support is considered to stay static, as a current level or decrease sequentially, but there will be regulations toward the fair market competition carried out, such as competitive bidding and transparent procurement. The Finnish energy and climate policies remains unchanged, but climate change policies like emissions trading will be possibly changed.

Scenario 4 (Favoring policies)

The fourth plausible scenario determine pivotal roles for the policy driven factors which will largely steered to force national wind energy development until it becomes gradually competitive. This scenario remains fossil fuel generation as negligible in the country, promoting the locally generated energy. The national action plan concerning EU 2020 strategy and EU Emissions Trading System will be determinant in further European trend establishment. The favoring policies will be basis for the wind industry thorough development, including the feed-in tariffs and direct investments in large offshore projects, as well as conducive for technologies adaption support. It is implied that those governmental leverages will lead to wind energy's costs decreasing and high interests from private sector involvement. Finding more suitable sites will be expectably less difficult, while bureaucratic constraints will be abolished. The nuclear power energy will continue to follow predefined trends. The availability of bioenergy resources will be dependent on the future production of the forest industry, which generates side products suitable for energy production, and this will have a stable growth.

It is assumed that offshore demonstration project from Finnish Ministry will have positive response in regard of new findings allocation to Energy and climate strategy. The international cooperation is planned to be deployed and emphasized. The financial support for these arrangements is required different sides incentives and national capacity to promote wind energy intensively.

Scenario 5 (Environmental consciousness)

The fifth scenario places climate changing concernment as a key factor influencing on development of wind energy and accompanied renewable. In this case, environmental consciousness drives the incentives toward deployment all available renewable sources of energy, increasing efficiency of existing industrial appliances and promoting biofuel as alternative to petroleum based fuel in transport sector. The economical situation in this scenario is considered to follow the current slight increase and doesn’t impact much on energy trends. The scenario relies on a market based instruments in promotion renewable energy, demanding high industry party involvement and social consciousness about global resource limitation and harmful effect of conventional generation technology. Finns are expected to buy wind electricity voluntarily on a large scale, as a part of public support.

The persistent ecological problems should consolidate governmental incentives into set of comprehensive and efficient mechanisms to action. The prices for emission allowances are anticipated to increase and the European level support in terms of green technologies will play important role. The wind farms development, alongside with CHP plants will provide a possible solution to atmospheric air pollution and global temperature increase hazards.

4.3. Expert panel formation

For the FCM workshop carrying out, there were experts convoked to take a part on a voluntary basis. The experts were selected from the academic staff of Lappeenranta University of Technology, assuming their awareness regarding to prospects of Finnish wind energy development for the year of 2030. Subsequently, there were several professors and doctoral students invited from the following LUT units:

- Faculty of Technology Management;
- Laboratory of Machine Design;
- Laboratory of Electricity Markets and Power Systems;
- Laboratory of Control Engineering and Digital Systems.

The experts were met in a form of personal workshop for giving presentation and useful instructions concerning maps development and technique description. During the workshop, experts got familiarity with the raw scenarios and concepts descriptions, and then they were given blank maps with the concepts, as fragments of future map, and asked to choose scenario drivers (concepts) that will have influence on wind energy deployment and identify weights (strengths) and causal links diversity, using 5-point Likert-type scale. The Wilson matrix concept prioritizing was also conducted in the workshop meeting. Inputs proposing and deploying were conducted afterwards by email, due to the shortage of academic hours available from the experts. To enhance the credibility of the cognitive maps, separated files were sent beforehand to each expert participated:

- FCM presentation
- Raw scenarios description
- Concepts description
- Blank map
- Demo case map

The workshop approximately took 1-2 hours, depending on expert’s preparation and presentation comprehensibility.

4.4. Composing integrated FCM

Since the all five experts have a different mindsets and preferences concerning wind energy development in Finland, there was recommended to construct integrated FCM, capturing all related knowledge jointly. It increases data credibility and enables considering variety of suggestions. These five individual maps are attached as Appendix 1 to the master thesis.

All the five maps are transferred into individual matrices, then summed and divided to five, in order to get FCM adjacency matrix, using Microsoft Excel worksheet, which will be used in further simulation. If the map is not showing a specific concept or edge weight, then in the FCM matrix “0” effect is considered as the edge weight. From some connections with numbers less than “1”, weights were adjusted to the “0”, due to the very weak signals detected in total sum.

												E	F	F	E	C	T	S													
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
	C1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C2	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
	C3	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C4	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C5	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C6	0	0	0	0	0	0	0	4	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
E=	C8	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C9	0	0	0	0	0	0	0	0	0	0	4	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C10	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C	C11	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A	C12	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
U	C13	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S	C14	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
A	C15	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L	C16	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I	C17	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T	C18	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y	C19	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	4	0	0	0	0	0	0	0	0	0
	C20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
	C21	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	C22	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C23	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	C26	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	C30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0

Figure 16: The FCM adjacency matrix

Striving for the demonstrativeness and visibility, the FCM adjacency matrix was depicted as integrated FCM map, taking average weights and arrow directions from the FCM adjacency matrix, as it was described in chapter 2.4.

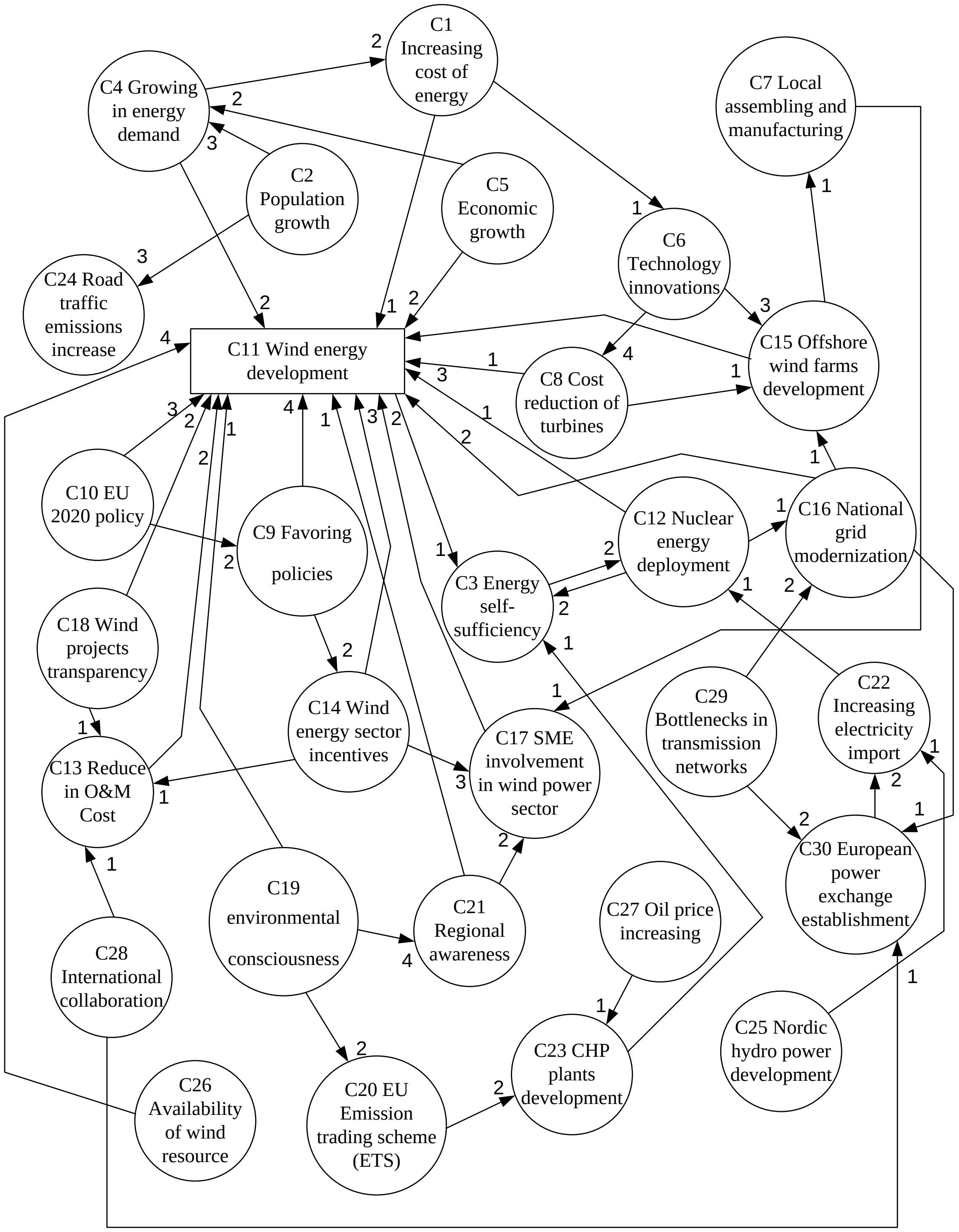


Figure 17: The integrated FCM

4.5. Inputs development

The second stage of workshop meetings required prioritizing the most interesting concepts for the research. Since the "wild cards" were chosen as the most interesting concepts, the experts defined five concepts for each, marking them in yellow on the individual maps (Appendix 1). From the all twenty five concepts collected, there were detected 8 concepts, which occurred twice: C4, C6, C15, C16, C17, C19, C21, and C26. From all of them that were decided to take C4, C16, C17, and C26 because these concepts have more strong connection weight to wind energy development in Integrated FCM, comparing to others. Additionally, the concept C15 (Offshore wind farms development) was also chosen for further consideration, due to its potential interest toward wind energy development in Finland. The priority was given to the "wild cards", while "mainstream" concepts are too obvious in established framework. Summarily, those five concepts were put in Wilson matrix.

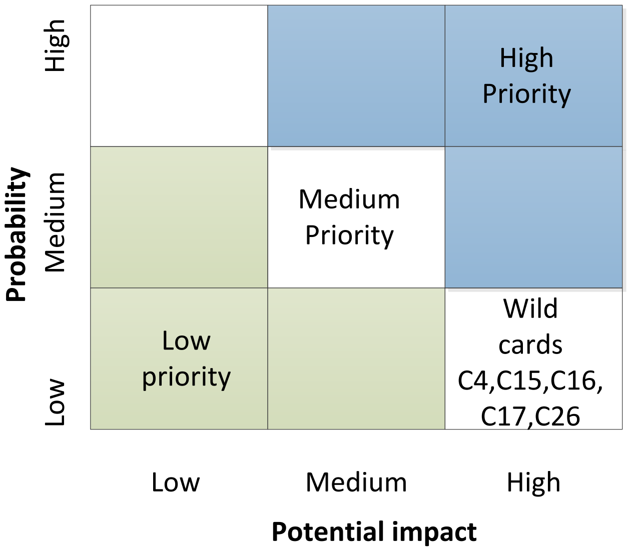


Figure 18: The Wilson matrix

After Wilson matrix composing, the morphological analysis was used to develop the input vectors. In that case, there were two numbers of development variation identified (Variations A and B). Variation A refers to positive concept's realization, while Variation B refers to negative one. This step eliminates incompatible combinations of concepts. Then, the experts were given concepts from the Wilson matrix and five inputs, consisting of plausible concepts variations were developed:

Input 1: 4B – 15B – 16B – 17A – 26A;

Input 2: 4A – 15A – 16B – 17B – 26A;

Input 3: 4A – 15B – 16A – 17B – 26A;

Input 4: 4A – 15B – 16B – 17A – 26B;

Input 5: 4A – 15B – 16B – 17A – 26B.

In pursuit of visibility, it is more comfortable to capture them in graphical scheme, using colored lines to perform the diversity of plausible strands.

Variations	Energy demand growing C4	Offshore development C15	National grid modernization C16	SME involvement C17	Wind resource availibility C26

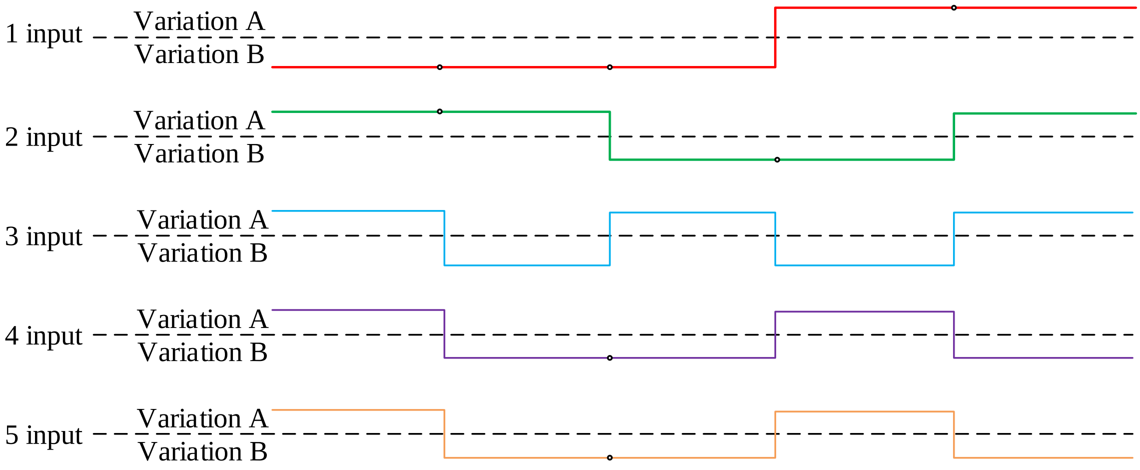


Figure 19: Morphological analysis and inputs developed

4.6. FCM simulation

The integrated FCM is tested against the five developed inputs. The raw scenarios developed beforehand, are involved in simulation process as a squashing functions trend setters. It is performed till the output vector becomes finally stable, by multiplying the input vector with the FCM and applying squashing binary function as a threshold function devoted to output vector. Values of concepts can be either “0” or “1”, which signals that a concept is turned “on” and “off”.

From the five raw scenarios, there were decided to keep only three scenarios, whose component drivers are highlighted in Wilson matrix and mostly response to experts' visions for wind energy development in Finland: *Scenario 1(SME), Scenario 2 (Offshore) and Scenario 3 (Economic growth).* These scenarios are taken for the FCM simulation, while the rest *Scenario 4 (Favoring policies)* and *Scenario 5 (Environmental consciousness)* are not considered as suitable for the actual study.

For the first scenario, FCM model is tested against the two concepts: SME involvement (C 17) and Wind resource availability (C26). These two concepts are most likely to coexist with the Input 1. For the first input vector, the initial states of C17 and C26 are set as turned "1" and always set back to its initial activation level (clamped). The rest of concepts are turned "0" for the first input vector.

		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	**C17***	C18	C19	C20	C21	C22	C23	C24	C25	**C26***	C27	C28	C29	C30
I=		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0

Figure 20: First Input Vector

Simulation proceeds by multiplying Input vector (I) and FCM adjacency Matrix (E), then applying squashing binary function in Microsoft Excel (=IF(value>0;1;0)) to get output vector (S1), which is multiplied again with the FCM Matrix (E) and binary function is applied. Simulation is computed till the output vector get stable.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	**C17***	C18	C19	C20	C21	C22	C23	C24	C25	**C26***	C27	C28	C29	C30
I'=	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1 binary=	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	**C17***	C18	C19	C20	C21	C22	C23	C24	C25	**C26***	C27	C28	C29	C30
I''=	0	0	1	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S2 binary=	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	**C17***	C18	C19	C20	C21	C22	C23	C24	C25	**C26***	C27	C28	C29	C30
I'''	0	0	1	0	0	0	0	0	0	0	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S3 binary=	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	**C17***	C18	C19	C20	C21	C22	C23	C24	C25	**C26***	C27	C28	C29	C30
I''''	0	0	3	0	0	0	0	0	0	0	7	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S4 binary=	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	**C17***	C18	C19	C20	C21	C22	C23	C24	C25	**C26***	C27	C28	C29	C30
I'''''	0	0	3	0	0	0	0	0	0	0	8	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S5 binary=	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	**C17***	C18	C19	C20	C21	C22	C23	C24	C25	**C26***	C27	C28	C29	C30
I''''''	0	0	3	0	0	0	1	0	0	0	9	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S6 binary=	0	0	1	0	0	0	1	0	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	**C17***	C18	C19	C20	C21	C22	C23	C24	C25	**C26***	C27	C28	C29	C30
I'''''''	0	0	3	0	0	0	1	0	0	0	9	2	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
S7 binary=	0	0	1	0	0	0	1	0	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0

Figure 21: Results of simulation for the first input vector

For the first scenario, the output vector got stable after the seventh iteration, resulting into few concepts activated: C3, C7, C11, C12, C15, C16, C17, and C26.

For the second scenario, FCM model is tested against the two concepts: Wind energy sector incentives (C14) and Offshore wind farms development (C15). These two concepts are most likely to coexist with the Input 2. For the second input vector, the initial states of C14 and C15 are set as turned “1” and always set back to its initial activation level (clamped), while the initial states of C4, and C26 are basically turned “1”. The rest of concepts are turned “0” for the second input vector.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	**C14***	**C15***	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
I=	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Figure 22: Second Input Vector

Simulation is presented on Figure 23, and the output vector got stable after the fifth iteration, resulting into few concepts activated: C3, C7, C11, C12, C13, C14, C15, C16 and C17.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	**C14***	**C15***	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
I'=	2	0	0	0	0	0	1	0	0	0	9	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
S1 binary=	1	0	0	0	0	0	1	0	0	0	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	**C14***	**C15***	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
I''=	0	0	1	0	0	1	1	0	0	0	8	0	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
S2 binary=	0	0	1	0	0	1	1	0	0	0	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	**C14***	**C15***	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
I'''	0	0	1	0	0	0	1	4	0	0	7	2	1	0	3	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
S3 binary=	0	0	1	0	0	0	1	1	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	**C14***	**C15***	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
I''''	0	0	3	0	0	0	1	0	0	0	11	2	1	0	1	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0
S4 binary=	0	0	1	0	0	0	1	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	**C14***	**C15***	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
I'''''	0	0	3	0	0	0	1	0	0	0	10	2	1	0	1	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0
S5 binary=	0	0	1	0	0	0	1	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

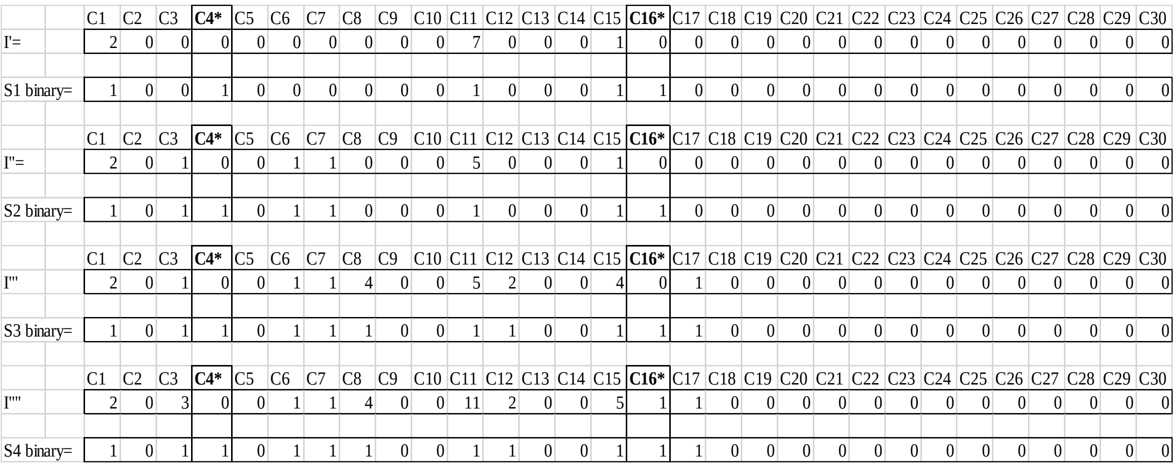
Figure 23: Results of simulation for the second input vector

For the third scenario, FCM model is tested against the two concepts: Growing in energy demand (C4) and National grid modernization (C16). These two concepts are most likely to coexist with the Input 3. For the third input vector, the initial states of C4 and C16 are set as turned "1" and always set back to its initial activation level (clamped), while the initial state of C26 is basically turned "1". The rest of concepts are turned "0" for the third input vector.

	C1	C2	C3	**C4***	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	**C16***	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
I=	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Figure 24: Third Input Vector

Simulation is presented on Figure 25, and the output vector got stable after the fourth iteration, resulting into few concepts activated: C1, C3, C4, C6, C7, C8, C11, C12, C15, C16 and C17.



	C1	C2	C3	**C4***	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	**C16***	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
I'=	2	0	0	0	0	0	0	0	0	0	7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1 binary=	1	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	C1	C2	C3	**C4***	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	**C16***	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
I''=	2	0	1	0	0	1	1	0	0	0	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S2 binary=	1	0	1	1	0	1	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	C1	C2	C3	**C4***	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	**C16***	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
I'''	2	0	1	0	0	1	1	4	0	0	5	2	0	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
S3 binary=	1	0	1	1	0	1	1	1	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

	C1	C2	C3	**C4***	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	**C16***	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30
I''''	2	0	3	0	0	1	1	4	0	0	11	2	0	0	5	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
S4 binary=	1	0	1	1	0	1	1	1	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 25: Results of simulation for the third input vector

The simulation process went well, no faults or mutual exclusion were detected. All computations led to activation different sets of concepts, which will have impact on a scenarios deployment.

4.7 Scenarios deployment

The robust scenarios were developed with the aid of simulation's results. The idea behind the simulation was in the testing experts' knowledge asset against predefined scenarios formulations. It was assumed, that applied technique increased scenarios quality and credibility, that's why all iterations were made carefully, based on idea, that every small change in the computing process may cause the logical discrepancy. The robust scenarios were originated from the raw ones, which mean that it keeps on positive trend, considered for wind energy development in Finland. The robust scenarios have no new indications of negative suggestions towards wind energy development, since the integrated FCM captured positive causality generally.

Scenario 1(SME): C3, C7, C11, C12, C15, C16, C17, and C26* activated*

For the first scenario, there were seven iterations needed to make the output vector stable and found out which concepts are shown as experts knowledge response to chosen input. The resulted concept's range was considered as coexistence grounds for turning scenario into action, assuming that involvement of small and medium enterprises in wind energy segment will be important aspect of wind power development. Likewise, availability of wind resource was brought to the forefront, in terms of facilitation and information disclosure about the most potentially successful onshore and offshore sites location within the country.

From the testing computation, that was turned out involvement of small and medium enterprises in local assembling and manufacturing of wind turbine components is highly emphasized, alongside with offshore wind power farms development. These incentives will be highly depended on additional governmental support, which leverages the balance between onshore and offshore farms promotion, since there is no first-hand experience of real offshore wind parks in Finland, and investor's risks are quite significant relating to this factor. The step-wise approach from the public support would be quite appropriate, with a guaranteed feed-in-tariffs. The manufacturing activities would be reasonable to organize with a bias for cold conditions, basing on reinforced towel foundations, blade icing protection and other Nordic conditions. Apparently, the potential market could be wider, since the all Nordic countries are challenging with the implementing Directive 2009/28/EC regulations.

The Finnish national aspirations for developing diversified electricity production mix, in this scenario would be supported by adaptation of relevant nuclear programme extension. It might be the irreplaceable tool to cover the base electricity load, due to the country's top-of-the-league ranking in terms of transparency and low corruption level to contribute in national economy and energy security. The planning enhancement of nuclear energy share in total production from 28% in 2010 to over 30% in 2020 and correspondingly up to 60% in 2025, should be granted high national priority. For a successful implementation, the surplus of radioactive waste should be taken into account in terms of facilities available to bury the waste left.

For this scenario, there will be cross-border and national grid upgrades required, developing and gathering suitable infrastructure. Since the private companies are limited to have full access in national grid transformation, the government will be entirely in charge for grid infrastructure changes. The current grid is unable to succeed in absorption planned volumes, which future targets enable. That's why a concurrent infrastructure deployment is consistent path which provokes Nordic power system's modernization as well as national grid development.

Scenario 2 (Offshore): C3, C7, C11, C12, C13, C14, C15*, C16, and C17 activated*

For the second scenario, there were five iterations needed to make the output vector stable and found out which concepts are shown as experts knowledge response to chosen input. The resulted concept's range was considered as coexistence grounds for turning scenario into action, assuming that offshore wind parks development will play a crucial role in transforming national energy sector toward wind power dominance. Therefore, the key wind energy sector incentives are considered to have a powerful impact on further development and highlighted for this scenario.

It is worth noting that all range of favorable tools on a national level, including all kinds of promotional incentives, such as tax reductions, subsidies, low interest loans and demonstration projects, will be considered as inevitable, which ultimately places additional wind energy costs on a federal budget and relative governmental bodies. The predefined goal as 3000 MW in wind generation for the 2030 year, will be a basis for policies regulation, and to large scale development of wind generation. As it was mentioned earlier, the cost of offshore wind energy will be significantly higher than onshore, which resulted in separating regulations for onshore and offshore promotions and in calling for a new compensation's tools concerning offshore wind parks.

The significant factor for wind energy development in this scenario will be a technological capability to cut a general costs, such as investment's costs, operation and maintenance costs and network connection costs. This can be entailed by turbine's design evolving shifting toward multiple regime usage, as well as remote maintenance. In general, this technological breakthrough can be implemented with Finnish potential as innovations holder and active participant in international research activities regarding to wind turbines and components modernization. In this relatively new technology market, there are capabilities to obtain competitive advantage in order to run a local manufacturing of turbines and components, as well as provide consulting services for ongoing projects widely.

This scenario requires cross-border and national grid modernizations, developing and gathering suitable infrastructure with the emphasis on offshore wind parks connections, which are totally immature for large-scale penetration. The nuclear power extension must be considered as the irreplaceable tool to cover the base electricity load, due to the country's top-of-the-league ranking in terms of transparency and low corruption level to contribute in national economy and energy security. The planning enhancement of nuclear energy share in total production from 28% in 2010 to over 30% in 2020 and correspondingly up to 60% in 2025, should be granted high national priority, as well as gradual involvement of small and medium enterprises in wind energy segment.

*Scenario 3 (Economic growth): C1, C3, C4**, C6, C7, C8, C11, C12, C15, C16* and C17*

For the third scenario, there were four iterations needed to make the output vector stable and found out which concepts are shown as experts knowledge response to chosen input. The resulted concept's range was considered as coexistence grounds for turning scenario into action, assuming that growth in energy demand will play a crucial role in transforming national energy sector toward the wind power dominance. Thus, the transformation of national grid for incorporating larger capacities is also considered to have a powerful impact on further development and highlighted for this scenario.

For the third scenario, it was considered that country's economic breakthrough factors will lead to the increasing cost of energy, responding to the emergence a variety of large and small-scale consumers. In order to handle these kinds of economic trends, there is a strong need to leverage exterior energy dependence. It can be thought as signal to extend decisively nuclear power within the country to cover the base electricity load of newly introduced industries. The offshore wind parks are also pretended to be dominant in marginal price formation for the all price areas within the country, which is able to exist with the advanced grid infrastructure. Favorably, the wind sector is on the stable development path, the investments increasingly devoted to new technology exploration and commercialization in terms of renewable technologies, which possible lead to costs reduction for wind turbines components.

This scenario is pretended to be turned into action, without special package of policies or regulation incentives, but most likely this statement should be neglected, due to economic growth applied, which inevitably enlarge tax liabilities, apparently creating more fruitful conditions for supporting offshore wind energy. Growing private market share within the industry could be a favorable for investments consolidation around the energy related projects, as well as renewable sources.

Another significant factor for wind energy development in this scenario will be a technological capability to cut a general costs, such as investment's costs, operation and maintenance costs and network connection costs. This scenario similarly assumes development innovation-based solutions toward wind energy, being a strong prerequisite for attracting foreign direct investments in local manufacturing and deploying wind project mileu in Finland. The fossil fuel generators could be limited in their activity for this scenario existence, by mediating costs of emission quotas, binding producers to spend extra costs and gradually tend to renewable energy operating.

5. DISCUSSION

5.1 Research outcome

The idea behind research conducted, was in significant academic interest to scenarios forecasting techniques. The majority of research papers, which provide mature roadmaps for action, more often, based on qualitative methods, lacked of historical data sets and causality to form expectable future trends. Therefore, FCM technique was considered as worth to be taken and analyzed thoroughly alongside the master thesis. Due to the fast growing and potential capacity importance, wind energy sector was chosen for further scrutiny. That enabled to concentrate on factors which have potential influence on onshore and offshore wind energy sources in terms of plausible future forecasting.

The research was taken for highly substantial part of Finnish energy sector, as it considered to investigate wind power prospects alongside with the other significant energy sources broadly. In spite of formulated questions, there were some potential insights for wind energy development in Finland for the year of 2030 revealed, which could be taken for scrupulous examination. Those insights were identified commonly for all scenarios tested and seemed to be quite relevant in terms of nowadays forecasts. For the successful development of national wind energy sector by 2030, the key driver is accounted for small and medium enterprises, which have commercial interests in Finnish energy self-sufficiency establishing. From the governmental part, major incentives should facilitate national grid modernization and local manufacturing promotion for the general wind turbines' components. In a prior elaboration is the offshore farms development for integrating in the modern grid, as well as nuclear power is in the crosshairs for base load covering in country.

The first research sub-question was addressed to the feasibility of FCM technique adaptation for plausible scenarios development in wind energy. The study resulted in three robust scenarios, which incorporated given experts knowledge in a way of fuzzy cognitive maps. The scenarios revealed consolidated visions toward development of wind energy in Finland for the year of 2030 as sufficient part of national energy system. The paper's results represented rationality of applying FCM approach for Finnish wind energy sector. It generated worthful content, proved that scenarios forecasting can be a forefront technique in exploring future energy trends.

The second sub-question included a process of developing rational drivers for Wind energy in Finland, which resulted in thirty versatile concepts descripted within the study. From the bulk of concepts, there were distinguished concepts with the low probability but very high impact on wind energy development, and applied in the simulation. It helped to define concepts which influenced raw scenarios ultimately. The concepts were given with the descriptions and referenced to the every research paper reviewed.

The third sub-question tested causality links developed by experts in raw scenarios refinement. This step can be marked as satisfied, since the simulation run well and resulted into few drivers' activation. It can be concluded that causality dependence has a linear effect on a concepts activation and further robust scenarios development, depending on the weight and direction of suggested links. Moreover, the expert's knowledge data set placed a crucial role in defining variables for scenarios refinement.

The main research question examined whether FCM-based approach on the qualitative scenarios in Wind energy sector in case of Finland, will have salutary effect on robust scenarios development or not. Since all of three sub-questions are converged in a positive result, the conclusion about salutary effect of FCM-based approach can be done. The outcome of the study was a desired multiple wind energy scenarios, which gives a required insight and demonstrates agility of approach chosen. It pretended to facilitate independent researchers and industry stakeholders, aiming to foresee wind energy prospects in Finland. The paper was sent to the expert panel participants in order to demonstrate collaborative result of the work and provide inspiration about the favorable effects of the FCM technique.

5.2 General discussion

The research process was carried out with no aid of special software or scripts developed for the research tasks. It makes exploratory iterations with afford to fail and testing experimental variables. The variables were developed independently, counting 30 drivers on board, but there is an adequate suggestion to develop variables collaboratively with the expert panel, relying on experts brainstorming. It increases selective environment for research excerpts. Furthermore, there were few interesting concepts noticed by expert panel participant during the workshop, but due to the scarcity of expert's involvement rounds, the concepts were not highlighted in the overall set.

Expert panel's choosing envisages a situation, when researcher is able to mediate representatives grouping, which can affect the primary data variations. In other words, if researcher is purposed to obtain exact results, there is a fruitful atmosphere to proceed with it. Therefore, the selections should be conducted in unbiased approach. In conducted study selection originated in pursuit of multiplicity.

The demo case map, which was introduced to experts, had more power when it was supposed, because for majority of experts, who were not familiar with the technique at all, it was some kind of call for action. In spite of recommendations to use creative thinking and don't follow absolutely similarly to example given, only one expert demonstrated real fuzziness in terms of map drawing. It entailed doubtful saturation of connections around the general concept C11. This confuse was managed in integrated FCM by conducting adjustments in Microsoft Excel worksheet, by adjusting values less than “1,0” to “0”, due to the very weak signals realizing. Otherwise, it would lead to visible shift in multiplying toward the concepts located on both sides from concept C11. It is artificially weakens the importance of clamped concepts from raw scenarios and entails almost all concepts activating.

The workshops generated diversity of meanings and presumptions concerning wind energy development in Finland but it did not cause negotiations among the experts, which might create collaborative results and validate necessity either include each concept or not. Similarly, collective workshop would facilitate with “wild cards” consolidation. Moreover, there are even capabilities to run online group working, to incorporate more experts from different units, but it takes common time, which was in scarcity from experts for this research implemented. Moreover, the concept's pool might be performed as vivid set of tangible fragments, which makes the work easy to moderate. In sober fact, the study can be viewed as sequence of iterative communications with the participants, thus discussions and feed-back validations might be run every step, it ultimately enhances sensibility of FCM design.

The amount of concepts, which were clamped to each scenario for the simulation, can be under negotiation, because the wider raw scenario, the more predefined drivers it requires. This amount can be escalated, basing on matrix size, which in its turn, based on total number of concepts. The actual concepts listed don't reflect the full-fledged environment for wind energy development in this research approach, due to lack of negative connections between drivers. But still, the paper demonstrates good results within the established boundaries. This concern is mostly addressed to further research grounds and new approaches within the technique testing.

When the Wilson matrix was composing, there was decided to take concept C15 (Offshore wind farms development) alongside with concepts C4, C16, C17 and C26, which had more impact in terms of connection weights. This step distinctly left an imprint on research results. It is arguable that a more holistic approach would require testing the rest of concepts, such as C6, C19 and C21 and comparing the simulation outcomes, but this incitement implies another project framework and timeline. Implicitly, the concept C19 (Environmental consciousness) could be prominent in the same logic as C15, because it supplements the range of concepts nature among social, technological, economic, environmental, and political aspects. The results for different concepts chosen are considerable anticipated to be diverse.

Initially, there were five raw scenarios developed to have a range of possible experts' decisions proposing. Due to that fact, there were decided to keep only three scenarios, whose component drivers are highlighted in Wilson matrix and mostly response to experts' visions for wind energy development in Finland: *Scenario 1(SME), Scenario 2 (Offshore) and Scenario 3 (Economic growth).* The rest *Scenario 4 (Favoring policies)* and *Scenario 5 (Environmental consciousness)* are not considered as suitable for the actual study. This maneuver is made due to the lack of experts' workshop concerning raw scenarios consideration, but ideally this should be done with their participation in order to enhance credibility of preparatory research steps.

From the input vectors development, there were some questionable points to be revealed. It turns out that two inputs collected from the fourth and fifth experts are entirely identical:

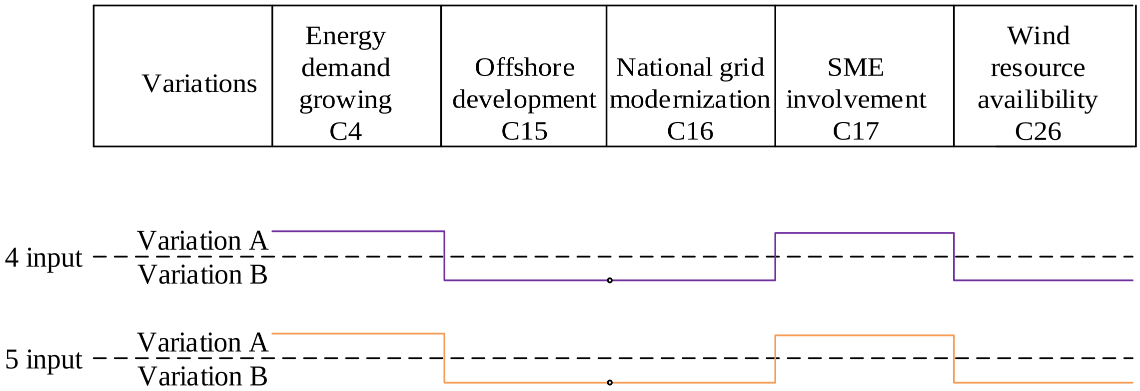


Figure 26: Identical inputs developed

This case has dichotomic impact on morphological analysis. On the one hand, there were developed more appropriate vectors to coexist with the scenarios assumptions (Input 1 and Input 3 wholly satisfied the “SME” and “Economic growth” prerequisites in the research), that’s why existence of two identic vectors was not given into account. But on the other hand, two similar vectors strengthen credibility of the observed scenario strand, since the two experts concurred in the given suggestions. Ultimately, Input 4 and Input 5 were not taken into further simulation. This concern reveals necessity to run additional expert’s validation of general presumptions.

The mathematical adjustment in matrix multiplying had a considerable nature within the taken research. As it was mentioned beforehand, the integrated FCM was deployed with adjustment values less than “1,0” to “0”, due to the very weak signals realizing. Another adjustment had a corrective nature, when the binary function was applied to output vectors. The values less than “0,5” were adjusted to “0”, while values greater than “0,5” to “1”. This presumption was based on basic adjustment rules and had not any another objectives, which did not affect the overall computation.

For the all three developed scenarios, there were commonly few concepts activated: C3, C7, C11, C12, C15, C16 and C17. That fact gave fruitful grounds to consider those concepts as a basis for further wind energy development. Since the research was not aimed to figure out probability of scenarios developed, it is arguable that listed concepts have a high priority for expert panel participants, to facilitate wind energy development in Finland. These drivers are not occurred in this exact combination in any researches carried out previously, that’s why the results can introduce new expert vision on a modern issues regarding to wind energy development in country.

As it was mentioned, there were few interesting concepts noticed by expert panel participant during the workshop, but due to the scarcity of expert’s involvement rounds, the concepts were not placed in the overall set. Among the concepts there were two solid factors revealed, which can affect much the wind energy development vision. The first concept is addressed to electricity storage prospects in Nordic electricity market, in terms of intermittent generation storing, which has a direct relation to renewable energy sources. This case relies on price formation instruments, which allows continuous electricity consumption in low peak night time. This might be competitive basis in general acceptance for renewables in Nordic power system. The second concept is relied on major energy industry stakeholders, which have hardened beliefs on energy sector development, and can force lobbying to leverage policies toward own interests, having conventional generation capacities as a fundamental.

5.3 Research contributions and suggestions for further research

It is to be noted that, in spite of mentioned limitations, FCM technique demonstrated forceful approach in scenarios forecasting. Since the majority of conservative approaches are also limited on all counts, the FCM approach has capability to encode dynamic behavior in graphical manner, as general benefit.

The research resulted in mature blank model for scenarios and concepts testing. The key feature of this model is ability to modify input scenarios and drivers in order to test against captured expert knowledge. In other words, the knowledge massive is extracted as independent module, which can be used in different research ways and applications. As well as expert module, the thirty of concepts identified during the study, can be used as single indicators in scenarios composing for wind energy in Finland or another Nordic country. The graphical model has good research contribution due to easiness of modifying and changing of weights and directions between concepts.

The study’s outcome can be used as a preliminary research attempt on the way toward full-fledged forecast and can be embedded in the structural approach, including diversity of forecasting methods embedded. Notably, it can be extended in further roadmap for Finnish vision regarding to national renewable policies and prospects, or performed for another local energy sources.

From a practical standpoint, the paper revealed a need to develop mass used software for collecting and computing data sets for Fuzzy cognitive maps scenarios. It enables fast and agile development of future scenarios, without matrix and tables construction by every single researcher. It can be performed in a way of advanced Microsoft Excel sheet, with a variety of facilities for specific purposes.

The approach taken, fostered creative thinking technique of expert's communication, it is one of approaches, which engrains close communication and outstanding suggestions revealing. Due to its novelty, the research technique was quite unexplored, but ultimately, it contributes as a joint part to overall FCM development and popularization, especially in energy sector such as wind. In academic terms, the paper made a small contribution to development of transitional techniques, between the qualitative and quantitative, which more sensitively responds to highly dynamic changes in industrial environment.

5.4 Research limitations

The research is based on FCM technique, which is not thoroughly studied and has different pros and cons, regarding to implementing. The more investigated technique in academic terms, the less chances existing to come up with a novelty, regarding to topic described. It entailed some risks in the beginning of the study, and figured out some limitations by upon completing.

The main limitation of the study is scenario one-sidedness regarding to energy sector studied. There is a bulk of negative scenarios anticipated, concerning to Finnish wind energy, as well as indifferent ones, as it was reviewed from the general forecasts. The existence of negative scenarios relies on existence of negative drivers discussed. In this way, there was no clear guidance in managing challenges and negative concepts for fuzzy cognitive maps, thus the study was limited by successful wind energy adaption in Finland. Therefore, there were no heterogeneous scenarios demonstrated.

From the integrated FCM map, one exception has done about negative connection existence, despite on major positive impacts predominance. Few experts strongly believed in this connection, and it was decided to compute simulation with a negative value embedded in adjacency matrix. This assumption did not emerge any controversion, since the simulation run in non-linear manner, but this step was rather experimental.

All mathematical calculations were conducted with the aid of Microsoft Excel software, therefore one limitation originated from the statistical assumptions. From some connections, which weights were adjusted to the nearest whole numbers, there were weak signals detected. After adjustment, some weak signals turned to zero, which did not mean their real elimination. The sensible assumption given, that weak signals have the same weak signals after vectors multiplying, but this fact worth to be mentioned, since there are different adjustment rules exist in Microsoft Excel.

Not all the inputs generated, were used in multiplying, since it was considered to use the most appropriate inputs for vector’s development, which were likely to coexist with the scenarios terms. The additional inputs testing might raise the interesting results for experts reviewing, even despite on primary discrepancy. This limitation is originated from the lack of workshops time and lack of additional reviewers in the study, which might be not from the general expert panel.

6 CONCLUSIONS

The research originated in the pursuit of applying FCM-based technique, which is considered as quite modern and recently emergent, for the Finnish wind energy sector. The national wind energy sector was chosen for further scrutiny, due to its fast growing and potential capacity importance for the industries. The idea of taking this kind of renewable energy sources accompanied the vision for energy as carbon-neutral in foreseeable future, which would reduce greenhouse gas emission and stop harming global climate stability. Moreover, wind energy development factors were distinct from the majority of conventional sources and assumed to have potential interest for examination.

In the theoretical part of study, there were different scenario techniques giving in comparison, as well as general order of implementing such kind of forecast. Then, the idea of filling the gap between the qualitative and quantitative scenarios methods, began on. This reasoning entailed intention of handling Fuzzy cognitive maps technique for Finnish wind energy case.

The research was conducted with a few experts assistance, who considered having a strong awareness about wind energy and regional features. This effort led to desired result and allowed important insights to be captured and proceeded, despite on taking much time when it was assumed. Gathered data was managed graphically and statistically, it helped with a formation of visual work design and with managing of dataset.

The main research question was in either having salutary effect on robust scenarios development or not, afterwards it was divided on three research sub-questions for convenience. Upon completing, the hypothesis was proven and all sub-questions are logically answered, which gives a title to consider research as successfully fulfilled. As outcome, there were three robust scenarios presented, as well as related concepts activated for every scenario from the simulation. Additionally, there were highlight drivers defined for Finnish wind energy prospects, which are considered the most solid upon the computation through experts' set of knowledge.

Empirical part of study was implemented with the aid of Microsoft Excel software, which gave a capability to adjust calculations easily and analyze the results agilely. The computation resulted in desired values which were deployed relatively to assigned objectives, giving a full-fledged scenarios expansion. Deployed scenarios were presented vividly and brought practical novelty.

The limitations mostly had a technical background and considered as not so fluent, which gave a required credibility to the paper. Discussion is provided on the analytic manner, describing possible variations of research direction.

The study contributed to managerial practice and partly to theoretical knowledge concerning FCM-based technique. It brought some value to existing papers about energy scenarios in Finland, as it was based on recently granted method. Moreover, the research can be handled as a strategic guide, when general drivers suggesting, regarding to national wind energy development. Developed scenarios can be taken for further roadmap composing or treated solely.

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APPENDICES

APPENDIX 1: Individual FCMs

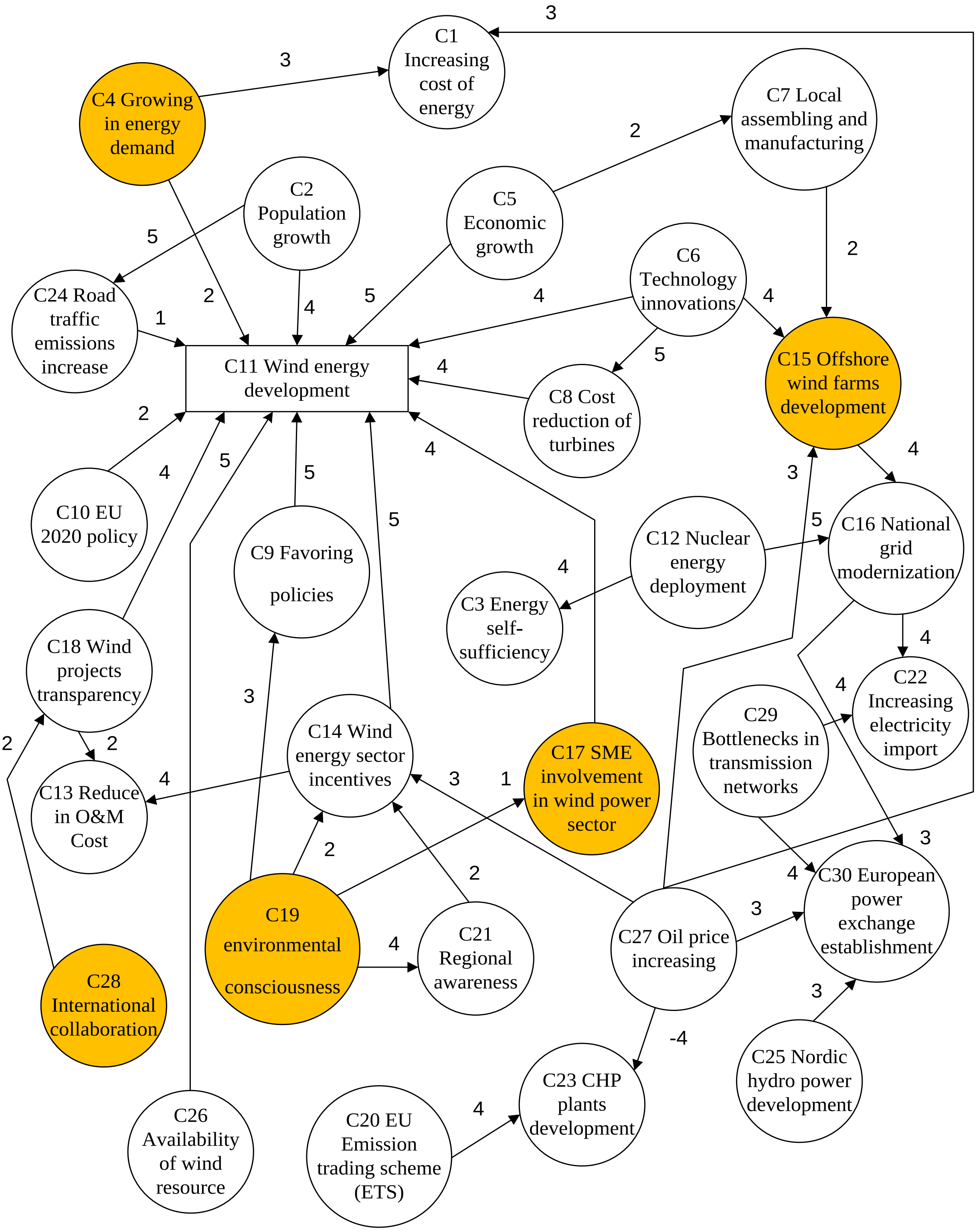

Figure 1: The first expert’s FCM

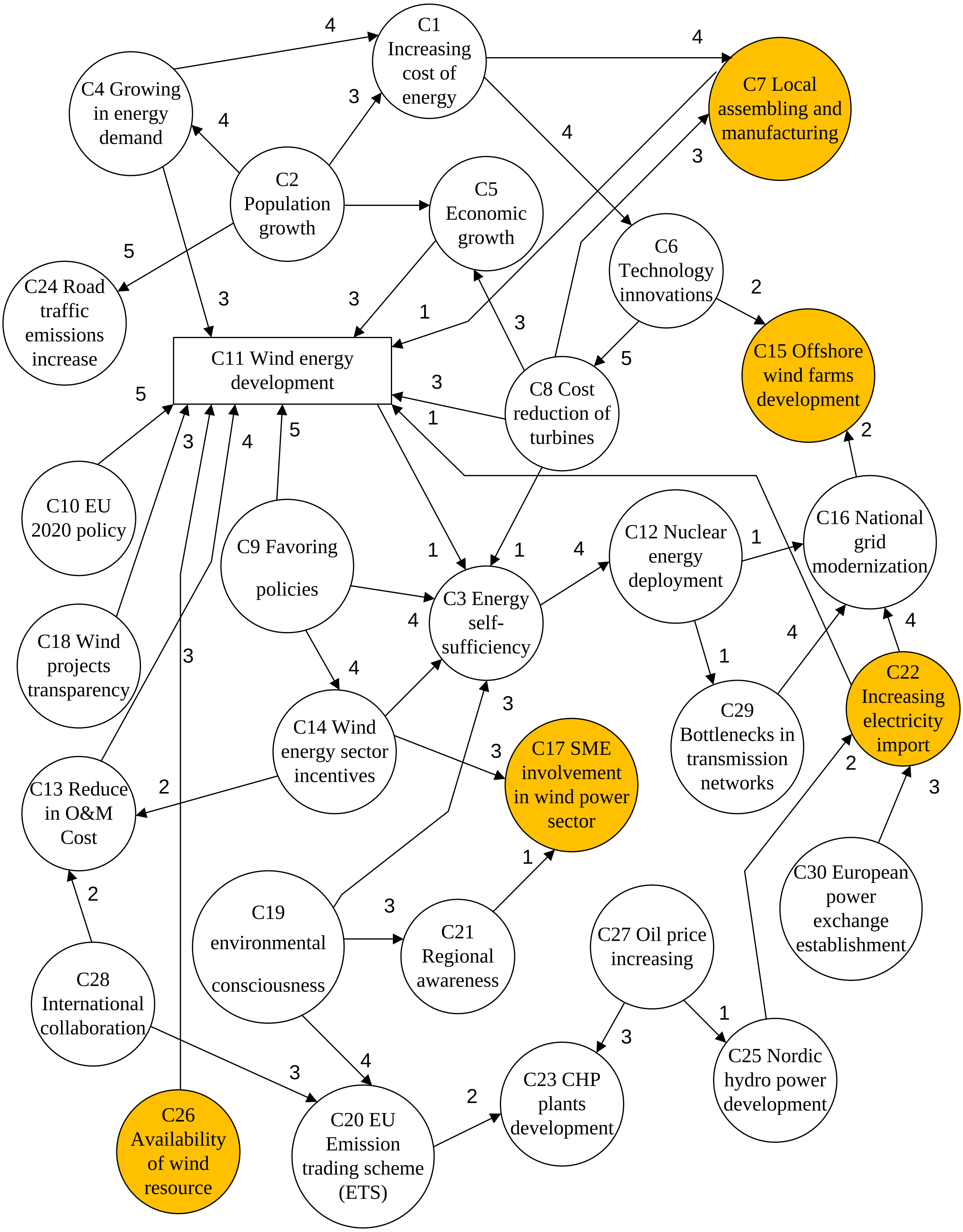

Figure 2: The second expert’s FCM

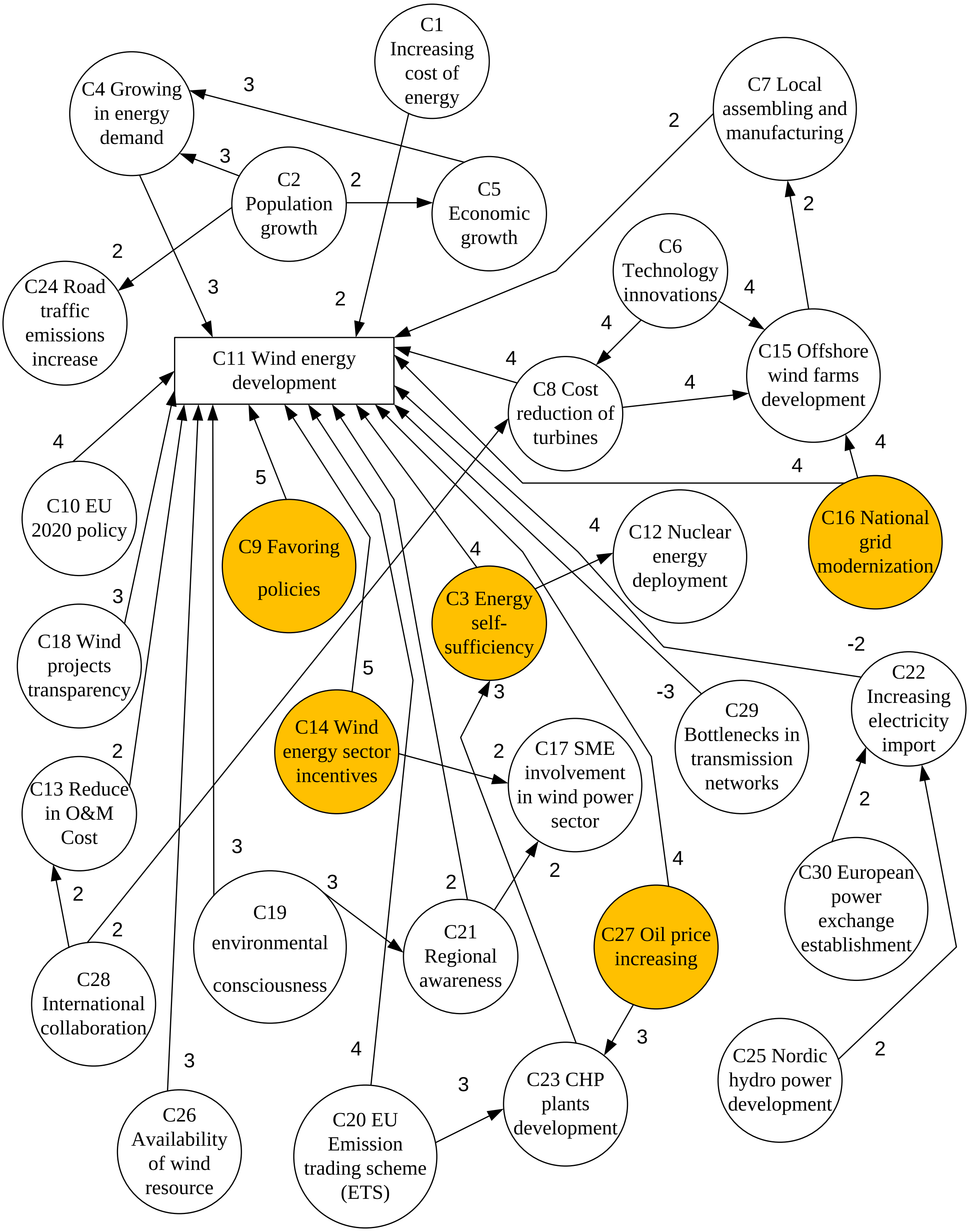

Figure 3: The third expert’s FCM

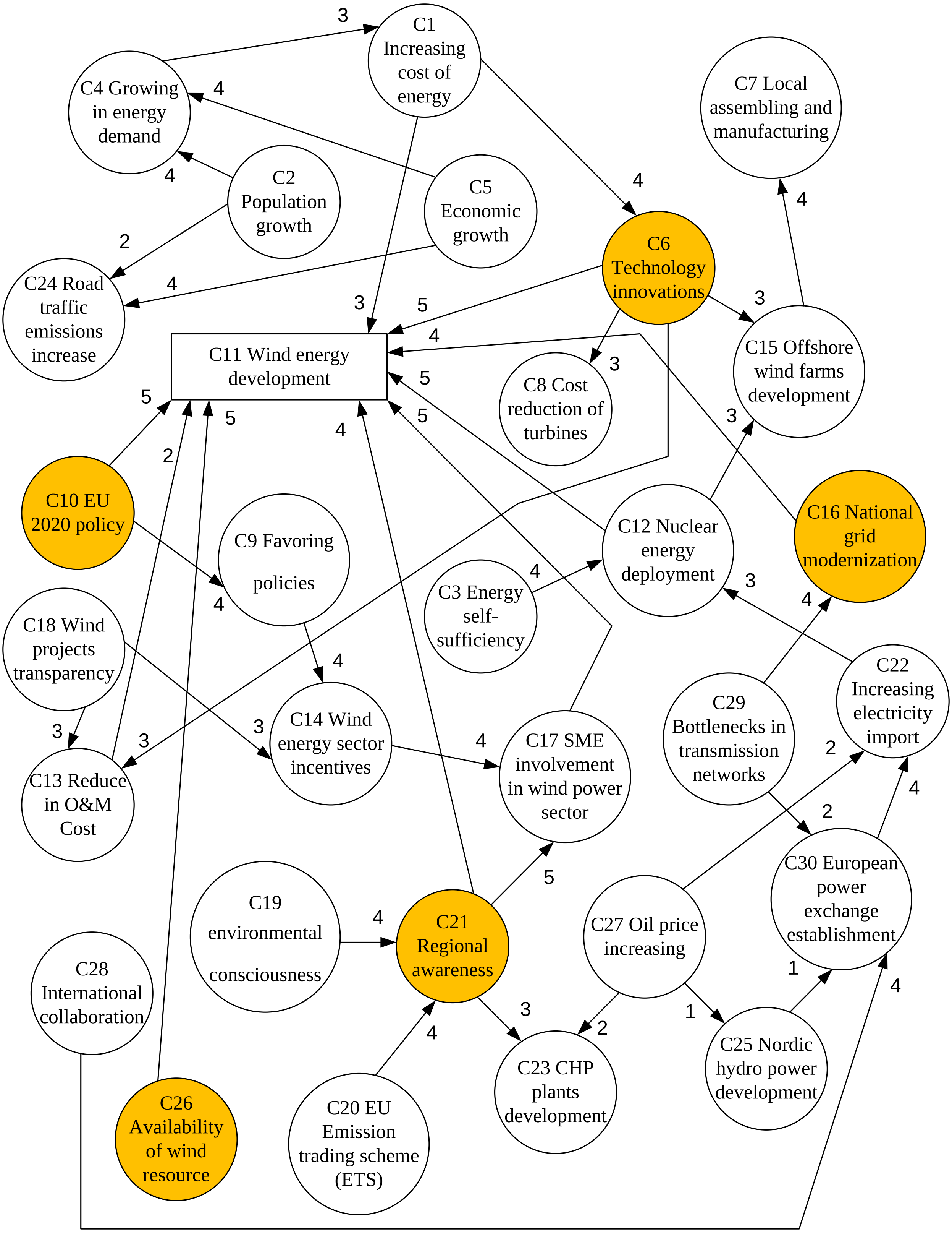

Figure 4: The fourth expert's FCM

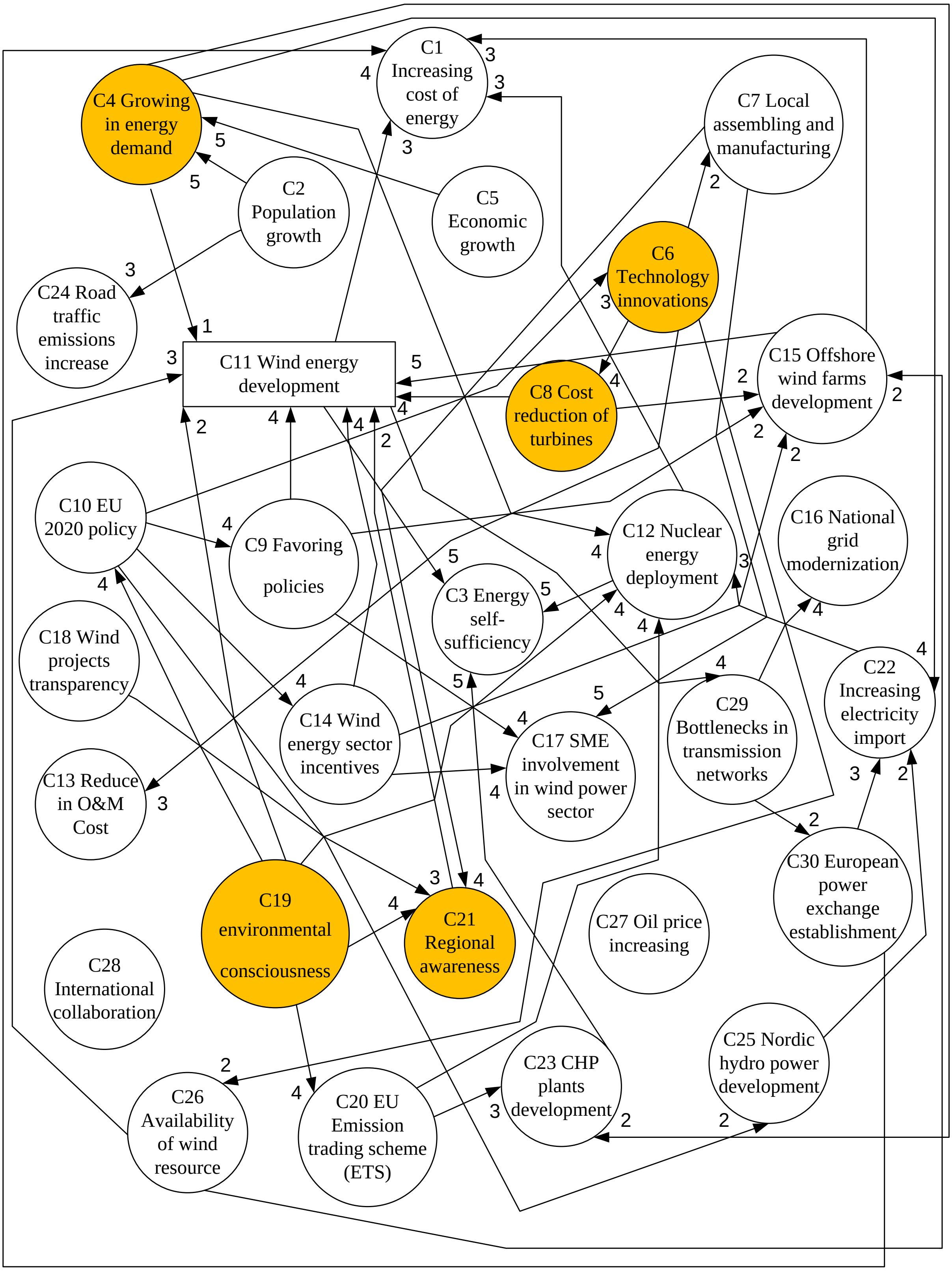

Figure 5: The fifth expert’s FCM

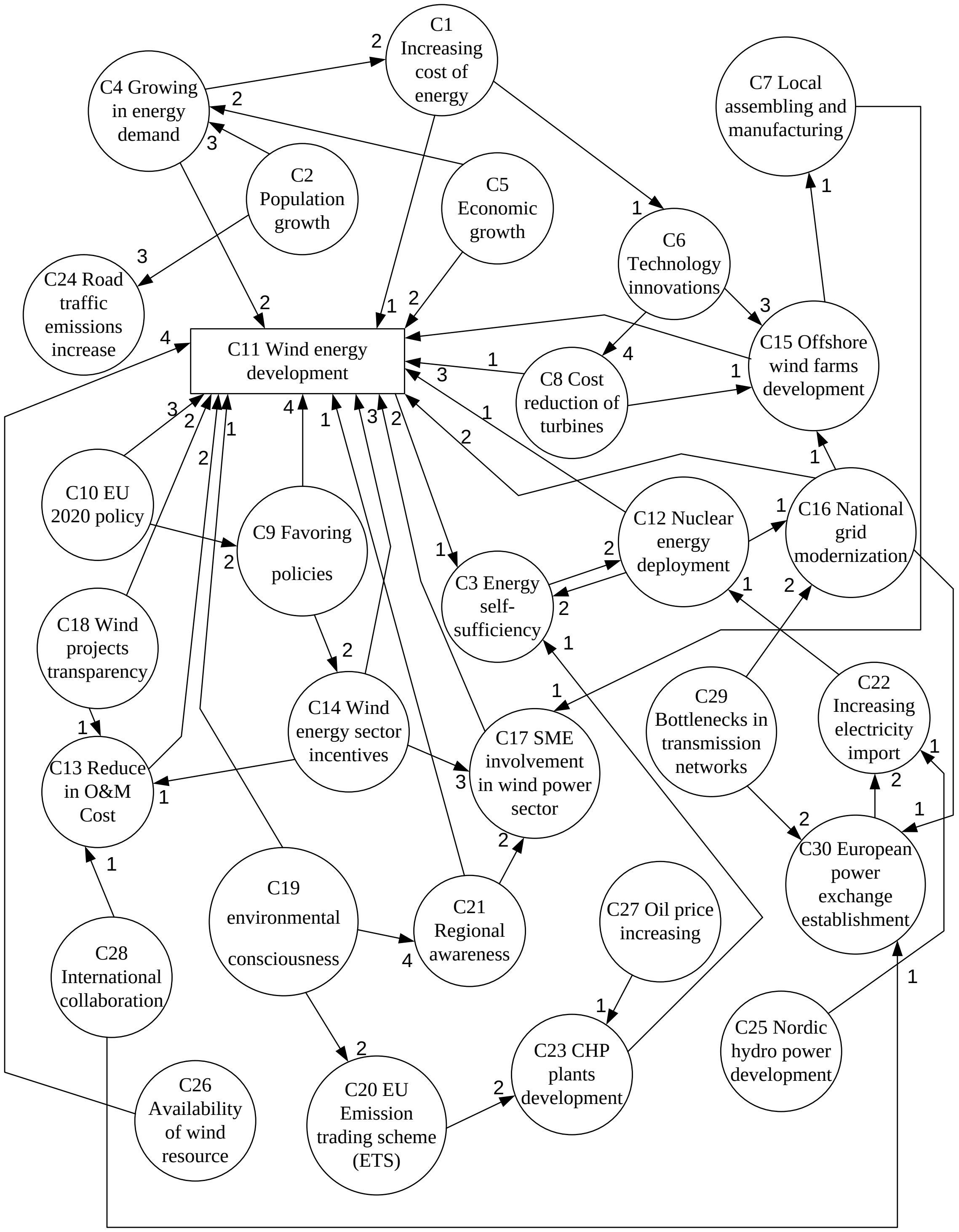

Figure 6: The integrated FCM

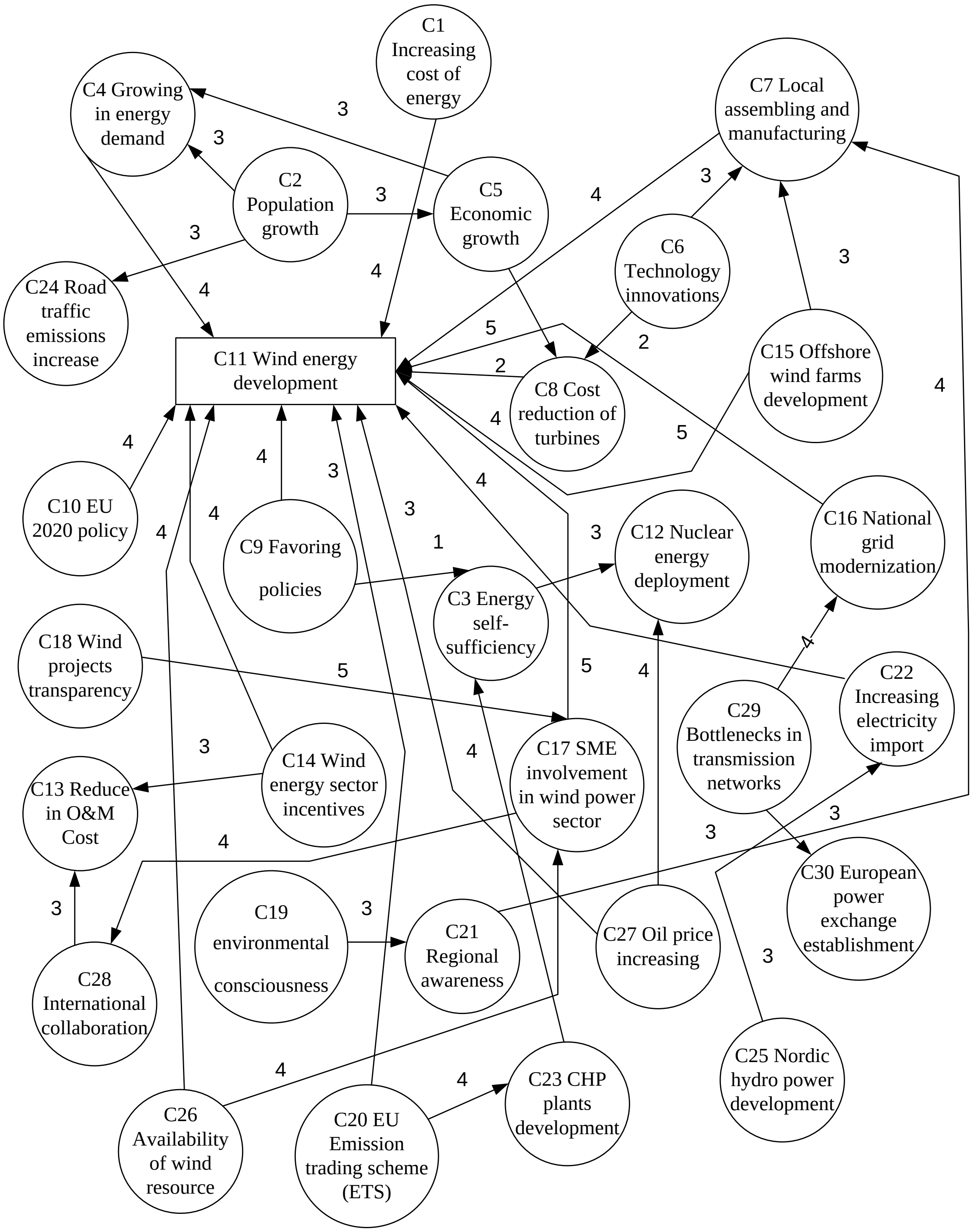

Figure 7: The technical note