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Summary

This report presents the synthesis of the needs to support the implementation of nuclear cogeneration.

The report takes into account the work performed in the European projects on deployment conventional cogeneration and support mechanisms. It is short summary of current status of nuclear cogeneration in Europe and in Poland. The report shows potential collaboration with USA and similar to SMEs challenges.

Approval

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1 Introduction

Nuclear energy plays an important role today in the world energy production. More than 400 commercial nuclear power reactors provide about 15% of the world's electricity. Nuclear power is a CO2 emission free as well as cost competitive technology and therefore can replace energy sources based on fossil fuels in industry in the near future.

2 Current status of support in Europe for cogeneration

According to original definition cogeneration is the use of a heat engine or power station to generate electricity and useful heat at the same time. Right now this idea is wide supported in Europe and it is provided by Directive 2004/8/EC of the European Parliament and of the European Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC. The Member States are obliged to develop support mechanisms adequate to economic conditions, energy market and climatic conditions. The national support mechanism in Member States are presented in the table below [1].

EU27 Member States	FeedIn Tariffs (FIT)	Feed-in Premiums (FIP)	Certificates	Tax Support	Capital Grant	Other
Austria	x					X (R)
Belgium			G, W			x
Bulgaria	X (only for RES) Upcoming					x
Cyprus						x
Czech Republic		x				x
Denmark						x
Estonia						x
Finland	X (only for RES) Upcoming				x	x
France	x					x
Germany		x				x
Greece	x					x
Hungary	x					x
Ireland						x
Italy			x		x	x
Latvia	x					x
Lithuania	x					x
Luxembourg						x
Malta						
Netherlands	X (only for RES) Upcoming				x	x
Poland						x (R,Y)
Portugal	x				x	x
Romania						
Slovak Republic	x					
Slovenia	x				x	x
Spain						x
Sweden					x	x
United Kingdom	X (only for RES)			x		

Certificates: W = White certificates, R = Red certificates, Y = Yellow certificates, G = Green certificates
RES= Renewable Energy Sources

Poland is an example of country supporting cogeneration, where a national incentive system based on certificates has been created. To compensate high cost of natural gas and high investment costs to small plant with power less than 1 MWe yellow certificates are given. Red certificates are equivalent of white certificates in other countries and are given to suppliers of energy in cogeneration (power, fuel). Red certificates are based on Directive 2004/8/EC and promote production of electricity in cogeneration with heat. In Poland white certificates are used to encourage companies to achieve better energy efficiency. Violet certificates are used in a limited scale to confirm the source of electricity generation from highly

efficient cogeneration units using methane from biomass processing. Green certificates support cogeneration in indirect way, as they certify the renewable sources of energy generation.

The list of energy certificates according to the volume of trading on Polish Power Exchange (Towarowa Giełda Energii, TGE)[2] in the first half of 2015, when the volume of trading in electricity was 89 640 103 MWh, is shown below.

Type of certificates	Volume of trading
Green certificates	5 809 099 MWh
Yellow certificates	3 107 328 MWh
Red certificates	16 383 641 MWh
Violet certificates	269 472 MWh
White certificates	15 323 toe

Until now supporting mechanism based on colored certificates is controversial, because it supports uncompetitive business. Bonuses for the power suppliers are paid by the power users which is against the rules of free market economy.

Other legislative documents concerning cogeneration:

- Directive 2002/91/EC of the European Parliament and of the European Council of 16 December 2002 on the energy performance of buildings
- Directive 2006/32/EC of the European Parliament and of the European Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC
- Directive 2006/32/EC of the European Parliament and of the European Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC

Projects of non-profit organizations promote cogeneration in Europe. The first great project was “CHP goes Green” realized between 1 July 2010 and 30 June 2013. Its general aim was to increase the share of CHP within RES. The CODE2 [3] (Cogeneration Observatory and Dissemination Europe edition 2), between 1 July 2012 – 31 December 2014, realised goals from Cogeneration Directive as aimed at realising Europe’s identified potential for cogeneration by developing 27 National Cogeneration Roadmaps. CODE2 focused mainly on 7 pilot Member States (Greece, Slovenia, Italy, Belgium, Netherlands, Germany) where the process of roadmap development and refinement will be implemented in priority. The ene.field [4] project (duration: 1 September 2011 – 31 August 2016) deploys up to 1,000 residential fuel cell Combined Heat and Power (micro-CHP) installations, across 11 key European countries and is the largest European demonstration of micro-CHP. A well-known non-profit organization is COGEN [5], which promotes development of cogeneration in Europe. It creates international network which covers the whole European Union, Central and Eastern Europe, includes also Japan, Australia and the United States (members from the government and industry), coordinates expert Working Group, and is an active participant of the projects.

3 Nuclear cogeneration in Europe

During the NC2I-R realization period projects SYNKOPE[6] and STAUB-II[7] were under way in Germany. The project SYNKOPE, funded by the Saxon regional government and supported by E.ON was launched in August 2012 for 2.5 years. The objective of SYNKOPE was to implement nuclear process heat in chemical processes for the refining of regional coal resources. The STAUB-II project, funded by the German Ministry of Economics and Technology, started in August 2012 for 3 years. STAUB-II concerns the nuclear safety of HTR systems, in particular dust particle transport phenomena during Loss-of-Coolant-Accidents (LOCA). Polish project HTR-PL[8] was launched in September 2012 for 2.5 years. The main objective of HTR-PL was to strengthen scientific and technical potential necessary for the implementation of a nuclear power programme in Poland.

Nuclear Cogeneration Industrial Initiatives (NC2I) is the only wide European initiative to demonstrate an innovative and competitive energy solution for the low-carbon cogeneration of heat and electricity using nuclear heat sources for the industry. As a part of the EU’s Strategic Energy Technology Plan (SET-Plan) it is a key solution for low-carbon technology securing the energy supply for European industry.

One of the results of NC2I-R is beginning of transatlantic cooperation. A large R&D programme on HTGR technology in the USA, called Next Generation Nuclear Plant – NGNP, has been conducted since early 2000s. The mission of the NGNP Industry Alliance is to commercialize HTGR technology and expand the use of clean nuclear energy for industrial applications while significantly reducing the dependence on premium fossil fuels in the future. The GEMINI Initiative calls for a simple, transparent, accountable and strong agreement between the U.S. and EU partners to work with their governments under an international agreement framework to carry out the design and regulatory work for the HTGR demonstrator. The GEMINI Initiative Vision Document was published in December 2014. The TWINS (Transatlantic Working partnership for Intrinsic Nuclear Safety) proposal which was not accepted in 2015 EURATOM call assumed employment of the similar features for HTGR type of reactor for the design that will optimize jointly economic competitiveness, flexibility and safety on both sides of the Ocean.

The Business Group has been established to provide strategic guidance to the European Nuclear Cogeneration Industrial Initiative (NC2I), including:

- Feedback from heat & power consuming industries and engineering firms
- Advice on financing schemes
- General guidance on the elaboration of a roadmap

The Business Group is composed of executives appointed by their organization from different areas:

- Heat-consuming industries
    - Chemical companies
    - Oil refineries
    - Fertilizer and ammonia producers
    - Soda ash producers
    - Metal makers
    - Glass makers
    - Industrial gases producers
    - Other energy-consuming industries
- Utilities
- Technology vendors and engineering companies
- Banks & other investors
- Other organizations such as industry associations

At the beginning of the NC2I-R the project was supported by the governments of Poland and The Netherlands expressed in Letters of Support from both governments. Poland and The Netherlands had expressed their support for further development of nuclear high temperature cogeneration at ministerial level. The support can be effective only if it continues independently of political changes. The lack of clear Member States declaration supporting nuclear cogeneration technologies results in lack of financing of the demonstrator project.

4 Small Modular Reactor contest

Small Modular Reactors according to the definition of International Atomic Energy Agency, are those with an electricity output of less than 300 MWe. SMRs include a large variety of designs and technologies and in general, consist of:

- advanced SMRs, including modular reactors and integrated PWRs;
- innovative SMRs, including small-sized Gen-IV reactors with non-water coolant/ moderator;
- converted or modified SMRs, including barge mounted floating NPP and seabed-based reactors;
- conventional SMRs, those of Gen-II technologies and still being deployed.

Ending of the NC2I-R project coincides with the announced interest in Small Modular Reactors in the UK. An SMR feasibility study commissioned by the government and carried out by the UK's National Nuclear Laboratory (NNL) - was published in December 2014. There are SMR concepts for a range of applications including electricity production, district heating, desalination and plutonium management.

HTGR fulfils the criteria for being an SMR and can be used for a range of applications including process heat supply for industry.

5 Challenge of FOAK and NOAK

It is clear that the challenges to build a demonstrator of nuclear cogeneration as well as SMRs are similar[9]. The generalized comprehensive economic model for first-of-a-kind (FOAK) through nth-of-a-kind (NOAK) is very important. In the economic model, a particular project's feasibility is assessed with regards to market conditions and by commonly utilized capital budgeting techniques, such as the net present value (NPV), internal rate of return (IRR), payback, as well as the levelized cost of energy (LCOE) in comparison with other energy technologies.

A reasonable level of design maturity should be reached before applying for a license for a first-of-a-kind (FOAK) project – and, by the time of first concrete, a high proportion of the detailed design should been completed.

Based on the experience with current SMRs, the same reactor cost challenges can apply:

- licensing will be very costly;
- FOAK costs will be higher than NOAK;
- Mass production may be key to achieving cost reduction potential.

Modularization of nuclear cogeneration units will reduce costs. In the early phase of deployment of nuclear cogeneration, without public co-funding for end-user, the building of the FOAK will be extremely difficult.

6 Polish support for nuclear power

Poland is a heavy consumer of coal. However, Polish government decided to differentiate energy mix and to introduce nuclear power in Poland. The reasons are:

- To assure long-term security of electricity supply;
- To maintain the reasonable level of electricity prices;
- To reduce emissions of SO2, NOX, PM and CO2.

The project of the first nuclear power plant in Poland was the result of an analysis of needs and potential tendencies of development of the national energy sector with environmental requirements associated with them. A milestone for these activities was the decision taken on 13 January 2009 by the Polish Council of Ministers to develop the Polish Nuclear Power Program (Polski Program Energetyki Jadrowej, PPEJ). Since 2013 a site investigation and environmental assessment activities are conducted in parallel at two locations in the Pomorskie voivodship: the „Choczewo" site (Choczewo) and the „Żarnowiec" site (Gniewino and Krokowa). The Company has selected the Technical Advisor for the role of Project Engineer and signed an agreement with AMEC Nuclear UK Ltd. in September 2014. In the original plan building permit and construction of the first reactor of the first nuclear power plant was planned for the III phase of the PPEJ project 01/01/2019 - 12/31/2024. Actualization of progress in the PPEJ showed that expected first unit connection to the grid can take place in 2029. The reason of this delay is the deficit of political consensus on nuclear energy implementation [10].

Up to the end of year 2015 it is planned to implement the new document "Polish Energy Policy Until 2050", but it is still under consultation.

In 2007 the National Centre for Research and Development (Narodowe Centrum Badań i Rozwoju, NCBiR) was created as the implementing agency of the Minister of Science and Higher Education. Currently, the Centre is implementing two strategic research and development programs[11]:

- Advanced Technologies for Energy Generation;
- Interdisciplinary System for Interactive Scientific and Scientific Technical Information;

and three strategic research projects:

- Integrated System for Reducing Energy Consumption in the Maintenance of Buildings,
- Work Safety Optimization in Mines;
- Safe Nuclear Power Engineering Development Technologies.

Projects from Safe Nuclear Power Engineering Development Technologies include development in the following areas:

- radiation methods, including the preparation of radiopharmaceuticals;
- processing technology and management of radioactive waste;
- fuel cycle;
- materials technology, electrical engineering, automation with regard to NPP;
- generation IV reactor;
- probabilistic models and software;
- integration of nuclear power with coal power to optimize use of national resources.

The national HTR-PL[8] project (2012-2015) was financed by NCBiR. HTR-PL was oriented on the demonstration of HTR cogeneration in Ploland as the way to decrease its CO2 emissions and to enhance its competitiveness.

7 Conclusion

Until now there is no specified organization in Europe decided to implement nuclear cogeneration. Lack of strong and continue interest in nuclear cogeneration project on national government level results in the a weak support from the European and national structures.

Following the Renewables Obligation, cogeneration plants using renewable energy fuel, such as biomass and biogas, benefit from a premium for each MWh of electricity produced. If "non-emission sources" replace "renewables sources" in tariffs, it will result in new kind of certificates and involvement of nuclear cogeneration in the game of supported mechanisms for any kind of cogeneration.

Basing on experiences of promotion of "conventional" cogeneration it is possible to accelerate deployment of nuclear cogeneration in Europe. One of long distance solution for competitive energy market can be the adaptation of common rules for cogeneration focused on the results – availability and total emission, not on sources.

As a result the stimulation of new initiatives on nuclear cogeneration is needed. As long as there is no real commitment from the government, there will be no interest from potential industrial users.

Joint cooperation under GEMINI Initiative can accelerate deployment of HTGR technology for process heat cogeneration for the industry in the USA as well as in Europe.

HTGR reactor technologies can be included in SMR technologies and might be applied for the cogeneration, as well as other technologies for lower temperatures. It opens the perspective of cooperation between NC2I, NGNP and the UK.

8 References

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