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PANEL SESSION: PART B

EUROPE: STATUS OF INTEGRATING RENEWABLE ELECTRICITY PRODUCTION INTO THE GRIDS AND DEVELOPMENTS IN DISTRIBUTED ELECTRICAL POWER GENERATION IN COMPLIANCE WITH THE KYOTO PROTOCOL (PANEL SESSION PAPERS 290)

(Dietmar Retzmann and Tom Hammons)

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Panelists and the Titles of their Presentations (Parts A & B) are:

PART A

0. T. J. Hammons Chair International Practices for Energy Development and Power Generation, Glasgow University, UK and Yvonne Saßnick, Vattenfall Europe Transmission GmbH , Berlin, Germany. Panel Session Introduction: Part A-- Europe: Status of Integrating Renewable Electricity Production into the Grids

1. Bernd Michael Buchholz, Vice President, Siemens AG, Erlangen, Germany and Yvonne Saßnick, Vattenfall Europe Transmission GmbH, Berlin, Germany. The German Experience of the grid integration of renewable energy sources
2. Nikos Hatziargyriou, National Technical University of Athens, Athens, Greece; I Skotinos, National Technical University of Athens, Athens, Greece; and A. Tsikalakis, National Technical University of Athens, Athens, Greece. Status of Integrating Renewable Electricity Production in Greece: Prospects and Problems.
3. John Olav Tande, SINTEF Energy Research, Trondheim, Norway. Options for Large Scale Integration of Wind Power
4. Joao A. Peças Lopes, INESC Porto and Faculty of Engineering, Porto University, Portugal. Technical and Commercial Impacts of the Integration of Wind Power in the Portuguese System having in mind the Iberian Electricity Market.
5. Juan Manuel Rodríguez García, Fernando Soto Martos, David Alvira Baeza; Red Eléctrica de España., Madrid, Spain; and Susana Bañares, Red Eléctrica Internacional., Madrid, Spain.. The Spanish Experience of the grid integration of wind energy sources
6. D. Barry, ESB National Grid, Dublin, Ireland; and P. Smith, ESB National Grid, Dublin, Ireland.. Analysis of the Integration of Wind Generation into the Irish System

PART B

0. Dietmar Retzmann, Siemens, Germany and Tom Hammons, Chair International Practices for Energy Development and Power Generation, Glasgow University, UK:

Panel Session Introduction Part B: Europe: Status of Integrating Renewable Electricity Production into the Grids and Developments in Distributed Electrical Power Generation in Compliance with the Kyoto Protocol

7. Ahmed Faheem Zobaa, Cairo University, Giza, Egypt. An Overview of the Different Situations of Renewable Energy in the European Union
8. PAMULA Anna. Lodz-Region Power Distribution Company, Poland; SZYMCZAK Tomasz. Lodz-Region Power Distribution Company, Poland; ZAWORA, Jacek. Lodz-Region Power Distribution Company, Poland; and ZIELINSKI, Jerzy S. Lodz-Region Power Distribution Company, Poland. Some Remarks on Renewable Electricity in Poland.
9. Ola Carlson, Associate Professor and Stefan Lundberg, Lic., Chalmers University of Technology, Sweden. Integration of Wind Power by DC-Power Systems
10 A. Sauhats, V. Chuvychin, N.Gurov, V. Strelkovs, I.Svalova, Riga Technical University, Latvia; and O. Linkevics, J. Rivkins, VAS Latvenergo, A. Svalovs, Dispatch Centre of the Baltic Power Systems, Latvia. The Latvian experience and problems of the grid integration of renewable energy sources in the power system
11. Brendan Fox, Queen's University, Belfast, UK. Wind Intermittency, Mitigation Measures and Load Management.
12. Etienne Gehain, Research Division, Gaz de France; Jacques Deuse, Tractebel Energy Engineering. DEEP: a European Integrated Project with a Different R&D Approach to the Integration of Distributed Energy Resources and Renewable Energy Sources in Markets and Energy Grids

INTRODUCTION: PART B

This Panel Session will discuss Europe: Status of Integrating Renewable Electricity Production into the Grids and Developments in Distributed Electrical Power Generation in Compliance with the Kyoto Protocol

The decision of the Russian Parliament (or Duma) to ratify the 1997 Kyoto Protocol on climate change has re-energized international cooperation on cutting greenhouse gas emissions..

Russian ratification ensures that the Protocol is legally binding on its 128 Parties on 16 February, 2005 and launches an exciting new phase in the global campaign to reduce the risks of climate change. We must all get down to the serious business of reducing emissions of carbon dioxide and other greenhouse gases, by giving industry, local authorities and consumers incentives to take action on climate change. Russia and the 29 other industrialized countries that have joined the Protocol will set themselves on a path to greater economic efficiency. Accelerating the development of the clean technologies that will dominate the global economy of the 21st century will earn them a competitive edge in global markets. What various countries in Europe are doing in this respect will be examined.

The Protocol contains legally binding emissions targets for 36 industrialized countries. These countries are to reduce their collective emissions of six key greenhouse gases by at least 5% by 2008-2012, compared to 1990 levels. This first five-year target period is only a first step. While developing countries do not now have specific emissions targets, they too are committed under the 1992 Climate Change Convention to taking measures to limit emissions; the Protocol will open up new avenues for assisting them to do so. In addition to inspiring national action to cut emissions, the Protocol's entry into force will strengthen international cooperation through the early start-up of an international "emissions trading" regime enabling industrialized countries to buy and sell emissions credits amongst themselves; this market-based approach will improve the efficiency and cost-effectiveness of emissions cuts. the "clean development mechanism" (CDM), through which industrialized countries can promote sustainable development by financing emissions-reduction projects in developing countries in return for credit against their Kyoto targets cooperative projects under the system for "joint implementation", whereby one developed country can finance emission reductions in another developed country.*the Kyoto Protocol Adaptation Fund, established in 2001, which will assist developing countries in anticipating and protecting themselves against the negative effects of climate change.

Development of Distributed Electric Power Industry in Europe

The developments in power industry in Europe depend on expectations for future political, financial and technical conditions. Embedding of renewable energy sources is a quite challenging task, based on conditions defined by the Kyoto Protocol.

The trend in the European power industry developments will be influenced by

- Liberalization and globalization with the goal to open markets, not only for delivery of equipment but also to include new market players in the generation and transmission of the energy.
- Increasing environmental constraints (e.g. CO2 reduction, regenerative power generation, and difficulties to get right of way for overhead lines) will influence the type and location of new generation and changes in the structure of power systems.
- Continuous increase of price for oil and gas can speed up the use of new generation technologies if they would be technically available.

In the deregulated environment, responsibilities for generation, transmission and distribution are separated. However, from technical point of view there are strong interdependencies among all the parts of power systems. Generation locations depend on the available primary energy sources (water, wind, etc.), mostly not close to the centers of power demand. The transmission system then has to transmit power over long distances. In case primary energy as gas or coal is available close to the load centers or it can be transported by other means (e.g. pipelines, shipping), generation can be placed close to the load, even in sub-transmission or distribution systems.

Financing of power plants plays an important role in the deregulated environment. Therefore payback times are an important factor in the decision for new power stations. Technologies with the shorter payback have economic advantages.

In the decades to come it can be expected that the main primary energy will still be gas, with declining use of coal. Studies show that the gas exploitation will increase for more than 4 times in the next 30 years. The renewable power generation (wind, solar and biomass) will increase considerably in some countries, especially in Europe; however, because of still high costs and the need for additional generation as running reserve, there are many on-going discussions on the feasibility of embedding large amounts of renewable energies within the existing grids.

New technologies as fuel cells are still in the early phase of the development. To be economical, the production costs have to be reduced considerably. This depends, however, on the progress in the development of new materials. The expectations for the economic break-through are therefore uncertain. In the next 30 years fuel cells will be used only for small ratings in distribution networks and will not play a major role in power industry.

Development in the field of fusion to produce electric energy is just at the beginning with problems in the field of materials that have to resist very high temperatures. The realization in the next future can not be expected. It can, however, be possible that fusion generation will be built in 50 years or even later.

According to the expectation for increasing power demand in the next decades the existing systems in many industrialized countries, also in Europe, will be loaded by additional power of at least 60%, without the possibility to build a larger number of new overhead lines. The existing lines, in Europe with a relatively low voltage level of only 400 kV will be therefore loaded up to their thermal limits. The solution in density populated areas will be to introduce more underground cables and preferably to use GIL (Gas insulated Lines) for bulk power transmission corridors, as GIL technology can transmit large amounts of power at reasonable costs through narrow rights of way. FACTS (Flexible AC Transmission Systems) technology could also help to improve the loading of power corridors. With the increasing load the short-circuit current will also further increase. Short-circuit current limiter solutions will be needed.

However, with the increasing complexity of power systems, the reliability of power supply will diminish as already shown by a number of large blackouts in Europe and America. Studies show that the probability for large blackouts is much higher than theoretically expected. Reason is that the fault sequences leading to blackout don’t result only from statistical failures. An essential role plays human errors, insufficient maintenance and systematic errors in planning and operation, leading to cascading of the faults. These systematic errors can not be completely avoided, because of too high complexity of the systems.

Improvements can be made also by the use of HVDC. Back-to-back HVDC could separate parts of the interconnected systems to avoid the widening of large disturbances throughout the system. HVDC will further be increasingly used to transmit large power blocks from the remote locations to the load centers.

The effective operation of large and complex power systems in many countries of Europe will ask for new modern control systems combined with new protection strategies. The goal of new control and protection will be to assure economic and reliable operation even under emerging conditions.

Power output of wind generation can vary fast in a wide range, depending on the weather conditions. Hence, a sufficiently large amount of controlling power from the network is required to substitute the positive or negative deviation of actual wind power infeed to the scheduled wind power amount.

On possible solution is to use HVDC long distance transmission, integrated into a synchronous AC network to reinforce the interconnection of different parts of the system, when an increase of power exchange is requested without overloading weak links or bottlenecks in the existing grid. Such a situation is expected in the German network, when large amounts of renewable energy sources, e.g. wind parks, shall be connected to the northern parts of the grid. At present, a total amount of about 12 GW wind power has already been installed in Germany (out of 120 GW totally installed generation capacity). A further increase of up to 50 GW wind power capacities can be expected in next decades, from which about 50 % will be generated by off-shore wind parks in the north- and east-sea areas.

Both tasks, to transmit surplus of power out of the northern wind generation area and to provide the controlling power from the generation in central and southern grid parts, would additionally load the existing network, thus leading to bottlenecks in the transmission system.

The loading in distribution systems will also increase leading to high current networks. In addition, decentralized power generation will be in larger extent connected to the distribution networks. The structure of distribution networks will therefore change from vertical oriented power in-feed to the mixed structure with part of power in-feed from the superposed power system and part delivered by own generation.

Distribution systems will operate in similar way as high voltage systems. Because of high short-circuit currents and reliability reasons they will be separated to smaller systems interconnected by current limiters or DC back-to-back stations.

The panel will address these various aspects of the European grid developments, today and in future. The Panel comprised of 6 to 8 eminent authorities from Europe will review developments in Distributed Electrical Power Generation in Europe to fulfil the Kyoto Protocol requirements where progress, developments and proposals in some of the more significant European countries: Germany, United Kingdom, Italy, Spain, Sweden, France, Poland, Czech Republic, Russia, and others will be critically analysed, discussed, and reviewed. There will be input from national governments and authorities, the utilities, power equipment manufacturers, and industrial and domestic consumers.,

PANEL SESSION SUMMARIES (PART B):

7 AN OVERVIEW OF THE DIFFERENT SITUATIONS OF RENEWABLE ENERGY IN THE EUROPEAN UNION

Ahmed Faheem Zobaa, Cairo University, Giza, Egypt

ABSTRACT— Renewable energy sources are indigenous, and can therefore contribute to reducing dependency on energy imports and increasing security of supply. Development of renewable energy sources can actively contribute to job creation, predominantly among the small and medium sized enterprises, which are so central to the Community economic fabric, and indeed themselves form the majority in the various renewable energy sectors. Deployment of renewables can be a key feature in regional development with the aim of achieving greater social and economic cohesion within the Community. This paper gives an overview of the different situations of renewable energy in the European Union.

Index Terms– renewable energy, electrical energy resources, electricity connections

I. INTRODUCTION

The promotion of renewable energy has an important role to play in addressing the growing dependence on energy imports in Europe (EU) and in tackling climate change. Since 1997, the Union has been working towards the ambitious target of a 12% share of renewable energy in gross inland consumption by 2010. In 1997, the share of renewable energy was 5.4%; by 2001 it had reached 6%.

Different strategies are being used to promote renewable energy sources for power generation world over. The current status in the EU is unique one, where regulatory frameworks try to rationalize electricity/energy pricing through a free market and regulatory approach, which varies from country to country, on the one hand and promotes renewable energy, which is costlier, on the other. A great deal of learning from previous promotional programmes, e.g. NFFO of UK, the German feed law etc., has resulted in the present policy environment.

This paper gives an overview of the different situations of renewable energy sources in the European Union (RES-E). Data is based on different sources. Firstly, on the reports from Member States on national progress in achieving the targets on electricity from renewable energy sources (Article 3 of Directive 2001/77/EC). These reports can be found in the web site of Directorate General for Energy and Transport [1]. Secondly, on a study launched by the Commission on the evolution of renewable energy sources [2]. And thirdly, on a variety of sources like the European Barometer of renewable energies [3], data from the industry, etc.

II. STATUS OF THE RENEWABLE ENERGY

AUSTRIA: The production of renewable energies (RES) in Austria is dominated by large hydropower and biomass for heat generation. The fastest-growing renewable energy source over the last decade was solar thermal energy. There is wide variety of policy measures for the support of renewable energies in Austria not only at the federal level but also at the provincial level. Stimulated by the new feed-in tariffs steady growth is also expected in the sectors of wind energy, biomass electricity as well as small hydro installations.

BELGIUM: Three different green certificate markets have started, one in Flanders, the Walloon region and the Brussels region. Because of the possibility of banking of certificates and increasing penalty rates and a shortage on certificates not much of trading has taken place, it is more favorable of paying penalties the first year and use the certificates in later periods. The three regional different systems complicate the implementation of RES-E market.

CYPRUS: Cyprus plans full liberalization of the electricity market to achieve until 2005. There is no electricity import or export. Almost all energy is produced from imported oil and diesel. The Electricity Authority of Cyprus (EAC) plans to invest in a new fossil fuel power plant, which would lead to an excess capacity for the next few years, being a major barrier for renewable development. Solar thermal energy is the major available renewable energy in Cyprus, and it is traditionally used by hotels and households for thermal purposes. The Government has recently adopted the “New Grant Scheme For Energy Conservation and the Promotion of the Utilization of Renewable Energy Sources” effective from 2003 to 2007.

CZECH REPUBLIC: The significant excess of generated electricity of around 27,000 GWh/year with the full commissioning of the Temelin Nuclear Power Plant is a major barrier for renewable electricity development for at least another decade. Poor reputation of wind energy caused by premature sales of prototypes to clients. Biomass and hydro are far the most utilized renewables. Geothermal is mainly utilized for balneological and swimming purposes.

DENMARK: The renewable energy market has dramatically declined over the last two years.

ESTONIA**:** There are low opportunities for solar and geothermal. However there is considerable potential in wind and biomass as well as hydropower. The biomass installations need high investment and though there are several wind projects in the pipeline the feed in tariff is hardly more than half of the amount the developers would favor.

FINLAND: Renewables currently cover around 28% of the Finnish total electricity consumption supplied by two key
Sources: hydro power (70%) and biomass (30%). Over the past decade a significant increase has been achieved in the deployment of biomass, in particular in the form of CHP and district heating systems.

FRANCE: Renewables cover currently around 16% of the French total electricity consumption. This supply is met mainly by hydro power. Despite significant resources wind, biomass and geothermal energy currently play an insignificant role in the electricity sector. The current use of heat from RES amounts to approximately 6,0 Mtoe which covers 7% of the domestic energy consumption for heating purposes. The use of biomass forms the main source for renewable heat and is relatively stable in size.

GERMANY: The renewable energy market in Germany is mature and showing large growth rates even at high penetration rates. Biomass might be considered as the only source that is significantly lagging behind expectations.

GREECE: Greece has a mature RES market especially for active solar thermal systems, hydro and geothermal installations in the heat sector. The general promotion schemes have been in place for a considerable time already and have undergone only slight change (degree of support) of late. A recent inter-ministerial decision is aimed at reducing the administrative burden affecting RES installations, as well as some geothermal projects.

HUNGARIA: There would be good opportunities for biomass, solar, geothermal and some wind energy development, although the investment climate was not favorable until now and only very few investment has taken place with different multilateral funding.

IRELAND: The Alternative Energy Requirement (AER) round 6 closed in April 2003. In Ireland there is no real voluntary market for renewable electricity.

ITALY: Obligatory demand for producers and importers. The GRTN, Italy's Independent System Operator, may sell certificates produced at eligible RES-E plants under the former CIP6 support scheme at a fixed price and only if the market is short to prevent excessively high prices on the market. Voluntary demand for green electricity may be included in the certificate system. The implementation of the Guarantee of Origin will make the voluntary market more transparent and open.

LATVIA: From 1996 to 2002, Latvia experienced significant growth in renewable energy projects as developers took advantage of the so-called double tariff, phased out the 1st January 2003. Latvia had a unique feed-in tariff, which was double the average electricity price for a period of eight years after grid connection for wind and small hydro power plants (less than 2

MW). Annual production at small hydropower plants increased from 2.5 to 30 GWh, while output from wind power plants built during the last three years increased to about 50 GWh. The plan to build an undersea cable from Finland to import cheap energy may jeopardize RES development. The political support of RES has decreased in Latvia since January 2003. The cheap production of electricity from large-hydro and the low regional import electricity prices are obstacles for further RES development.

LITHUANIA: Especially biomass supply is growing (wood and straw-firing boilers). There is still an important hydro potential. A big investment has been made in 2002 in geothermal energy. Although Lithuania has very good wind potential, there is no development of this energy up to now.

LUXEMBOURG: The national energy supply company Cegedel just started this year with selling green electricity. The latest support program is limited to 5 years, and there is a limit on RES resources for creating new capacity. Development therefore seems to be restricted.

MALTA: No commercial utilization of renewable energy. The Institute of Energy Technology and others have undertaken pilot projects and studies to assess the potential and applicability of renewable sources, mainly wind and solar power.

NETHERLANDS: Early in 2004 the total amount of green power supplied to consumers reached 2.4 million. Competition in green pricing and green power supplies has been fierce in the wake of the opening-up of the green power market in July 2001. Investments in renewable energy have been slowing down over the past few years because of political uncertainty about renewable energy support.

POLAND: Biomass covers more than 98% of renewable energy production. Biomass is considered to be the most promising renewable energy in Poland, for both electricity and thermal energy production. This is because of the abundant potential of straw and wood resources in Poland and maturity of this technology. At present there are 200 ha energy crops grown and estimations indicate that 1,5 million ha of arable land is available for energy crops. Polish hydro power has chances for development as neither the big hydro power plants are fully used (due to antiquated equipment) nor the small plants. There is also a considerable wind energy potential with developments in recent years.

PORTUGAL: In the recently approved energy policy, the Portuguese Government has set goals for the development of RES-E, giving special attention to wind power (with an expected capacity of 3.750 MW by 2010) and small hydro (400 MW). For the implementation of the guarantee of origin the grid operator REN is designated as the issuing body.

SLOVAKIA: There is no specific support for wind and solar energy. A very small portion of the biomass potential is used and the government’s priority is to use this source only in remote, mountainous, rural areas, where natural gas is not available. For small hydro there is an extended development programme with 250 selected sites for building small-hydro. Geothermal is extendedly used for bathing purposes.

SLOVENIA: Renovation of hydropower plants will increase the efficiency of these units, and could add as much as 150 MWe in generating capacity. Refurbishment of existing small scale hydropower as well as increasing the capacity of the large-scale units is part of the Government's renewable energy strategy.

SPAIN: Wind power has developed impressively. The biomass sector still needs an integrated policy, which recognizes the added value of environmental and rural development. Small hydro needs to overcome the administrative barriers.

SWEDEN: Renewables currently cover approximately 50% of Sweden’s total electricity consumption. This supply is covered mainly by hydro power. The use of biomass has increased substantially over the past decade, but its share is still relatively small. Wind capacity installed in Sweden is relatively low although the wind resource in the south of the country is comparable to Denmark’s. When the new certificate scheme was drawn up by the Government, market parties expressed fear and reluctance to invest.

UNITED KINGDOM: The buy-out revenues for non-compliances are recycled to the suppliers in proportion to the certificates they have used for complying with the obligation. This mechanism increased the certificate price above the buy-out price because the market is short. High prices in the first year gave the Renewable Obligation scheme (ROC) market a kick-start. Targets specified for 2010 and scheme duration specified until 2027 provide long-term security for renewable energy investors.

III. EUROPEAN SUSTAINABLE ENERGY--VISIONS 2050

The current version of the European Vision includes a vision for a transition of the energy supply and demand for the 15 current EU countries (EU-15) with phase-out of fossil and nuclear energy over a 50-year period.

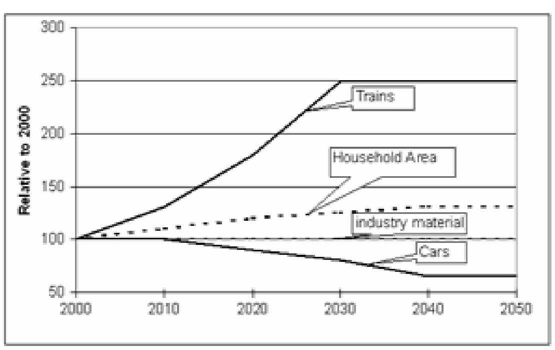


Figure 1 EU Vision 2050

The vision follows the EU target of 12% renewable energy in 2010, and the target proposed by a large number of NGOs of 25% renewable energy in 2020. The shares of renewable energy in 2030, 2040 and 2050 respectively are 35%, 55% and 100%.

Energy Efficiency

The European Vision is based on rapid growth of energy efficiency to reach in an average level in 2050 similar to best available technology today. Most energy consuming equipments will be changed several times until 2050, and if new generations of equipment are made with optimal energy performance, and markets are made to promote the most efficient technology, it will not be a problem to reach today's best available technology, even though the efficiency gains required are very large, - in the order of 4 times for stationary equipment, similar to an annual increase of efficiency of over 2% per year from 2010. This will not happen by itself, given that the "natural" technological development is about 1% per year. It will require concerted action from all stakeholders involved, but indications are that if the market is large enough for each new generation of efficient equipment, it will be a cost-effective development - the extra equipment costs will be offset by energy savings. It will also benefit equipment manufacturers that will get better products, also for the world market. It is, however, necessary to break the conservatism of many market players in this field, and develop a truly enabling market for energy efficiency throughout the society.

The Challenge of Reducing Heat Consumption

For buildings, the situation is different from equipment because buildings often have lifetimes of 100 years or more. Most of the houses to be heated in 2050 are probably already built. For the EU countries, the target heat consumption is 60 kWh/m2 as average. This will require about a 2.5 times increase of efficiency, compared with current EU-average (in 1990 this was 150 kWh/m2 which is estimated to have decreased to 140 kWh/m2 in 2000). If energy-efficiency measures are included in renovations, the change is possible. The increase in efficiency is estimated to be 2%/year from 2010, but only 5% in total 2000 - 2010. This could be realized by raising building-codes to current low-energy housing levels by 2010 (with a first step in 2005), requiring that all major renovations include a major energy-renovation, and embark on a major program for passive-houses to achieve that the majority of new buildings are made as passive houses, where internal energy sources and passive solar energy supply close to 100% of the demand for space heating.

Efficient Transport

For transport is assumed that the conversion-efficiency from fuel to transport-work is increased 2.5 times (from current 15- 20% in combustion engine systems to 50% in fuel cell systems with break-energy recoverage; direct electrically driven vehicles have even higher efficiency), and that vehicles are equipped with recoverage of break-energy, so the "end-use" of energy in transport is limited to the unavoidable friction losses in transport (except for aviation). The total efficiency increase is assumed to be in the order of 4 times compared with today's average transport efficiency. For rail, aviation, and navigation are "only" included increase in efficiency gains of 40%, 50% and 25% respectively.

Will Higher Efficiencies Be Possible?

There is not doubt that higher efficiencies will be possible than the factor 2-4 increases included in this vision; but given the current difficulties with realization of efficiency potentials in many European countries, the efficiencies have been limited to these levels. It is proven that for individual industrial companies and houses, factor 4-10 is possible for increase in efficiency. The challenge is to realize the efficiency on national and international levels.

Decoupling Growth

The growth of energy services, i.e. heated floor space, transported goods and people, energy consuming production, are expected to be the 50-year period in the vision. This is in line with the perception that the average Western European has reached a sufficient level of material consumption to satisfy needs, and that material growth should gradually be stopped leaving environmental space for the poorer parts of the world. If this is to be realized, it will require that the growth of energy services does not follow the expected economic growth, i.e. that the economic growth is decoupled from growth in material consumption such as energy services. Alternatively the economic growth should come to a halt. If economic growth continues with 2.5% per year, GDP will double every 30 year, and will have increased 3.4 times in 50 years. A 2.5% economic growth is a normal growth rate that economists typically expect for Western European countries. If this level of economic growth is to continue, the challenge for realization of the sustainable development described with this vision is to triple the economic value expressed as GDP compared with energy consuming structures and activities. Assumed growth in activities:

- Floor space, household and service: 30% increase 2000 - 2050 with 10% in the first decade and gradual decreasing growth
- Electric appliances in households and service: 10% higher growth than floor space, i.e. 43% in the period 2000 - 2050
- Production, all: no growth in physical production volume, i.e. 0% in growth 2000 - 2010, but the value will grow.
- Personal transport: the vision includes a 35% reduction in private car use and an increase in train & tram use of 2.5 times as well an increase in but use of 20%. Navigation and Aviation are assumed to be unchanged. This is a vision of a more human and sustainable transport.
- Freight transport: the vision includes a 50% reduction in road freight combined with 3 times increase in rail freight and 1.4 times increase in freight navigation. Pipeline transport is expected to increase 30% with decreased transport of fossil fuels.

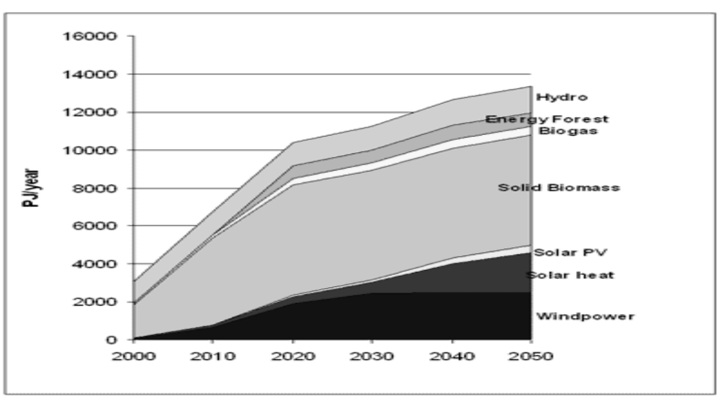
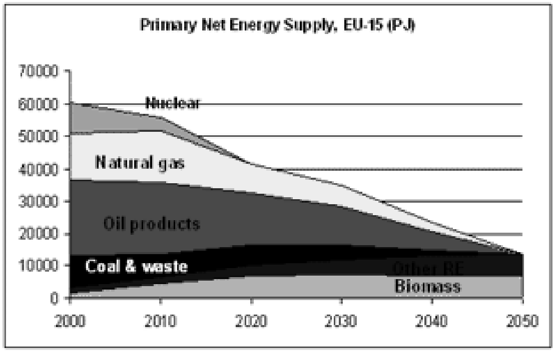


Figure 2 show renewable energy growth following vision 2050



Figore 3. Change of energy supply following vision 2050

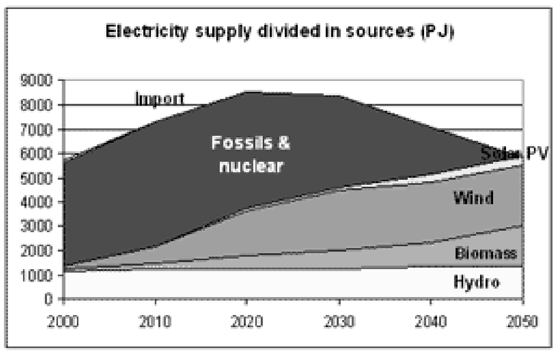


Figure 4. Electricity production and sources following vision 2050

Figures. 2-4 show renewable energy growth, change of energy supply and electricity production and sources following vision 2050.Fig. 2 renewable energy growth following vision 2050.

IV. CONCLUSIONS

In the EU member states renewables are being promoted as a tool to control energy-related GHG emissions. The European Renewables Directive clearly sets the objective of increasing the contribution of renewables to electricity generation to 22.1% by 2010. All the major member states have announced long-term targets for the contribution of renewables in the overall energy, as well power sectors. These targets vary from 10–20% by the year 2010. Though the actual implementation mechanisms vary, the strategies adopted to achieve the targets have two major components:

- Legislation making it mandatory to produce a certain percentage of total power generation from renewable sources of energy
- The higher cost of energy from renewables is passed on to the consumer
- The subsequent formulation of a system for issuing and trading of green certificates
- Imposing a tax on energy from conventional sources e.g. climate change levy of UK, Eco tax of Germany, etc.

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[3] http://europa.eu.int/comm/energy/res/publications/barometers_en.htm

VII. BIOGRAPHY

Ahmed Faheem Zobaa (M’01-SM’04} received the B.Sc.(hons.), M.Sc. and Ph.D. degrees in Electrical Power & Machines from the Faculty of Engineering at Cairo University, Giza, Egypt, in 1992, 1997 and 2002.

Currently, he is an Assistant Professor in the Department of Electrical Power & Machines, at Faculty of Engineering, Cairo University. He was an Instructor in the Department of Electrical Power & Machines, with the Faculty of Engineering at Cairo University from 1992 to 1997 and Teaching Assistant from 1997 to 2002. He regularly reviews papers for eight IEEE Transactions especially all IEEE/PES transactions and seven journals in his areas of interest. He is author or co-author of many refereed Journal and Conference papers. His areas of research include harmonics, compensation of reactive power, power quality, photovoltaics, wind energy, education and distance learning. He is an Editorial Board member for *Electric Power Components & Systems Journal* and *International Journal of Computational Intelligence*. He is an Editor for *IEEE Power Engineering Letters*. Also, he is an Associate Editor for *IEEE Transactions on Industrial Electronics*, *International Journal of Power and Energy Systems* and *International Journal on Modelling and Simulation*.

Dr. Zobaa is a member of the IEEE Power Engineering / Industry Applications / Industrial Electronics / Power Electronics Societies, the Institution of Electrical Engineers and the International Solar Energy Society.

8. **SOME REMARKS ON RENEWABLE ELECTRICITY IN POLAND**

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Abstract

The aim of the report is to characterize regulations, technical- and organizational environment in domestic power energy sector with special attention paid to the utilities responsible for integration of renewable energy sources into existing grid. The Lodz-Region Power Distribution Company is a case study presenting present state and future development of the renewable energy sources.

Full Summary Pending

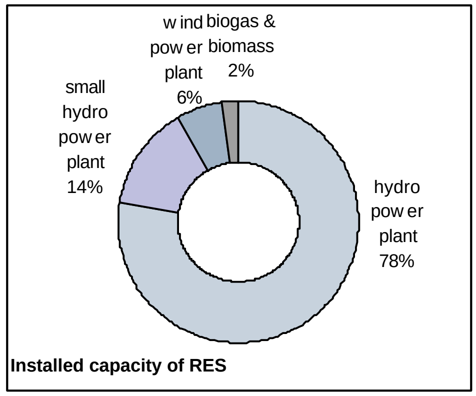
INTRODUCTION

Contemporary state of renewable electricity in Poland depends on the following facts:
- installed capacity in existing power plants exceeds the electrical energy consumption, - necessity in pollution limitation according to EU regulations needs exchange old power plants with new electrical energy sources,
-according to [1] installed capacity per capita in Poland in 2001 equal to 0.9 kW is lower the average in EU (1.5 kW).

The above mentioned circumstances expands area for introducing renewable electricity in Poland.

RENEWABLE ELECTRICITY

Few years ago Renewable Energy Sources (RES) in Poland with low installed capacity were Dispersed Energy Resources (DER) using following primary energy: water, wind, biogas and very rare biomass. EU regulations need growth of RES and at the end of 2003 total installed capacity equals to 955.9 MW (2.7% capacity of the power system) with annual energy production 1.8 TWh (1.2% annual electricity production) [6]. Most of the RES installed capacity is in the professional- and small-hydro power plants. Distribution of installed capacity and electrical energy production in RES are presented in Fig.1.



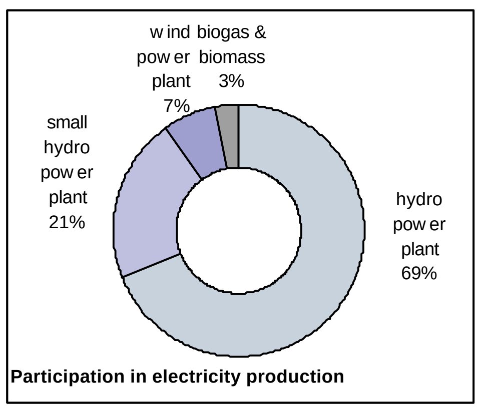


Figure1.Installed capacity and electricity production in RES (2003)

Upon influence of the EU regulations Poland modify domestic rules concerning renewable electricity. For example "Strategy of Renewable Energy Development" from September 2000 defined participation of RES generation equal to 7.5% in 2010 and 15% in 2020 of electrical energy production (according to EU in 2010 it would be 12%). Polish Energy Rule defines following nonlinear growth of obligatory participation renewable energy in total electrical energy generation from 2.85% in 2004 up to 7.5% in 2010 what means necessity to install more than 1700 MW in RES. Installation of RES in Poland has number of barriers in existing domestic regulations mainly fiscal and grounds being risky business.

DER influence on power system and according to [3] it will decrease number of 110 kV lines and HV/110 kV transformers with loading exceeding 70% nominal capacity and decreasing losses 10%, 17% or 19% in 2010, depending on considered variant. In case of wind farm it is necessary to take into account limitation of installed capacity due to transmission grid [4].

According to [2] purchasing of electrical energy from RES in 2002 was equal to 1.82% of an expected level (2.5% of total generated electrical energy). One of the reason may be great participation of hydro power plants depending on hydrological conditions in RES electrical energy generation.

DISTRIBUTORS AND RENEWABLE ELECTRICITY

Most of DER (except of large wind farm) will be connected to the distribution grid changing it's characteristics in result of great number of generating nodes, two-directional energy flows and necessity of installing new technical systems of control- and automatic protection [9]. It implies necessary investments in the distribution grids belonging to electrical distribution companies. As a consequence important problem concerning transition of consumer benefits resulting from DER development to distributors investing in the grid and purchasing more expensive energy from RES arises.

Nevertheless number of new RES installations growth and it is necessary to apply new organization of local energy market introducing Local Trading Strategy (LTS). Parallel to this process they are going new solutions following the deregulation what needs introduction new regulations influencing on electrical distribution companies.

Let us consider as a case study the Lodz-Region Power Distribution Company (L-RPD), one of 21 utilities in Poland, operating in the central region (area of 15,000 km^2) in Poland.

Some parameters characterizing the Company:
-length of distribution network 39,775 km,
-11,020 substations with installed capacity 3,311 MVA,
-sale of electrical energy 4,131 GWh/a,
-590,091 consumers.
-purchased renewable electrical energy is equal to 1.13% of total purchased energy.

In the region of the L-RPD activity one can observe growing number of RES, from 19 in 2001 up to 32 in 2004. In the end of October in the L-RPD operate:

- 24 small hydro power plants with installed capacity from 10 kW up to160 kW,
- 2 hydro power plants with installed capacity 3.40 MW and 5.04MW,
- 2 CHP with installed capacity 5.04 MW and 8.00 MW,
- 2 biogas plants with installed capacity 0.34 MW and 0.40 MW,
- 1 wind plant with installed capacity *350* kW (another one wind plant with installed capacity 70 kW does not operate in result of new fiscal rules),
- discovered geothermal source is considered for electrical energy generation.

Connection of RES to the distribution grid needs fulfilling number of technical and organizational parameters by the investor as well as by the L-RPD. Lack of domestic experience as well as not too much information from abroad which could be applied in Poland implied signing the contract on participation in the EU-DEEP (The birth of UEropean Distributed EnErgy Partnership) project [8].

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9. INTEGRATION OF WIND POWER BY DC-POWER SYSTEMS

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Introduction

The world climate is changing, the temperature has increased by one degree Celsius lasting the past 100 years and the CO2 concentration in the atmosphere is rapidly increasing. The use of fossil fuels has to decrease to save the world from more increase in temperature. To achieve this electric power must be produced using renewable energy sources, such as hydro, wind and solar power.

Wind turbine development

The development of the modern wind turbine started in the early 80s. During that time the power of a typical wind turbine was 50-100 kW and the diameter of the turbine was typically 15-25 meter. The tower height was 20 meter. The largest prototypes of wind turbines of today are over 100 m in diameter, with a hub height of 100 m and power output close to 5 MW. There are still design efforts exploring solutions for even larger turbines.

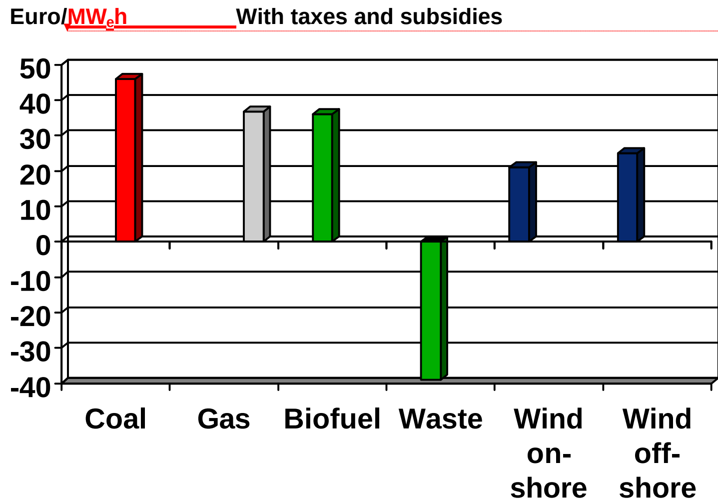
The driving force behind this development is the cost per produced kWh. For this reason and to avoid spreading wind turbines over a very wide area in the landscape, wind turbines are today planned and erected in large groups called wind farms. These wind farms have a total installed power of 10-1000 MW.

The produced power of a wind turbine greatly depends on the wind speed at the site. This can clearly be seen in the Nordic countries where wind turbines are placed in the western part of Denmark, the southern part of Sweden, on the island Gotland in the Baltic Sea. In Norway, large wind farms are being installed on the west coast.

Today close to 20 % of the electricity of Denmark is produced by wind power, this is also valid for Gotland. For the rest of the Nordic countries the figure is less then 1 %. During high wind and low load there is a surplus of wind power on the west part of Denmark, on these occasions wind power has to be exported to Sweden and Germany.

The Danish company, BTM Consultant, has published on their website that the annual growth of wind power has been 26 % during the last five years. The total amount of installed wind power by mid 2004 was 42,000 MW. BTM Consultant predicts the amount of wind power to be 95,000 MW by 2008 and 194,000 MW by 2013, [1].

The cost of producing electric power with newly built production plants has been investigated by the Swedish research organisation Elforsk, [2]. The result of the investigation shows that wind power has the lowest cost in Sweden if taxes and Green certificates are taken into account. The cost of production is 20 Euro/MWh for wind power and about 50 % more for biomass and gas. Without taxes and subsidies, the cost is more equal, about 40 Euro/MWh, see Figure 1.



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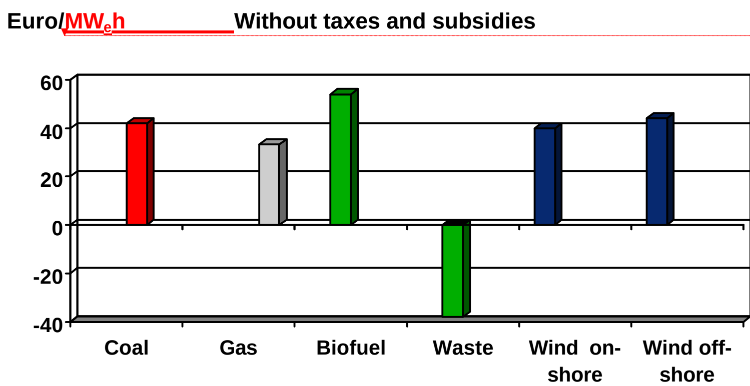

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Figure 1: Power generating costs.

Combination of wind and hydro power

In the Nordic countries, the electric power mixture is as follows: Hydro:54 %, nuclear: 23 %, fossil fuels: 22 % and wind power 1 %. In Sweden, the power mix is about 50 % hydro and 50 % nuclear.

The use of renewable energy sources, such as, hydro, wind and solar will always give an uncertainty of possible energy production. The energy of hydro will vary +/- 30 % on a yearly base during a period of 30 years, wind will vary +/- 20 %. The capacity factor (one year production divided by one year production with rated power) of hydropower in Sweden is about 50 % and wind power is 25 % on shore and up to 40 % off shore.

These figures clearly show that hydro and wind energy can complement each other in a good way. When there is a lot of wind the water is saved in dams, and when there is no wind, power can be produced using water. In Sweden, the use of electricity is 150 TWh per year. Investigations have shown that with 30 TWh of wind power in the system there will be no extra costs due to the irregularity of producing wind power. Another study treated the combination of wind and hydro in a river, in the northern part of Sweden. It shows that if 30 MW wind power are installed close to the hydro power station the wind turbine spillage out of possible production will be 1.5 %. Out of 90 MW wind power the spillage will be 7.3 %. Hydropower generation is 250 MW, which is also the power limit of the grid. Similar studies are carried out in [3].

Wind farm connection

All wind farms of today are designed with an internal AC-grid and a high voltage AC-connection to a 70 or a 130 kV transmission line. This system operates well if the distance between the wind farm and the point of common connection is not too far. If the distance is far, approximately more than 50 km and the connection has to be done with cables, it is advantageous to use a High Voltage Direct Current (HVDC) connection, [4].

There are two types of HVDC techniques available, one with thyristor valves and another with Insulated Gate Bipolar Transistors (IGBT). The IGBTs are connected to form a Voltage Source Converter (VSC) and thereby the power can flow in both directions with the same voltage polarity, both active and reactive power can be controlled. It is also possible to build a multi terminal scheme, see Figure 2. The HVDC-VSC is also of compact design and suitable for operation from an offshore platform.

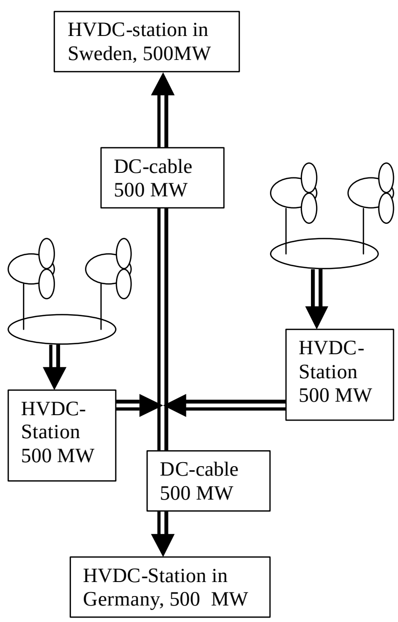

Figure 2: HVDC Wind farm connection.

The layout in Figure 2 illustrates the potential to transmit 500 MW in any direction between the two countries or to transmit 500 MW of wind power to Sweden and at the same time transmit 500 MW to Germany.

Connection between the Scandinavian Countries and the main land of Europe

As suggested in Figure 3, the Scandinavian countries should be connected to the main land of Europe by HVDC-VSC connections and offshore wind farms should be connected in between. This will allow the transmission lines to be used for several purposes as follows:

- Trading of electric power between Scandinavia and main land of Europe.
- Optimal use of the hydropower in the northern Scandinavian countries to balance the wind and solar power of Europe.
- Transport of wind energy to onshore consumers.
- The risk of voltage stability problems in the grid is reduced due to the control of reactive and active power.

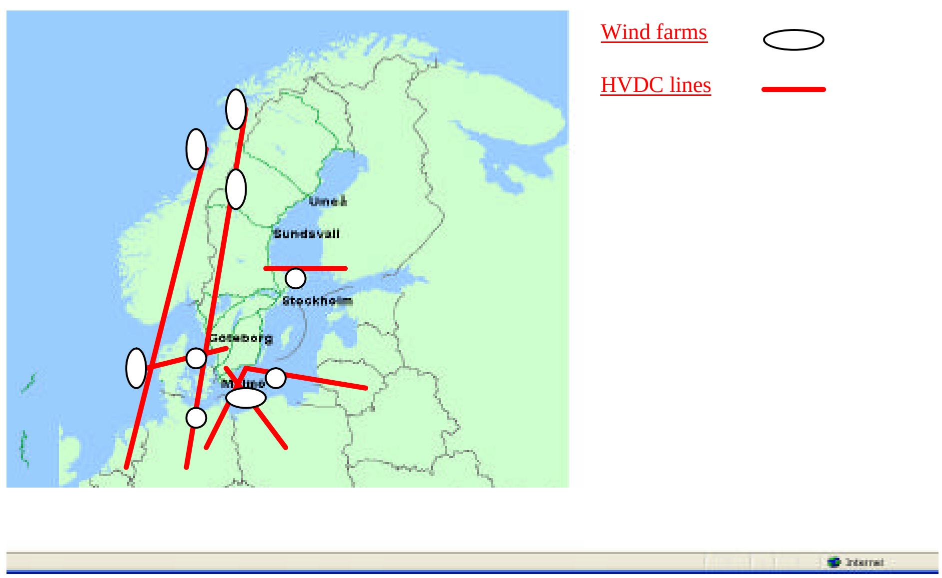

Figure 3: Suggested HVDC-connections for high penetration of wind power.

Wind farm layout

The grid within the wind farm can be designed with AC-voltage and one HVDC-VSC connection to the DC-cable. It is also possible to have a single rectifier connected to each wind turbine generator and make a DC-grid within the wind farm. To control the torque of the wind turbine and the rise of voltage for transmission of the power, there is a need for at least two types of DC/DC-converters. In [4] a Boost Converter is suggested for the current control and a Full Bridge Converter for the increase of voltage. It is also possible to connect the rectified voltage from several wind turbines in series and thereby increase the DC-voltage. In [5] it is shown that a wind farm with series connected wind turbines can be the most economic solution for a offshore wind farm, for the electrical layout see Figure 4. Although, there are several new technology challenges to overcome, such as the following:

- To design a transformer for high frequency, 5-10 kHz, and high voltage with the rated power of 5 MW
- Type of insulation of the windings
- What type of material should be used in the core of the transformer?

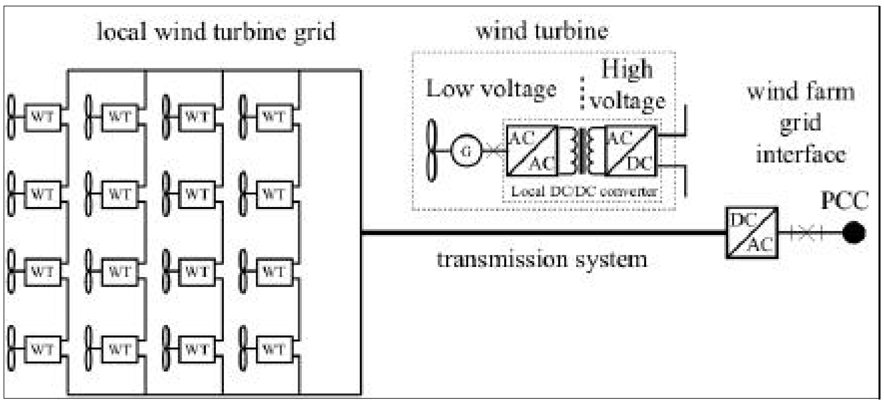

Figure 4: Wind farm layout with series connected wind turbines.

Models of electrical systems for power system studies
As part of the planning and design of electric power systems, it is well established that the transient and dynamic stability of the electrical power system needs to be studied, and studies are now ongoing in many countries that further address this issue. Studies are commonly conducted using commercially available software packages for simulation and analysis of power systems. These packages normally facilitate a set of well-developed models of conventional components, such as gas and coal-fired power stations, transmission lines and transformer stations, whereas models for wind turbines or wind farms are not standard features. Hence, the user is left to build his or her own wind farm model. Clearly, this is not trivial and results will be sensitive to model assumptions. However, during 2004 some models were made available in some commercial programs but very few have been validated against measurements. In a Nordic research project "Large-scale integration of wind energy into the Nordic grid" some progress has been made with a model of a fix speed, stall controlled wind turbine. Figure 5 shows the response of the wind turbine active power to a voltage dip in the grid. As can be seen, measurements and simulations are more or less identical. Due to the electrical model the fast transients are neglected in the simulations. The wind turbine model is a third order model with a mechanical two mass model. In the IEA, Annex XXI, "Dynamic models of wind farms for power system studies" similar research is being carried out. Previous research on this subject is presented in References [7] and [8].

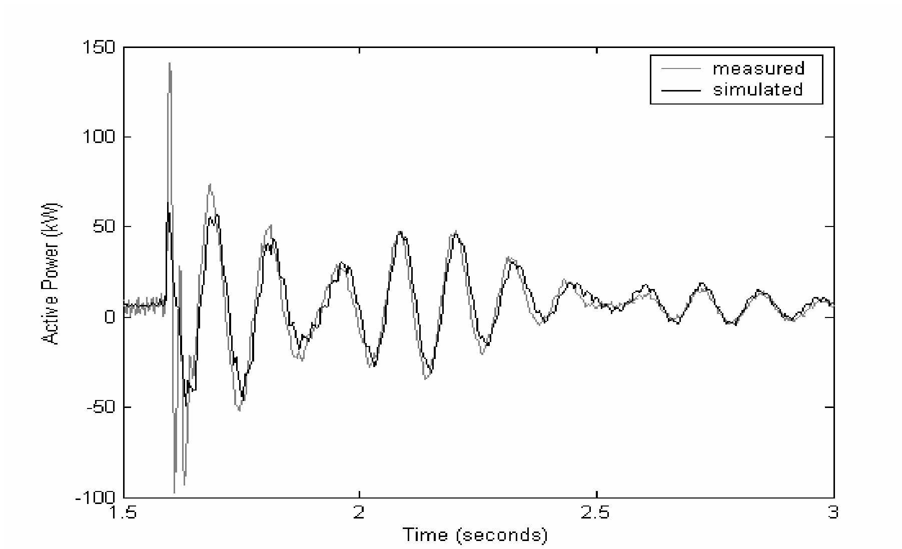

Figure 5: Measured and simulated active power of a wind turbine during a voltage dip.

Acknowledgments

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10. THE LATVIAN EXPERIENCE AND PROBLEMS OF THE GRID INTEGRATION OF RENEWABLE ENERGY SOURCES IN THE POWER SYSTEM

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Abstract – Paper considers development trends and perspectives for widespread implementation of distributed generation, based on renewable energy sources (RES) in the Baltic States. The main issue of the research is integration of RES into the power grid and electricity markets. Paper provides an overview of legislative statements and main rules, which regulates formal relationships between power producers using RES and network operators. Major problems and barriers that limit intensive development of RES are identified and possible solutions to overcome them are proposed.

Index Terms – renewable energy sources (RES), distributed generation (DG), distributed energy sources (DER), grid and market integration.

I. INTRODUCTION

The development of distributed generation and renewable electricity generation technologies in 25 years perspective are essential for achieving energy supply effectiveness, security, and commitments to reduce greenhouse gas emission [1,2]. Tendency of widespread deployment of RES technology is common for the most European and worlds' countries. At the same time philosophy and policy for effective use of the new technology and arrangements depends very much on particular conditions of individual country and geographical area [2,3]. Determining conditions are: climatic conditions, (water resources, wind velocity, solar activity), availability of generating units and their characteristics, availability of local and imported energy sources, transmission and distribution networks' configuration, parameters of end-users. To justify effectiveness of the DER implementation it is not enough to analyse only economical aspects of profit from selling of energy and cost of generation. The other aspects that have to be considered are: necessity to decrease environmental pollution, to increase power supply reliability, to raise quality of power.

This paper considers specific conditions of DER and RES implementation in the Baltic States region.

II. IMPACT OF CONVENTIONAL CENTRALISED POWER SUPPLY ON DER & RES DEVELOPMENT

Probably nobody seriously think, that DER and RES in the future could totally replace conventional centralised

power supply chain. The question is "what is the right balance (proportion) between DER / RES and centralised sources mostly based on fossil fuels? Let's consider this question on example of Baltic power system.

After the restoration of independence in 1991, when most sectors of economy, particularly industry and agriculture had readapted the activities to new market

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conditions, the power demand and power flows in the system had significantly decreased.

On the other hand, one can notice reallocation of the consumption centers, and necessity for network reinforcement in large cities, where load demand is growing most dynamically.

West regions of all three Baltic States, which include such a big industrial centers as Tallinn, Ventspils, Liepaja and Klaipieda, might face congestion problems in the future in case there would not be improvements of power network and installation of new generating capacities. At the same time, these regions potentially have favourable weather conditions for wind farms operation. Construction of considerable number of such power plants would lead to necessity of network reinforcement.

As another peculiarity of Baltic States, the low density of population, particularly in rural areas should be mentioned. The energy-consuming objects are usually located in nearby area. All these aspects result in long length of the lines, particularly at distribution level, between energy infeed points (generation or HV substations) and the end-user. Consequently, despites the low load, power quality problems becomes usual in rural areas.

Furthermore, in Latvia 500 remote households still remain unconnected to electricity supply, due to high costs of installations (total estimated costs ~4.5 MEUR). Similar problem exist in Lithuania and Estonia. In the cases, when conventional installations or reinforcements are not economically reasonable, possibly RES could provide technically suitable and economically attractive solution. In fact in some areas connection costs are so huge, that isolated system based on wind generator and battery could be a better alternative.

Another significant issue is development of ancillary services (balancing and reserve) market in the Baltic States. It will encourage more predictable power supply and demand, and responsibility of each market participants for scheduled transactions. It’s not clear to what extent RES should participate in this market.

Nowadays the level of wholesale power prices in the Baltic States does not encourage the development of neither central power plants, nor distributed generation sources. However the structure of power supply in the Baltic electricity market will change significantly in the next 5-10 years as the result of market liberalization and developments in the generation and transmission asset.

The negative impact of various economics sectors, including energy sector on environment has substantially reduced since 1990. About 47% of total electricity demand in Latvia is covered by renewable energy resources, which is much higher than EU target for 2010 – 22.1%. Cogeneration power plants share in Latvia’s energy balance is around 24%, which is also higher than EU target for 2010 – 18%. Thus, Latvia has a potential of selling CO_2 emission quotas. Deployment of RES will have minor effect on emissions reduction.

III. POTENTIAL CLIENTS OF RES

- Potential consumers (especially households), who are willing connection to electrical network, but who are located in a good distance from the network (high interconnection costs, potential place for installation of autonomous DER).
- Consumers who would like to increase its security of power supply (who need emergency power sources).
- Small dispersed consumers, who are supplied through power network of high capacity rating with high power losses.

- Consumers, who plan to increase its power demand, but who could not be satisfied (without substantial distribution investments) due to bottlenecks in the network.
- Consumers (usually industrial or commercial) who would like to be independent from the centralized power supply and prefer to have their own generator (without disconnection from central power supply).

IV. Comparison of RES Development in The Baltic States

Development of renewable energy sources in each country of the Baltic's was determined by its legislation and promotion schemes. Comparison of figures in Table I show that Latvian legislation was the most favorable for wide deployment of RES.

This superiority of Latvia in development of DER and RES seems to be quite understandable, because Latvia is the only country from the Baltic States that have insufficient capacity (capacity deficit) to cover the demand.

TABLE I: Existing Renewable Energy Sources in the Baltic States

	Number of Plants			*Capacity MW*		
	Estonia	Latvia	Lithuania	Estonia	Latvia	Lithuania
Small hydro						
Big hydro	-	3	1*	-	1535	100
Wind	2	16	-	2.0	26.9	-
Biogas	-	1	-	-	2	-
Landfill gas	1	1	3	0.8	5.3	0.8
Total	**21**	**170**	**51**	**6.3**	**1595.4**	**117.7**

** Kruonis hydro pump storage plant (800 MW) is not taken into account.*

According to Directive 2001/77/EC [8], Member States shall take appropriate steps to encourage greater consumption of electricity produced from renewable energy sources (RES) [9]. Global indicative target for RES (electricity production) is 12% of gross domestic energy consumption in the year 2010, for the European Community the target is 22,1%. National targets (Table II) for power production from renewable energy sources for the Baltic States are fixed in the Treaty of Accession to the European Union of 2003. Each country made obligation to increase its share of electricity production from RES by approximately 5% by the year 2010, however relative to gross electricity consumption of the year 2000.

If we assume the average capacity utilization factor for small hydro and wind plants about 28%, then by the year 2010 each country should build additionally 200-400 MW of RES. Taking into account the size of the systems this goal seems to be very ambitious, but realistic.

TABLE II. National targets for power production from renewable sources for the year 2010

Country	*Existing share of RES-E (average in 1999)*	*Target for RES-E 2010 (% of total gross power demand in 2000)*
Estonia	0.2%	5.1%
Latvia	42,4% (including large hydro)	49.3%
Lithuania	3,3%	7%

The role of renewable energy sources has been constantly increasing in the power sector of Latvia. During the last ten years the output of small dispersed RES has grown almost 6 times (Fig. 1).

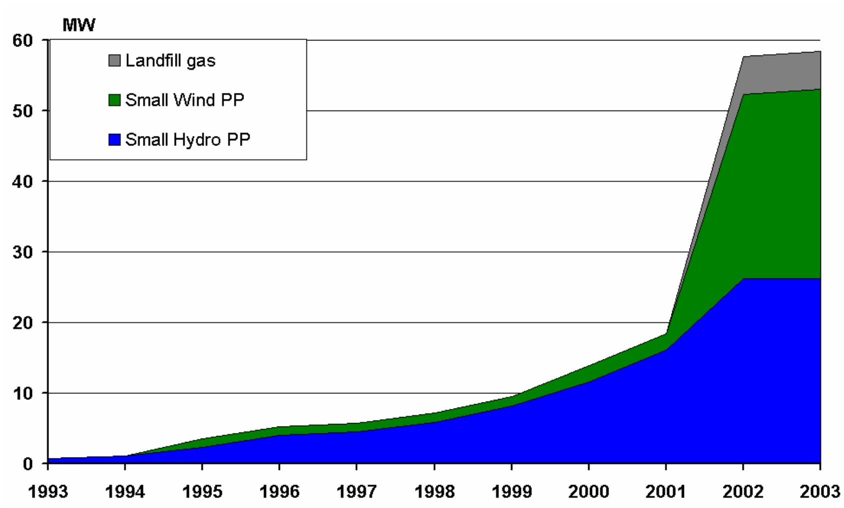

Figure 1. Development of RES's capacity in Latvia

Practically all RES in Latvia are connected to the power system at medium and low voltage levels, and do not operate as isolated systems. This is the result of influence of promotion schemes, which by incentive tariff encourage RES power producers to sell all power to system operators.

Many wind power projects were proposed, but only several of them were implemented in reality. The biggest wind project in Latvia is the windmill Veju parks (in the Western part of Latvia) with total installed capacity of 19.8 MW, which consists of 33 generators (were registered as 11 companies Veju parks 10-20).

Production pattern of Veju parks is practically unpredictable. In some periods it's operating with nominal capacity, but in some with capacity less than 1 MW.

Also on monthly basis the output of Veju parks is fluctuating (Fig. 2).

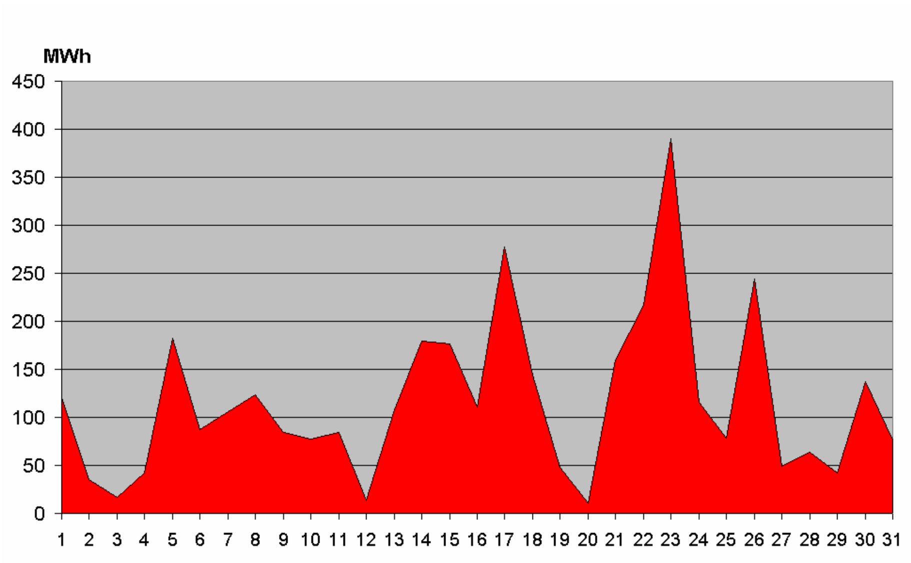

Figure 2. Output of Veju parks on monthly basis

Cogeneration and majority of RES are not flexible in terms of capacity availability (Fig. 3). They are energy limited energy sources, which depend from heat demand, water inflow, wind conditions, solar activity, availability of wastes, etc. For the year 2003 capacity utilization factor for RES in Latvia were as following: wind generators – 20%, small hydro – 22%, Landfill gas plant – 38%.

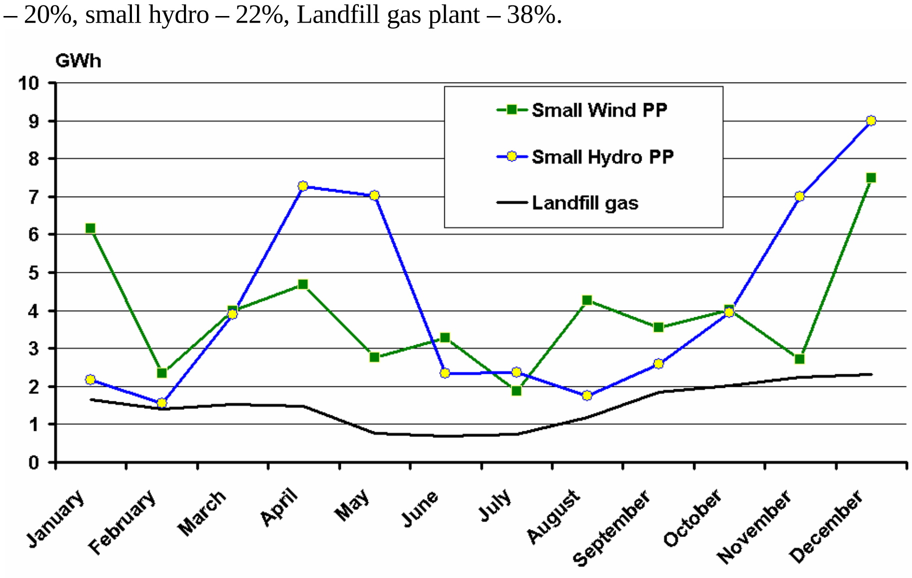

Figure. 3. Monthly output of RES and DERs in Latvia

V. LEGISLATION ON RES

In Article 40 of the Energy Law of Latvia obligation for system operators was provided to purchase mandatory a surplus of power (that has been left after consumption for own needs and corresponds the electricity quality parameters) from renewable energy sources (RES):

- Small Hydro PP with capacity not exceeding 2 MW for the price, that corresponds a double average electricity sales tariff (for the period of 8 years) if its operation was launched before 2003 and at average electricity sales tariff after.
- Power generators, which utilize household wastes or their processing product (biogas) with the capacity not exceeding 7 MW at the price, which corresponds the average electricity sales tariff, if its operation was started before 2008.
- Power generators, which use other renewable energy resources (wind, biomass, solar, etc.) at tariff set by the Regulator.

Nowadays the Electricity Market Act substituted provisions of Energy Law [4,5]. According to the Act Public Wholesaler should purchase mandatory all the power from RES at incentive tariffs (but less than double tariff). Both captive and eligible consumers are obliged to purchase (from Public Wholesaler) the share of RES electricity, proportional to its demand, (alternatively) compensate Public Wholesaler expenses or purchase “green certificates”.

Currently average energy tariff at distribution level is equal approximately to 48.7 EUR/MWh, while double tariff at distribution level is 97.5 EUR/MWh.

Table III shows the list of power plants which will receive governmental support.

Table III: Total Volume for Installation of Capacities in 2002-2004 and Specific Volume for Each Type of Electric Power Generation if Renewable Energy Resources are Utilised for Electric Power Generation

Type of RES	*Volume for Installation of Capacities, MW*		
	2002	2003	2004
Hydro-power	10	0	0
Wind power	0	1	0
Energy acquired from bio-mass, forestry or peat	10	1	1
Energy from municipal waste or their processed products (biogas)	10	1	1
Energy of sun, sea waves and geothermal energy	0	0	0
Total	**30**	**3**	**2**

In Estonia according to the chapter 59 (Purchase obligation) of Estonian Electricity Market: a network operator shall purchase (mandatory) electricity generated from renewable energy sources from a producer connected to the network of the network operator at a price equal to the weighted average price of electricity sold by the producer specified in subsection 75 (5) of this Act (Narva Power plant regulated price) multiplied by a coefficient of 1.8 (this is about 54.4 EUR/MWh) [6]. Besides in Estonia exists Green Certificate market, which may compensate partly expenses of green power producers. Cogeneration power plants have no this privilege on the price now. Its price should not be higher than the market price basically set by Narva PP. However there are discussions now to change this situation and apply the same coefficient 1.8 as for renewable sources.

In Lithuania power from renewable energy resources is purchased (mandatory) by the market operator at incentive price:

- small hydro power plants (with capacity less than 10 MW) - approximately 57.8 EUR/MWh.
- small wind power plants - approximately 63.6 EUR/MWh.
- biofuel power plants - around 57.8 EUR/MWh.

VI. Examples of the Problems Caused by Renewable Sources Implementation

Implementation of renewable resources cause many new technical and control problems for the power system [7]. This chapter illustrates some problems caused by massive penetration of renewable energy sources.

In the presence of RES in the power system there is a need in analysis of some peculiarities at the stage of planning and control of normal conditions of the power system:

- Taking into account possible problem of reactive power control. Appearance of DC/AC converters can cause excess of reactive power in a network.
- Estimation of impact of RES on frequency control in the power system. Usually RES are not participating in frequency control that put on other generators additional burden.
- Estimation of RES impact on operation stability of the power system.
- Analysis of RES parameters’ influence on quality and security of power system operation during normal operational condition. To estimate possibility and application limits for the use of RES for secure control and management of interconnected grids.
- Taking into consideration possible increase of error for the weekly and monthly forecasting of generation with a growth of RES percentage.
- Impact estimation of RES implementation to a structure, operational principles and coordination of protective relaying, automation and control systems for transmission grid.
- Analysis of operation of out-of-step protection in the power system in the presence of RES. Specific parameters and operational conditions of RES can cause specific dynamic characteristics of transients.

A. Example of frequency control in the power system containing wind power

One of the main power quality parameters is power system frequency. Power system frequency control becomes more complicated with penetration of the wind power. The reason of that is instability of wind velocity (Fig. 2). For small percentage of wind power penetration in Latvian power system problem of frequency and power control were not very important. The only problem raised was voltage and reactive power control near the wind park location site. With the growth of wind power penetration frequency control problem becomes more complicated.

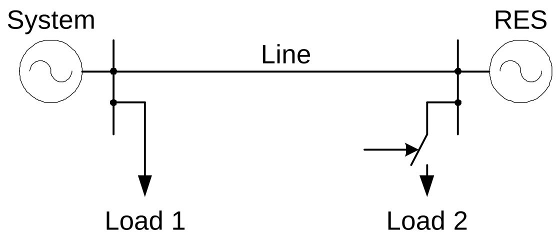

Figure 4 The structure of analyzed power system

Few modes were suggested to solve the problem. All suggested solutions provide requested frequency control quality to the certain level of wind power penetration. Paper illustrates simulation results for frequency control of joint power system containing considering amount of wind-generated capacity (Fig. 4). Wind Park has asynchronous non-controlled generators that are connected to the main grid via transmission line. Penetration of renewable sources without governors and voltage control devices put on the remaining controlled part of the system additional burden. Generators with governors should cover reserves for the primary and secondary frequency control for all power system. The larger the RES penetration the larger is needed reserves of conventional part of the power system. The second problem associated with the frequency control is possibility of non-uniform distribution of frequency control equipment along the power system. For example, wind parks mostly are concentrated in specific areas. That means that these areas will not be provided with frequency control equipment. It causes possibility of overloading transmission lines connected wind park areas with the rest power system.

Additional features, which should be taken into account during the RES implementation, are necessity to disconnect generators on the underfrequency. Fig. 5 presents results of frequency behavior simulation of emergency situation in the power system caused by connection of additional load (Load 2) to the power system. Created 10% of active power deficiency cause decline of the system frequency. When frequency reaches 48.5 Hz level protection devices disconnect the wind park. The loss of additional 5% of generation causes frequency avalanche in considered system leading to the system blackout.

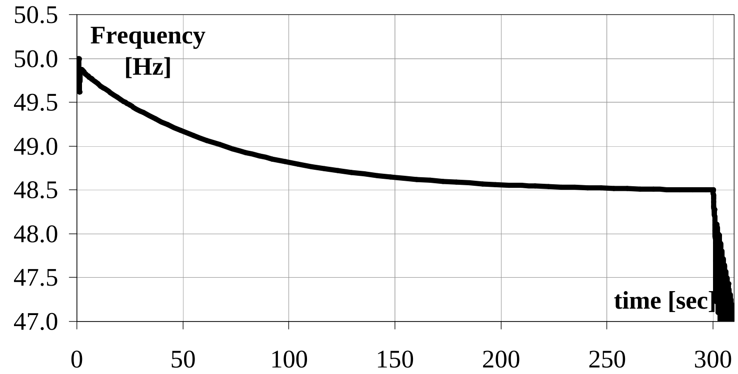

Figure 5. Results of simulation

B. Features of out-of-step conditions in the presence of RES

Another problem raised due to a massive implementation of RES units is problem of power system synchronism. With many distributed RES units being installed, the impact to the power system stability may be significant. Now RES generators are located close to the distribution network. Loss of the synchronism problems for the generators in the transmission network are well studied [8,9]. Analysis of out-of-step conditions at the distribution level is the new problem. Many RES units are not designed to stand asynchronous condition. For a full assessment of the overall performance of the distribution network and of the proposed RES the following steady state and transient stability investigations may be undertaken:

- prediction the ability of the generator to recover and remain connected to the network following a fault within the network;
- assessing the interaction of the generators and other rotating plant connected to the network immediately following a fault;
- to ensure that there is little possibility of voltage disturbances due to the failure of the generator to remain in synchronism.

The devices for detection and elimination of asynchronous operation (AO) (out-of-step and first swing protection) are widely accepted in the networks, having the increased risk of the loss of synchronism [4].

Within the framework of this paper the possibility of application of the considered device type is examined further with the purposes of providing a stable operation of networks with distributed energy resources including RES units. The issues include the dynamic stability consideration within the RES, the loss of synchronism example for RES and inspection of the application of an AO detection algorithm.

C. Special features of the distribution networks from the loss of stability point of view

The loss of stability processes in RES are influenced by a number of the new conditions:

- a number of new generation technologies is available and profitable for RES that operate in the same AC distribution network with synchronous generator (SG);
- specific SGs, connected to the distribution network, have small inertia constant. Difference of the generators inertia can play significant role (generation unit sizes, parks of generators);
- operational parameters of relay protection and automation devices of RES units are different from transmission networks and must be taken into account.

The electrical characteristics of synchronous generators, induction generators and electronic inverters are quite different particularly with respect to continued operation under fault condition that may lead to the loss of synchronism.

The specific transient processes are illustrated in the following section taking into account all mentioned above conditions.

D. An example of the loss of synchronism processes' dynamics

The possibility of the appearance of such processes is indicated by simulation results and presented in this paper.

A part of urban distribution system in Latvia with planned increase in RES penetration has been modelled using PSS/E software (Fig 6.). Model includes 10 kV grid, synchronous generators of different sizes (buses 57, 58, 78 and 79) and generating source connected via electronic inverter (bus 54), and connect point to the 110 kV grid.

According to the results of the simulation the fault led to the loss of the synchronism of the generators, which remained in operation.

Fig. 7 shows a change of the angles of rotor for different generators.

We can show further that the loss-of-stability process can be detected with the use of a protection device (PD in Fig. 6), which measures, for example, the current and voltage of a 110/10 kV transformer.

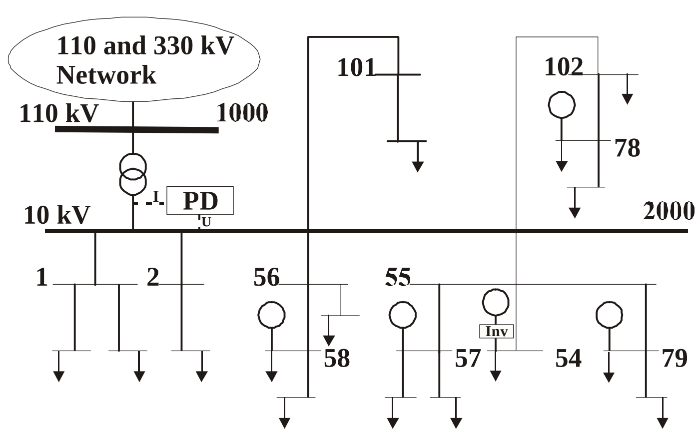

Figure 6. Diagram of the distribution network model

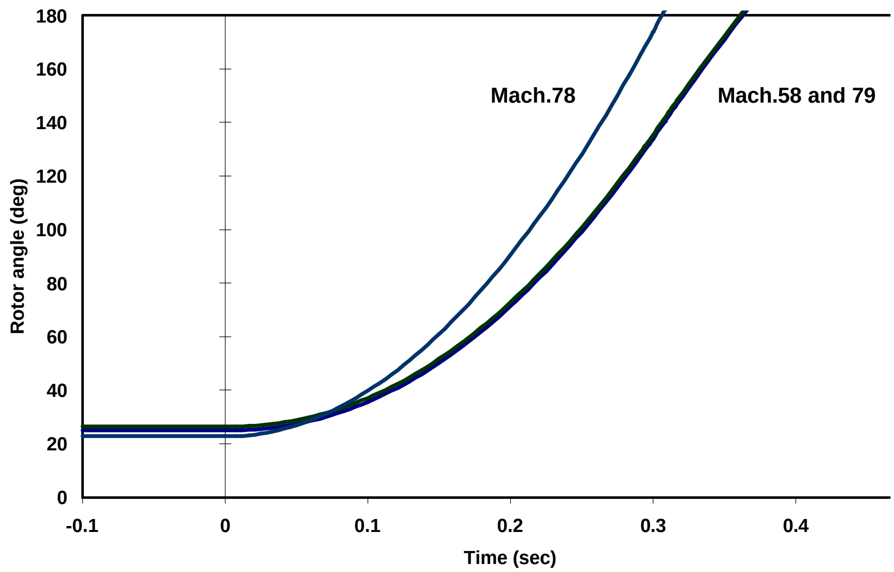

Figure 7. Rotor angle instability

E. New algorithm for detection of out-of-step condition in the network with RES

The algorithms of devices for elimination and liquidation of unstable processes in the transmission networks are well developed and checked in practice [10,11,12]. For example, in the Baltic States (Lithuania, Latvia and Estonia) the local devices of automation, which prevent angular instability in the transmission grid, obtained wide application [13].

The possibility of applying the algorithms, developed by authors for detection of asynchronous conditions in the presence of RES, is the object of the further consideration in this paper.

The operation of the local devices under consideration is based on control of the angle *j* between two simulated voltages $\underline{U}_1$ and $\underline{U}_2$ in a two-machine circuit, which corresponds to an angle *d* between two non-synchronous equivalent EMF $\underline{E}_1$ and $\underline{E}_2$.

Calculation of the phasors of equivalent EMF $\underline{E}_1$ and $\underline{E}_2$ based on the following two hypotheses:

1. There are known modules of EMF, $\underline{E}_1$ and $\underline{E}_2$ (in power systems the voltages at the network nodes under normal conditions vary within relatively narrow limits) [13].
2. There are known angles of impedances Z_{1S} and Z_{2S} (in a network these angles vary within relatively narrow limits).

The proposed Algorithm was tested using an appropriate software package for simulation of dynamic transient processes in the power system.

The calculated value of the angle between asynchronous EMF fully corresponds to a real transient process for all the adopted values of modules $\underline{E}_{1S}$, $\underline{E}_{2S}$ (simulated angle difference). The results obtained allow for a positive estimation of Algorithm's characteristics in the process of control over the difference of angles between the phasors of asynchronous equivalent EMF in the distribution network.

VII. CONCLUSIONS

1. Latvian utility has already positive experience with high share of RES.
2. Problems and limits for massive RES penetration are clear enough.
3. Presented examples show possible solution of the RES implementation problems.

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11. WIND INTERMITTENCY, MITIGATION MEASURES AND LOAD MANAGEMENT.

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Abstract**—**A major problem with wind power is that it is intermittent. Even if it were predictable, the problem of matching generation to demand is difficult. Storage is sometimes advocated, but this tends to be very expensive. The paper examines the main conventional solutions to the intermittency problem – provision of extra reserve generation to compensate for unexpected wind power lulls, and increased interconnection to facilitate support from, and for, neighbouring utilities. The paper then considers a third avenue – use of wind energy to supply heating load. It is feasible to incorporate low-cost energy storage as part of a wind-powered heating package for domestic consumers. It is argued that co-ordination of the dispersed storage can help solve the wind intermittency problem.

Index Terms**—wind energy, thermal energy storage**

Introduction

Wind energy can provide abundant electrical energy at modest cost in many parts of Europe. However, the power from wind at the level of a small country, such as Ireland or Scotland, is variable. Utilities can deal with the variability of wind power in a number of ways

:

- Adjusting conventional generation
- Increasing power interchange with neighbouring utilities
- Matching part of the utility load to wind generation

Operating a wind-rich utility is hampered by the difficulty of forecasting wind power and by the inflexibility of conventional generators. Reinforcing interconnections is expensive and may be unpopular. Nonetheless, utilities have tended to adopt one or both of these approaches as wind capacity has expanded.

We will consider the problems with these mainstream attempts to mitigate wind power variability. Fortunately, there is an alternative – load management allied to wind generation. The paper will examine the prospects for this 'third way'

.

GENERATION SCHEDULING WITH SIGNIFICANT WIND POWER PRODUCTION

There are two broad approaches to this problem – 'business as usual' or active scheduling based on a wind power forecast.

The first approach assumes that wind power over the scheduling period – typically the following day – will be zero. The result is a very conservative schedule. Should wind power become available, fossil-fuel generation is reined back, with a fuel saving. The fuel saving would be greater if one or more generating units could be de-committed, but this option is not taken in case of a wind power lull. The effect on emissions is less clear-cut. In the case of combined-cycle gas turbines (CCGTs), there would be an almost proportionate reduction in carbon dioxide emissions. However, nitrous oxide emissions increase dramatically when CCGTs are run at part load.

In spite of the drawbacks, conservative scheduling has been the natural response of most system operators. It is probably the best approach when wind energy penetration is less than 5%, which is the current situation in Ireland and the United Kingdom. This *modus operandi* is referred to as the ‘fuel saver’ option.

When wind energy penetration exceeds 10%, the fuel and emissions cost of part loading fossil fuel generation demands integration of wind production in the scheduling process. There is now a need for wind power forecasting. A forecast of significant wind power could reduce the committed capacity of fossil-fuel generation. This capacity would then be more cost-effective and produce lower emissions than the fuel saver option. The problem is that an optimistic wind power forecast would undermine the system’s operating reserve. It may not be possible to redeem the situation by committing more generators – most conventional plant requires a lead time of 6 – 12 hours to come on-line. Quick-start generation is expensive to run and adds to CO_2 emissions. The challenge here is to balance aggressive scheduling against the cost of quick-start generation and the associated emissions. There is an optimum level of scheduling aggression – the more accurate the wind power forecasts, the more confident the system operator can be about de-committing conventional generation to make way for wind power.

It should be noted that a market-driven energy exchange will face the same challenges from wind power as the traditional centralized control structure. The main difference is that generating companies will decide not to commit some conventional generation when significant wind power is expected. This will reduce the company’s fuel bill by avoiding the no-load costs of running superfluous plant [1].

UPGRADING INTER-CONNECTORS

It is well known that the temporal variability of available wind power decreases as the area of interest increases [2]. Thus wind power in Ireland has significant variability. When Ireland is considered along with Great Britain, the variability of the increased resource is less. If this process is applied to an entire continent, say Europe or North America, the total available wind power approaches a constant amount. It is sometimes therefore asserted that the solution to temporal variations within national boundaries is to invest in interconnection. The nearly constant wind power generation across a continent may then be wheeled around from productive to non-productive areas.

This argument is misleading. Wind power has a low load factor, typically between 30% and 40% [2]. Furthermore, the probability of wind power surfeit at the same time as low local demand is lower again. Thus there will be a low probability of export/import opportunities – and these occur when demand, and hence price, is low. Thus the value of wind export/import on a large scale is unlikely to justify investment in transmission.

Energy markets have tended to highlight the economic realities of transmission costs. Capacity is purchased well in advance to facilitate trading between predictable demand and firm capacity. It is unlikely that scarce inter-connector capacity would be made available to accommodate occasional wind power imbalances. It would probably be more economic to spill the excess wind power on the rare occasions when transmission is congested, rather than to expand transmission just to rescue the small amount of energy involved.

MANAGED HEATING LOAD

The value of wind power for electricity supply is undermined by its poor correlation with demand. Unpredicted wind power ‘dumped’ on the system attracts low energy payments, reflecting the fact that the utility will probably have had to reserve firm generation capacity for the expected demand. Thus the wind energy is competing with the fuel element of thermal generation cost only.

Power system operators have always wanted to tailor the demand to suit the available supply. One area where this philosophy has been applied is to domestic off-peak space or water heating [3]. The heat demand is shifted in time from peak periods, when generation capacity is stretched, to night-time, when spare capacity is available. The generating cost is also less at off-peak times.

This approach is possible because heating devices have inherent storage. A well-lagged domestic hot-water tank of reasonable size can deliver adequate hot water over 24 hours derived from 7 hours of supply during the night [3].

The suggestion here is to match water and space heating load with wind power output. When wind power is plentiful, water in a large, insulated storage tank is heated to a high temperature. A point may be reached when further water heating is impossible. ‘Excess’ wind power would then be available to the pool, probably earning less as a result. Conversely, there will be times when heating energy is required during wind power lulls. At such times the stored hot water would supply the domestic heat demand.

There will be times when wind power is insufficient to maintain a minimum water storage temperature. The stored energy could then be topped-up by using off-peak brown electricity. This should actually be quite rare, because wind power is loosely correlated with heating demand. It is windier in the winter than the summer, and windier during the day than during the night. Furthermore, the space heating demand will be somewhat greater when it is windy – the ‘wind chill’ factor.

How can such a scheme be achieved in practice? One approach may be to use mains signalling or radio tele-switching [3] to communicate favourable wind conditions to consumers. Wind power level could be communicated as a signal which adjusts the local water heater power, perhaps using MOSFETs switched to achieve a suitable mark-space ratio. A possible co-ordination scheme is illustrated in Figure 1.

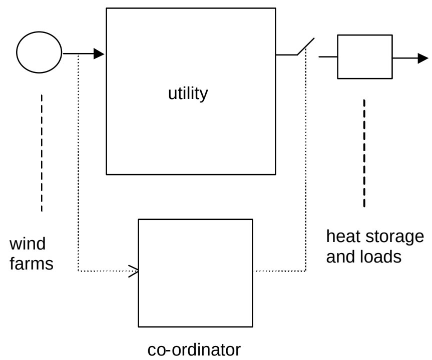

Figure 1. Wind power and heating load coordination

The heat demand for a typical domestic dwelling with good insulation is 1 kW. A water heat store of 1 m^3 could be charged to 90^0C by a 3 kW heater from an ambient temperature of 10^0C in 31 hours. If the temperature is allowed to decrease to 70^0C, the store would provide the average I kW of heating load for 23 hours, ignoring losses. The losses could be significant. However, locating the heat store in the house would enable these losses to contribute to space heating.

Assuming a wind farm load factor of 0.333, a capacity of 300 MW could be associated with 100,000 consumers with an average demand of 100 MW. The coordinator's task would be to minimize the imbalance between current wind production and heat demand. In this he would be helped not just by the dispersed storage, but also by the loose correlation between heating demand and wind speed.

The effectiveness of the proposed scheme would depend heavily on the overall design. The heating and storage system would have to take account of the building design, especially the level of insulation. The size of the store and its temperature variation would need to be optimized in relation to the heating requirement and the variability of the wind power supply.

The coordinator has a number of options which could improve the overall economics of the scheme. For example, it may be economic to use cheap, off-peak, brown electricity to top up the stored heat when wind power is scarce. Conversely, wind power could be sold to the pool when electricity is expensive. The overall effect of these actions would be to reduce the peak demand for conventional plant and to increase the off-peak demand. Thus the system would experience a smoother demand variation, due fundamentally to the dispersed storage. The smoother demand variation would probably result in lower transmission losses.

There would also be lower losses at distribution level. In addition, peak wind generation at times of low demand could be off-set by heating demand on the same feeder. This would reduce distribution voltage rise and enable a greater wind capacity to be connected.

The adoption of wind power for domestic heating would require a commercial incentive for consumers. The competition is oil- and gas-fired central heating. The price of these fuels is increasing steadily, while the price of wind power is decreasing. Also, the cost of the water storage tank and heater is likely to be less than a boiler. Maintenance costs would be negligible. Fitting new low-energy housing with this technology, perhaps allied to under-floor heating, would reduce the size, capital and running costs of the installation.

There is also a potential system benefit. The 'green utility', embracing a number of wind farms/parks and a balancing heat demand with local storage, has the ability to disconnect load for periods up to perhaps an hour without detriment to consumers. This emergency reserve capability could be sold back to the host utility, helping to defray the use of system charges.

Conclusion

Wind power generation is intermittent, and this contribution has summarized three possible mitigation measures.

It is possible to simply remove load from conventional generation as wind generation increases. At wind energy penetrations above 10%, it becomes possible, and desirable, to de-commit fossil-fuel generators to make way for the greater wind power levels. An unexpected wind power lull would then require the use of quick-start but inefficient generation with increased emissions. Cost and emissions savings when the wind power forecast is accurate should exceed the extra cost and emissions of quick-start generation needed to compensate for optimistic forecasts.

It is difficult to argue strongly for investment in inter-connectors to handle occasional wind power export.

The central proposal here is to develop a market for wind-powered electric domestic water heating. This would feature hot water storage to help the heating system ride through wind power lulls. Off-peak brown electricity could be used during longer wind power lulls. The scheme provides a match between a low-grade, intermittent source and a low-grade application. This has significant environmental advantages over using premium fossil fuels for heating. A properly engineered and marketed delivery system would be competitive with fossil-fuel based heating, thus directly contributing to greenhouse gas reduction.

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Biography

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12. DEEP: A EUROPEAN INTEGRATED PROJECT WITH A DIFFERENT R&D APPROACH TO THE INTEGRATION OF DISTRIBUTED ENERGY RESOURCES AND RENEWABLE ENERGY SOURCES IN MARKETS AND ENERGY GRIDS

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Introduction

Distributed Energy Resources (DER) is already used in Europe (for instance wind farms or combined heat and power mostly in industry). However there is a trade-off between the benefits of DER and the adverse grid effects at the transmission and even distribution level. This is particularly true in areas where stochastic Renewable Energy Sources (RES) are present such as the large wind farms in the northern part of Europe.

Grid Effects

Adverse grid effects are partly responsible for the relatively limited development of RES. Much R&D has been devoted to mitigate these adverse grid effects in the past. Most of this R&D is aiming at developing new grid components and management strategies. However these approaches suggest that a comprehensive overhaul of the electrical grid system is necessary in order to accommodate large amounts of DER and RES.

R&D Approach

A different R&D approach has been recently proposed by a group of eight European utilities and has been accepted for funding by the European Commission within its 6th R&D Framework Program. This approach is implemented in the Integrated Project named "The birth of a European Distributed Energy Partnership that will help the large-scale implementation of distributed energy resources in Europe" (EU-DEEP). The new approach does not require upfront large modifications of the electrical grid, but relies instead on existing technologies and practices. Both the existing and the new approaches are nevertheless complementary (see Fig. 1).

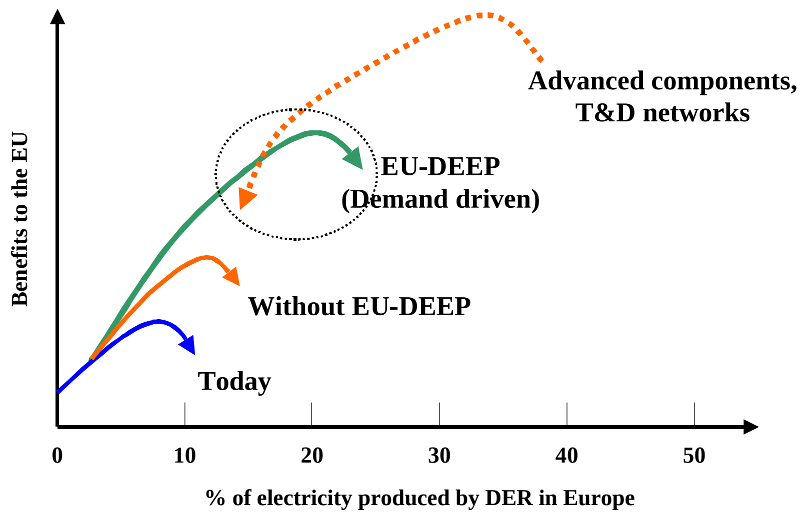

Figure 1 Relationship between the new demand-pull approach and the existing technology-push approach

Together with manufacturers, research organizations, professionals, national regulators and a bank, the utilities propose to remove, in five years, the most important technical and non-technical barriers which prevent massive deployment of DER in Europe. This partnership will implement a demand-pull rather than technology-push approach. By sharing market data and constructing a model of the European demand, this approach allows to identify demand segments which can benefit from DER solutions, and foster the R&D required to adapt DER technologies to the precise demand of the selected segments.

In order to validate this approach, a set of five demand segments will be studied in three market sectors (industrial, commercial and residential) for one or two types of DER demands ("incremental-DER" from existing DER applications, and/or "DER-breakthrough" from the study of disruptive behaviors introduced by new trading mechanisms). After a one-year experimental measurements campaign to gather realistic data on the life cycle costs of the candidate technologies, manufacturers should be in a position to launch industrialization tasks of the most promising DER solutions. In addition, regulatory bodies should be able to release some of the barriers that still prevent more DER solutions from reaching market applications.

This activity has been subdivided into 9 Work Packages (see Fig 2):

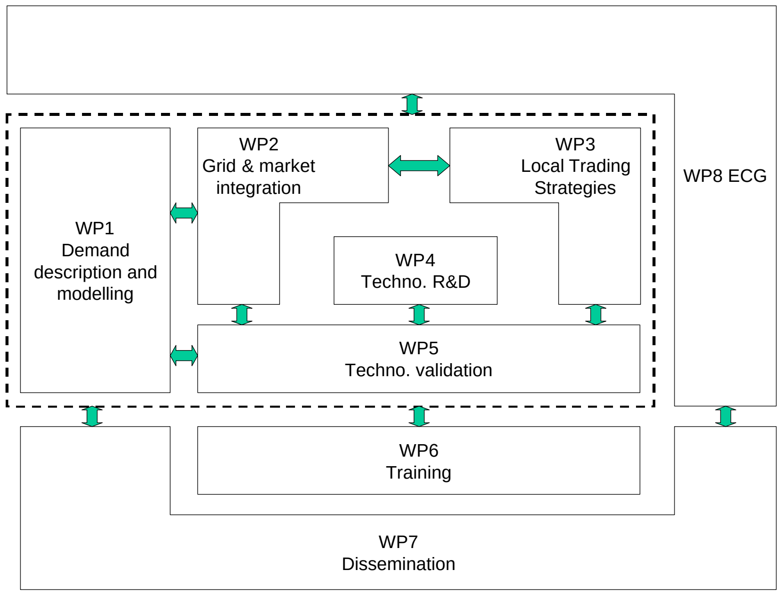

Figure 2 Organisation and inter-relations between Work Packages in the EU-DEEP Integrated Project:

The first 5 Work Packages are highly inter-related:

1. **In WP1:** the demand for DER is detailed into demand segments that will provide a range of specifications from end-users;
2. **In WP2:** network and system issues are examined by simulating respectively limited to large penetration of DER. For the segments identified in WP1, equipment specifications are drawn-up for safe and reliable connection to the grid, yet adapted to the demand segments identified in WP1;
3. **In WP3:** the local trading strategies are studied and developed, with a possible feed-back to demand segments in WP1 and/or grid management in WP2. Equipment specifications are drawn-up for the implementation of Local Trading Strategy (LTS) approaches adapted to the demand segments identified in WP1;
4. Meanwhile, market rules and regulations are also examined **in WP2** on the basis of the specification from end-users from WP1, grid management issues in WP2 and the possibility of local trading strategies in WP3;
5. **In WP4:** the specifications for equipments are drawn-up from end-users requirements obtained in WP1, and the equipment specifications obtained in WP2 and WP3. These are provided to equipment manufacturers in WP5.
6. **In WP5:** the equipment manufacturers are provided with the specifications from WP4. They can therefore perform research and finalize the development of their DER technologies.

7. Finally, a one-year experimental measurement campaign is prepared and performed in WP4 in order to provides validated performances back to grid connection issues and LTS approaches in WP2 and WP3 respectively.

This interaction will be repeated for 5 demand segments over the course of the 5 years project, covering up to two types of demand segments in each of the three "fundamental" market sectors (residential, commercial and industrial):

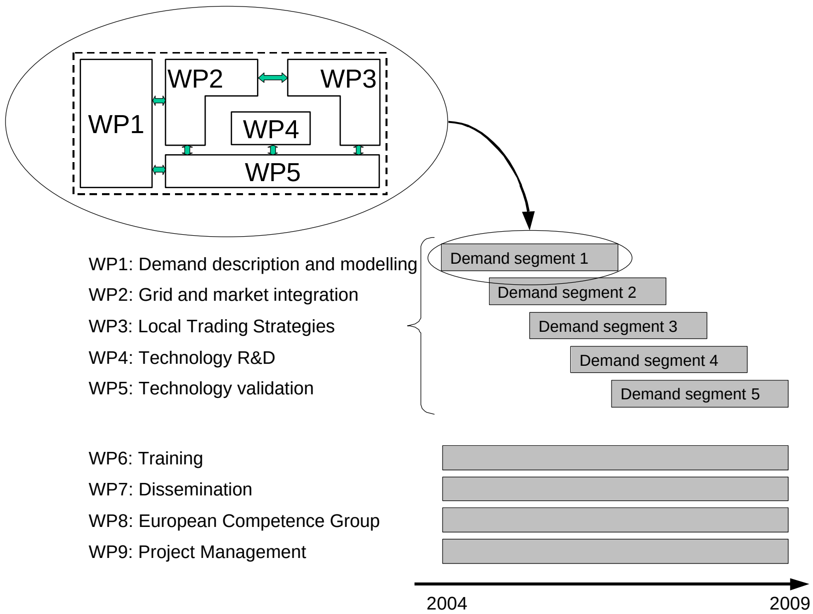

Figure 3 Overview of the time spread of the analysis of the 5 demand segments

The last 4 Work Packages are more linearly linked:

8. **In WP6:** the training activities exploit results obtained in WP2, WP3 and WP5. A feed-back from training activities is expected in WP1 and WP8;
9. **In WP7:** dissemination are carried out that should prepare DER stakeholders for the commercial exploitation of the project results by the ECG.
10. **In WP8:** the European Competence Group (ECG) is built. It provides the business models for fast-tracks penetration of DER in Europe on the basis of all the results obtained in WP1, WP2, WP3, WP4, WP5 and WP6;
11. **In WP9:** is where the coordination and strategic management of the project takes place.

This new R&D approach applies to any DER technology, including RES. It has the potential to help identify "fast track options" for large-scale penetration of RES in Europe. With a budget of approximately 29 M€ (of which 15 M€ are provided by the European Commission) it should produce complete results for the first of the five selected market segments by mid-2007.

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