Project logo:

Priority logo:

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ENTER

Proceedings

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6th BALKAN POWER CONFERENCE

1st Decision Makers Workshop

"Best practice transfer in RES technology"

Moderator: Prof. Vlastimir Glamočanin

1. Prof. Lucian Toma, The University "Politehnica" of Bucharest, Romania
"The design of micro-hydro power plants and implementation projects in Romania"
2. Mr. Almir Ajanović, Intrade – energija ltd., Bosnia and Herzegovina
"Techno-economic characteristics of SHPP-s use - case of Bosnia and Herzegovina"
3. Prof. Nikos Hatziargyriou, NTUA, Greece and Prof. Pavlos Georgilakis, NTUA, Greece
"Techniques for maximizing the wind power penetration in autonomous power systems"
4. Ms. Vesna Bukarica,University of Zagreb, Croatia
"Techno – economics characteristic of wind energy use – Case of Croatia"
5. Dr. Constantine Karytsas, CRES, Greece
"Low enthalpy (T<150ºC) geothermal power generation"
6. Prof. Dimityr Popov, Technical University of Sofia, Bulgaria
"Prospects for biomass based power generation in WB Countries"
7. Ms. Elena Boškov, DMS Group ltd., Serbia and Montenegro
"Analysis of possible connection of wind turbine on 10 kV network using DMS software"
8. Mr. Borut Del Fabbro, Istrabenz Energetski sistemi, Slovenia
"Financing a RES project - case of a small HPP"
9. Prof. Vlastimir Glamočanin, "Ss. Cyril and Methodius" University, R. Macedonia
"Legislative incentives and implementation projects of SHPP in R. of Macedonia"

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EESTEC LC Skopje

LC SKOPJE

BACK

Legislative Incentives and Implementation Projects of SHPP in R. of Macedonia

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Faculty of Electrical Engineering,
Ss. Cyril and Methodius University, Skopje, Macedonia

Sixt Framework Programme, Priority 6
Sustainable Development, Global Change and Ecosystems ; Contract: INCO-CT-2004-509205

General Provisions of *the new* Energy Law

- The Energy Law governs:
  - …market for thermal or geothermal energy, requirements for realization of energy efficiency and promotion of the utilization of renewable resources.
- One of six objectives of the Energy Law stands for:
  - energy efficiency enhancement and encouragement of the utilization of renewable resources
- Detailed list of energy activities (23 activities) is defined by the Energy Law and two of them are related to EE and RES:

Energy Policy

- The policy for renewable energy resources exploitation is established within the Strategy for renewable energy resources exploitation The national policy for the energy sector shall be established based on 7 principles among which:
  - Promotion of energy efficiency and sustainable development of renewable energy sources
  - The National Energy Policy shall be laid down in the Energy Development Strategy and the Implementation Programme of the strategy. The Energy Agency shall provide support to the Government in the implementation of the energy policy.
- The Development Energy Strategy shall address:
  - …
  - incentives for investment in energy facilities that shall utilize renewable energy sources;
  - incentives regarding the enhancement of energy efficiency;
- The Energy Development Strategy shall be adopted for a period of at least ten years.

The Programme for Realization of the Energy Development Strategy

- The Programme for realization of the energy development strategy, adopted by the Government of the Republic of Macedonia shall address:
  - …energy efficiency, possible utilization of renewable energy resources...
- The Programme shall be adopted for a period of five years.
- The Programme shall, in particular, determine:
  - …
  - the measures and activities for enhancing the energy efficiency and generation of energy from renewable sources.

The Regulation of the Energy Activities

- The regulation shall be ensured on way accordance with this law, through adoption of:
  - …
  - Methodologies for price setting as to certain types of energy and regulated services,
  - Tariff systems with regard to relevant types of energy;
  - Prices of specific types of energy in compliance with the price setting methodologies and tariff systems for relevant types of energy and services related to the pursuing of different energy activities;
  - Construction of new and reconstruction of existing buildings from the aspect of energy efficiency;
  - Certificate for energy characteristics of a building;
  - Energy efficiency labeling of home appliances;
  - Utilization of renewable energy resources;
  - Green certificates;
  - …

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Construction of New Energy Facilities

- By exception, if, based on the Strategy for energy development in the Republic of Macedonia, the prognosis for the demand of electricity and the possibilities for satisfying those needs, it is estimated that the long - term security of supply has been disturbed, the Ministry may launch a public announcement concerning the construction of new electricity generation facilities.
- Before the adoption of the decision for starting the public announcement procedure for the construction of new facilities, the Ministry shall determine whether the security of electricity supply may be assured by energy efficiency measures.
- The public announcement for the construction of facilities may be published in function of determining a preferred producer of electricity, in accordance with the Strategy for energy development in the Republic of Macedonia, due to the necessity of reducing the negative impact on the environment and improvement of the exploitation of renewable energy resources, as well as the introduction of new technologies and combined electricity and thermal energy production.

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Energy agency

- The Energy agency of the Republic of Macedonia gives its support to the Ministry in the elaboration and implementation of the Strategy for improvement of energy efficiency and the Strategy for renewable energy resources exploitation.
- The Energy agency of the Republic of Macedonia gives its support to the Ministry in the elaboration of the Programme for the implementation of the Strategy for renewable energy resources exploitation.

The Strategy for Improvement of Energy Efficiency

- The Strategy for improvement of energy efficiency defines the aims for increase of energy efficiency and the modalities according to which those aims should be accomplished, namely:
  - reducing the energy consumption per GDP unit in the Republic of Macedonia;
  - increasing the energy efficiency in all sectors of state policy;
  - promoting new technologies with high degree of energy efficiency;
  - promoting measures for increasing the energy efficiency;
  - raising the public awareness for the aims of the energy efficiency; and reducing the harmful effect on the environment provoked by the production, transfer, distribution and exploitation of energy.
- The Strategy for improvement of energy efficiency shall be adopted for a period of at least 10 years.

Programme for the implementation of the Strategy for improvement of energy efficiency

- The Programme defines the measures for improvement of energy efficiency and contains:
  - measures;
  - financial resources;
  - implementation requirements;
  - indicators for achieved results;
  - technical regulations and national standards for energy efficiency
  - other relevant data, and
  - the entities performing the activities and the delays for realization of envisaged activities.
- Programme for the implementation of the Strategy for improvement of energy efficiency shall be adopted for a period of at least 5 years.

The Strategy for the exploitation of renewable energy resources

- The Strategy for the exploitation of renewable energy resources defines the aims of renewable energy resources exploitation and the modalities of achieving these aims, namely:
  - the potential of renewable energy resources;
  - the possibilities for exploitation of the potential of renewable energy resources;
  - the volume and dynamics of representation of renewable energy resources in the energy balance;
  - introducing production certificates for renewable resource energy for the purpose of establishing market economy;
  - defining transitional measures for subvention of the renewable energy resources exploitation through special tariffs, financial assistance and other.
- The Strategy for the exploitation of renewable energy resources shall be adopted for a period of at least 10 years

Programme for the implementation of the Strategy for renewable energy resources exploitation

- Upon the proposal of the Ministry, the Government of the Republic of Macedonia adopts a Programme for the implementation of the Strategy for renewable energy resources exploitation.
- Programme for the implementation of the Strategy for renewable energy resources exploitation shall be adopted for a period of at least 5 years.

The Rulebook on the exploitation of renewable energy resources

- The Rulebook on the exploitation of renewable energy resources defined by the minister in charge of energy issues closely defines the measures for exploitation of renewable resources, namely:
  - the target percentage and year of including renewable energy resources in the energy balance;
  - the percent of participation and dynamic plan for realisation of the target percentage of participation of renewable energy resources in the energy balance;
  - the procedures for issuing and registration of green certificates for renewable energy for the electricity suppliers;
  - providing financial assistance;
  - implementation requirements;
  - indicators for achieved results;
  - raising the public awareness about the advantages of renewable energy resources exploitation;
  - other relevant data, and
  - the entities performing the activities and the delays for realization of envisaged activities.

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Green certificates

- EARM issues and maintains a registry of issued green certificates.
- All electricity suppliers shall provide or produce a relevant quantity of green certificates in the course of one year. The quantity is defined as a percentage of their annual sale of electricity determined in the Rulebook. Only the green certificates entered in the Registry may be used for fulfillment of this obligation.
- The supplier having a lack of green certificates shall make a payment per certificate determined by the Rulebook, to a special account published by the EARM for the purpose of financing new renewable energy resources.

Tariffs for purchase of electricity from renewable energy sources

- Until the establishment of functional mechanism for trade in green certificates, the Regulatory Commission shall establish relevant tariffs for purchase of electricity from the distributional generation of electricity from renewable energy sources.
- The green certificates produced by the distributed producers of electricity that use special tariffs shall be considered as property of the Government of the Republic of Macedonia.
- A distributed producer of electricity from renewable energy sources must not use special tariffs and green certificates simultaneously.
- In order to support the exploitation of thermal renewable energy resources the Regulatory commission establishes feed–in tariffs for purchase of thermal energy produced by renewable energy resources

Financial assistance for realization of the Strategy for renewable energy resources

- A mechanism for financial assistance is established for the realization of the Strategy for renewable energy resources exploitation.
- The means for financial assistance shall be provided by:
  - The Budget of the Republic of Macedonia;
  - The budgets of municipality or budget of Town Skopje
  - grants, donations, sponsorships by foreign and domestic entities; and
  - foreign and domestic loans;
  - state subsidiary in accordance with Law for state subsidiary.

Hydro potential of Macedonia

- 80% mountains
- 2% water comprising 35 large and small rivers, 3 natural and 50 artificial lakes make Macedonia’s hydro potential.
- The total theoretically exploitable energy potential of all rivers is 6.434 GWh. Only 1.370 GWh of that potential is used, which gives less than 22 % usage.
- In this moment almost 30% of installed energy capacity in Macedonia is from HPP
- 7% is from 21 sHPP.

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RENEWABLE ENERGY SOURCES IN WESTERN BALKANS

Existing 21 sHPP in Macedonia

Total capacity 45,5 MW

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RING of 7 sHPP

FIRST CONCESSION PROJECT IN MACEDONIA for Rehabilitation, Operation and Transfer of 7 sHPP's:

- HPP DOSNICA
- HPP KALIMANCI
- HPP MATKA
- HPP PENA
- HPP PESOCANI
- HPP SAPUNCICA
- HPP ZRNOVCI

CONCESSION GRANTED TO MAKHIDRO

- **Total investments 20 mil EUR**
- **Total capacity 30 MW**
- **Total generation 86 GWh**
- **Period of concession 11 years**

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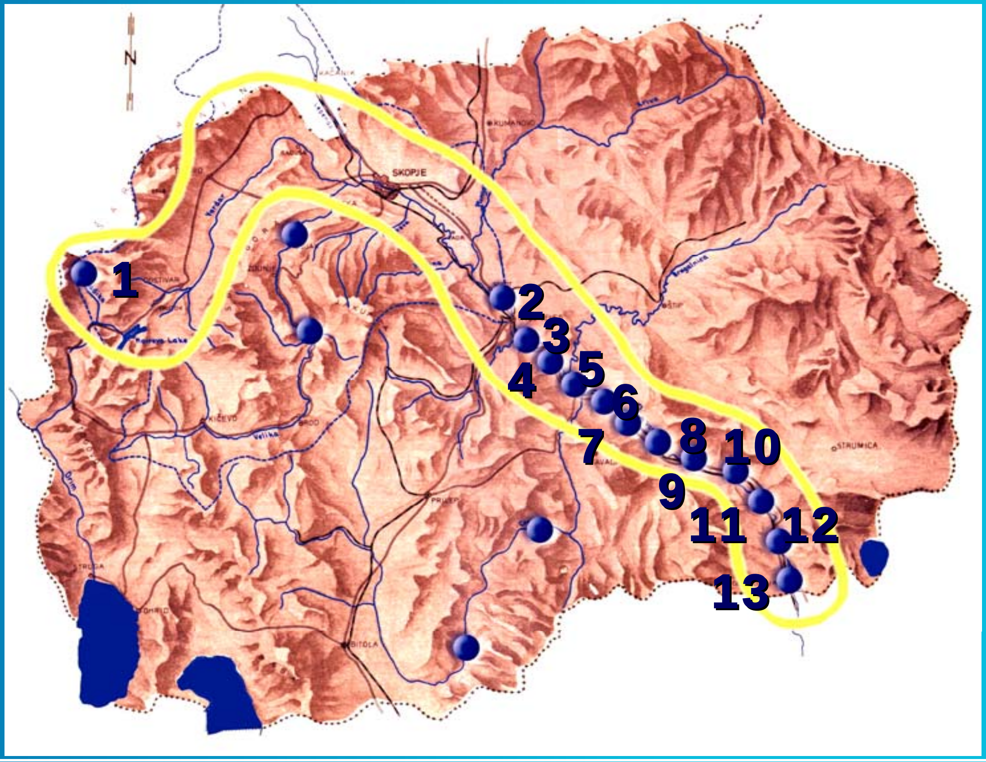
Vardar Valley project – 13 sHPP

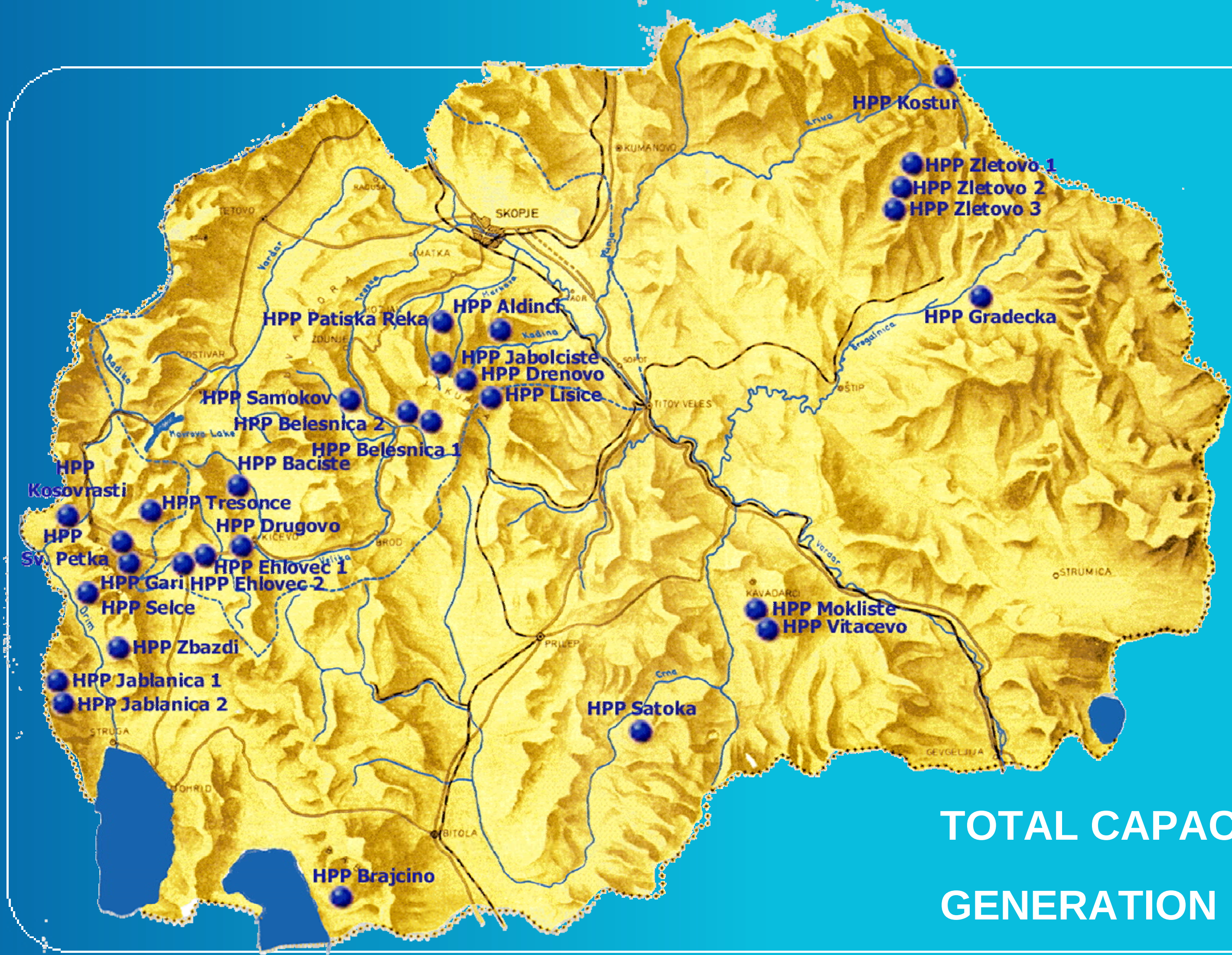
The Feasibility Study deals with development of:

- Energy sector, Agricultural sector, Environmental protection



1. **Storage Lukovo Pole**
2. **HPP Veles**
3. **HPP Babuna**
4. **HPP Zgropolci**
5. **HPP Gradsko**
6. **HPP Kukurecani**
7. **HPP Krivolak**
8. **HPP Dubrovo**
9. **HPP Demir Kapija**
10. **HPP Gradec**
11. **HPP Miletkovo**
12. **HPP Gavato**
13. **HPP Gevgelija**

Possible investment projects for 29 sHPP



TOTAL CAPACITY 100 MW

GENERATION 335 GWh

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Legislation documents for sHPP

1. Energy Law (Official Gazette of RM No.63/2006)
2. Law on water (Official Gazette of RM No.4/1998) and Law for modification and amendment of the Law on water (Official Gazette of RM No.42/2005)
3. Law on concessions (Official Gazette of RM No.25/2002) and Law for modification and amendment of the Law on concessions (Official Gazette of RM No.24/2003)

Guide for realization of sHPP

- Paper issued in October 2005 by Economic Chamber of R. Macedonia deals with the key components for project development of sHPP with installed capacity up to 10MW:
  - plan,
  - location,
  - cost and financing permissions,
  - building interconnection,
  - exploration,
  - maintain and development
- 400 new locations are selected with about 200MW projected installed capacity. The project documentation of different level exists for almost 100 of them.

Conclusions

- In this moment a sufficient legislative support for starting sHPP projects realization exists.
- The new Energy law delivers regulations and supporting documents for RES and EE.

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DMS Group, ltd

Novi Sad, Serbia & Montenegro

Analysis of possible connection of wind turbine on 10 kV network using DMS Software

Elena Boskov

Sixt Framework Programme, Priority 6
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Introduction

- The most important technical regulations for the successful connection of the small power stations (wind generators) to the distribution network

- "Power industry of Serbia" – distribution network department

- Technical recommendation No. 16: "Base technical requirements for the connection of the small-scale power stations to the distribution network of Serbia“
  - Clarification of technical connection aspects
  - Instructions for potential investors in DG

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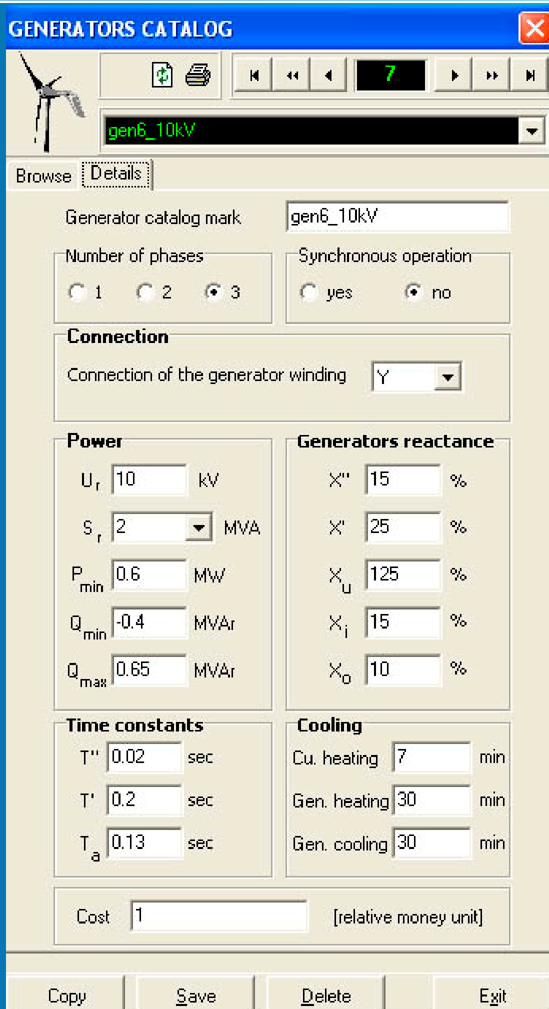
Data for defining generator catalog type:



Generator catalog name;
Phases: 1 - single phase, 2 - two phases, 3 - three phases;
Synchronous operation: yes or no;
Connection of the generator winding: 1 - Delta (D), 2 - Wye (Y);
Rated voltage [kV] [0.1-24];
Rated power [MVA] from drop-down list [0.001-100];
Minimal generator power (biological minimum) [MW];
Minimal reactive power consumption [MVAr];
Maximal reactive power generation [MVAr];
Generator subtransient reactance [%];
Generator transient reactance [%];
Generator steady state reactance [%];
Generator inverse reactance [%];
Generator zero reactance [%];
Subtransient time constant [sec];
Transient time constant [sec];
Aperiodical time constant [sec];
Thermal constant for cooper heating [min] [1-15];
Thermal constant for generator heating [min] [10-45];
Thermal constant for generator cooling [min] [10-45];
Cost per generator unit [relative money unit].

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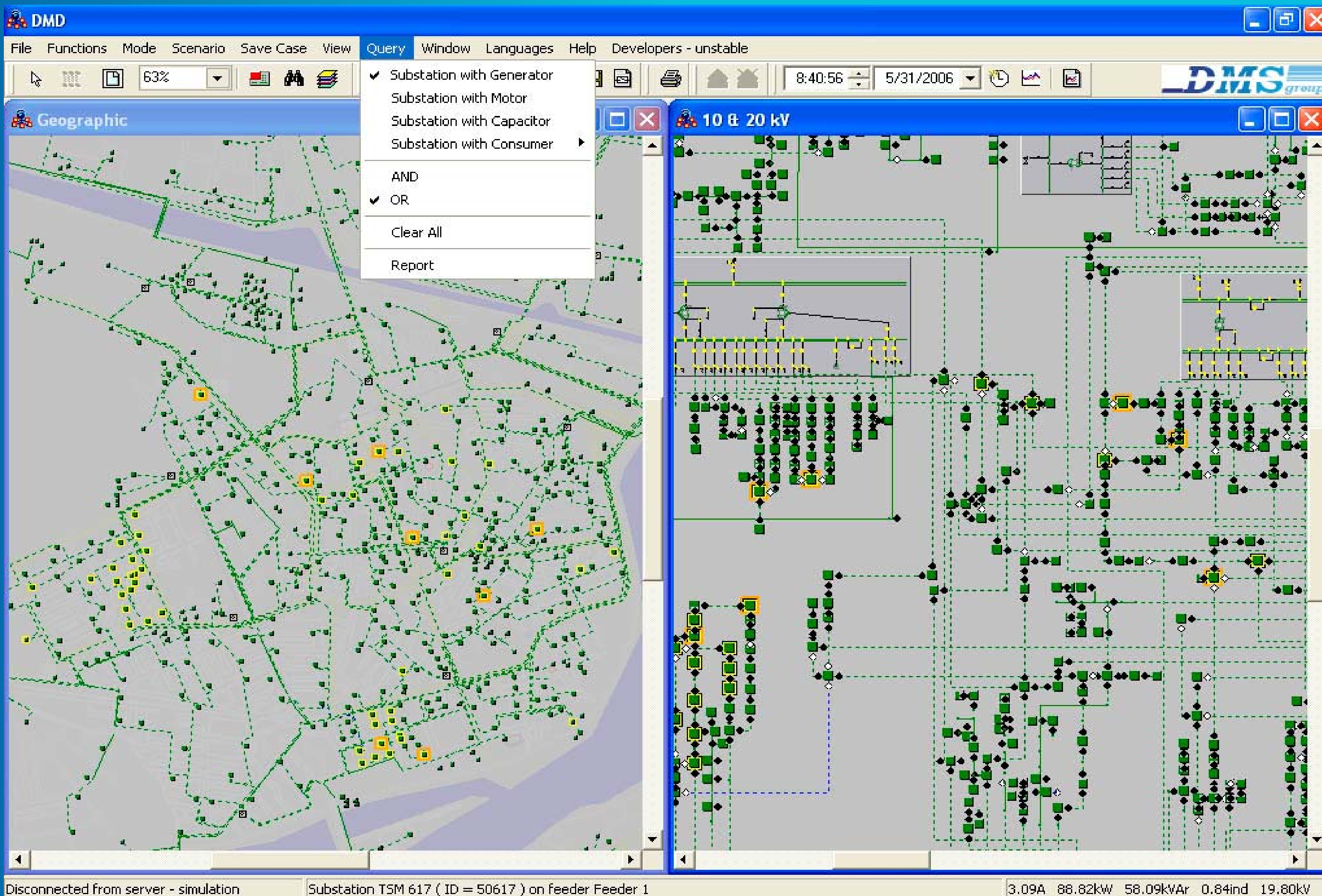
Overview of the network



Generator Location application

The "Generator Location" application would be used previously established calculation engine for other DMS functions:

- network planning,
- fault calculation,
- state estimation and
- relay protection.

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Algorithm

Steps:

1. **defining generators features** (defining set of generators that can be installed),
2. **set of potential locations** (feeders and substations) where generators can be installed; normally possible locations for installation of generators are known in advance; dilemma that appears in which point of the network is the most appropriate to connect this generator;
3. **defining set of constrains**,
4. **connecting generator in the first of possible points**, calculations and checking constrains
5. **repeating of step 4** for other possible connecting points,
6. **identification of solutions** where constrains are not violated and identification of possible solutions.

In-field verification:

- Five important aspects are specially stressed:

(*i*) the significance of a "good and accurate history",
(*ii*) the estimation of voltages is significantly "better" than one of currents (powers),
(*iii*) the estimation error decreases as the estimated point supplies higher number of loads,
(*iv*) the ratio of weights of the history and measurements in the distribution estimation is quantified and
(*v*) the contribution of measurements to the distribution estimation is also quantified.

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Set of data required:

- generators features (set of possible generators which can be potentially installed in the network),
- set of potential locations (feeders and substations) where generators can be installed and
- set of constrains that have to be checked:
- rated generator current have to be less or equal with rated current of connecting section (connecting section makes link between the generator and existing feeder; if connection of generator is directly in substation this constrain will be omitted)
- checking selectivity and functionality of protection (e.g. checking unexpected tripping of non directional relays on feeder head).

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Brief description of existing 10 kV feeder protection

- 10 kV distribution network of one real town. This network is mostly of cable type and only small part is of mixed cable/overhead type.
- Protection of feeders is very simple: low stage over current time defined protection J> with typical current setting in range 300 – 480 A (for standard size of conductors) while time delay is about 0.3 – 0.5 seconds. This protection is placed on feeder head only. Back-up protection: via over current time defined protection J> on supply transformers.

  Setting typically on 1.6 transformer rated current and time delay is 0.8 – 1 second.
- Design of distribution network protection is carried out with preposition of radial supply and radial operation. Installation of distribution generators along feeders introduces additional supply source and additional supplying of fault.
- Currents caused by distribution generators can initiate unselective relay tripping or even unnecessary relay tripping (so called hidden fault).

  => it is necessary to check if installation of distribution generators initiate selectivity problems on feeder relay.

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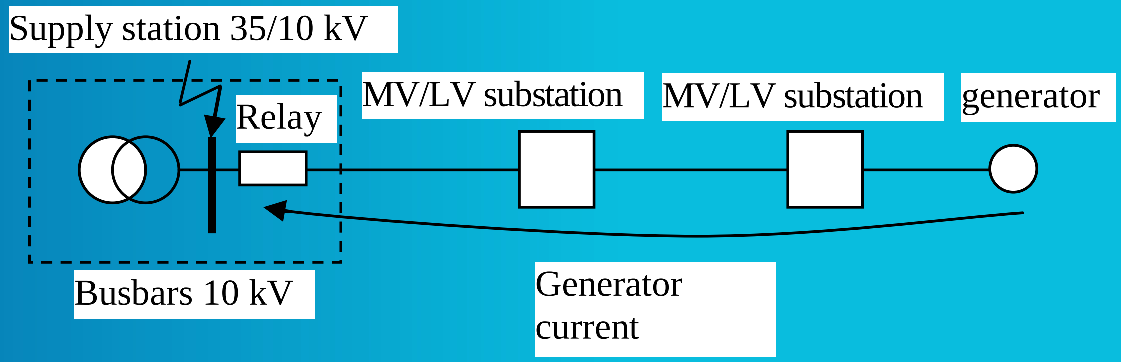
Impact of generators on existing 10 kV feeder protection

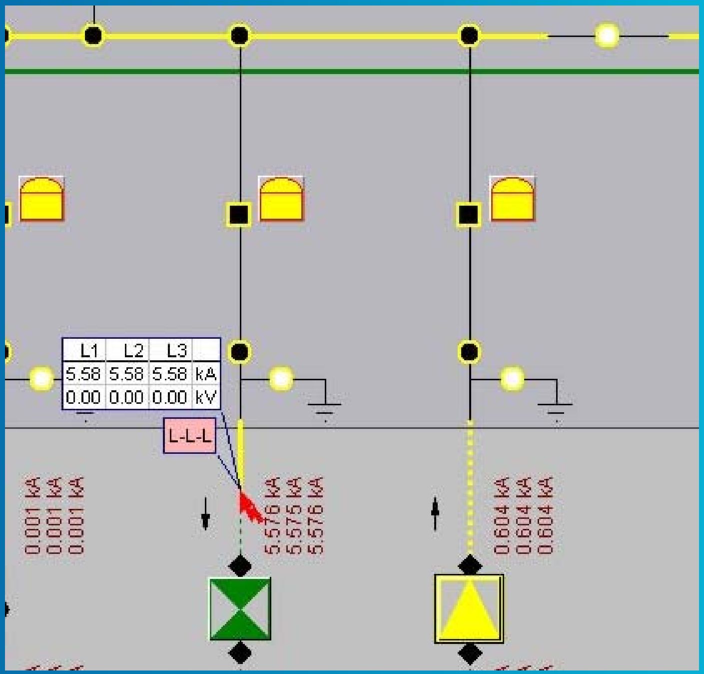
- State in distribution network is changed after generator appending. Changes are evident in both – normal and faulted state.
- Increasing of fault current on fault location is not significant, but the generator introduces an additional current flow



Fault on 10 kV busbars and direction of generator current

Selectivity issues caused by distribution generators

- One 10 kV generator has been connected on MV busbar inside the first MV/LV substation:



Fault on left feeder; Power of generator in yellow colored substation is 2500 kVA, current trough right feeder head is 0.604 kA

On these two feeders the following faults have been simulated (three phase faults – transient state, no load condition):

A. fault on the first section of left feeder (fault location is approximately 450m from feeder head); before adding generator, feeder protections have the same time delay; this means that current from generator will flow trough 2 feeder relays

B. fault on feeder heads (supply busbar),

C. fault on the first section of right feeder (fault location is approximately 220m from feeder head).

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Calculation results:

Table 1 – Currents trough right feeder head

Fault current on feeder head [kA] for:	Rated generator power Sng [kVA]					
	630	**1000**	**1600**	**2500**	**4000**	**6300**
A type fault	0.255	0.397	0.402	0.604	0.976	1.519
B type fault	0.265	0.419	0.408	0.635	1.011	1.584
C type fault	5.140 (0.263)	5.145 (0.417)	5.150 (0.405)	5.161 (0.633)	5.165 (1.012)	5.168 (1.586)

Setting of relay on right feeder head is 480A with 0.5 seconds time delay.

Table 2: – Changing generator location along feeder (generator power is the parameter); fault locations on supply busbar

Sng [kVA]	**630**	**1000**	**1600**	**2500**	**4000**	**6300**
distance[m]	**fault current [kA]**					
340	0.137	0.231	0.383	0.611	0.988	1.564
1300	0.137	0.221	0.357	0.591	0.937	1.435
4000	0.133	0.191	0.282	0.530	0.783	1.082
5440	0.132	0.177	0.247	0.501	0.714	0.943

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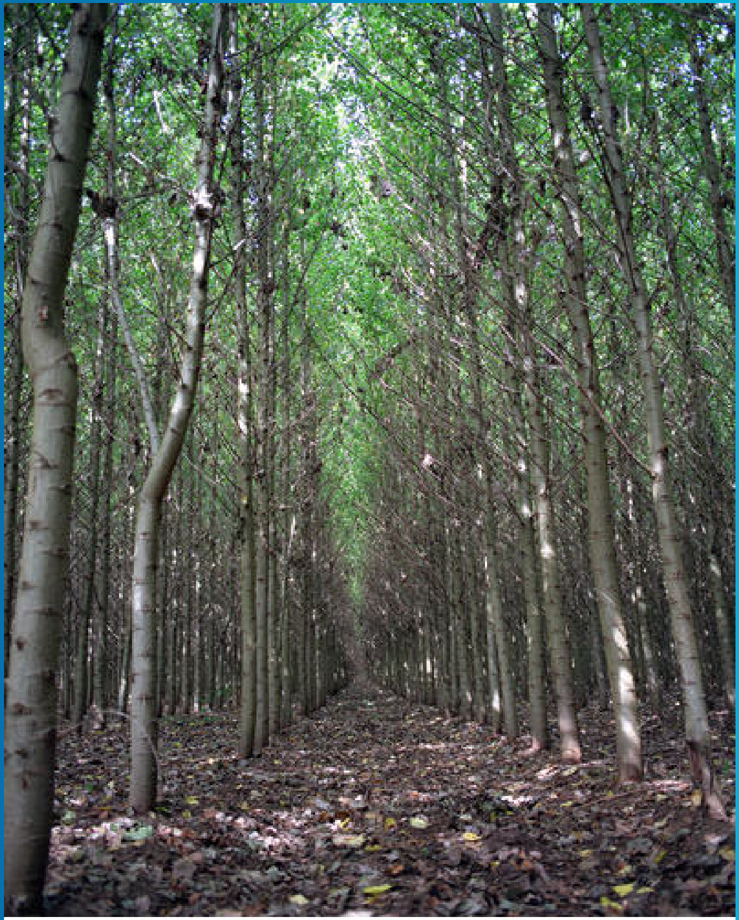
Conclusion

- the impact of wind generators is evident and has to be carefully taken into consideration.
- Numerical values that can be used during estimation of generator impact.
- The promoted idea: the problem of distribution generator installation of wind turbine should be considered trough special DMS application "Generator location" that can be powerful and useful for comprehensive analysis of generator impact.

Thank You for your attention

RENEWABLE ENERGY SOURCES IN WESTERN BALKANS

Prospects for biomass based power generation in West Balkan countries


Source of image: Warren Gretz, NREL/DOE

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Biomass is an extremely important renewable energy source

- wastes from forestry and sawmill operations (bark, wood chips, sawdust and logging debris)
- urban wood wastes (shipping pallets, packing and leftover construction wood)
- agricultural wastes (such as crop residues, sugarcane, rice husks, coconut shells, cotton residues and palm oil residues)
- fast-growing trees and crops (called “energy crops”), such as poplar, willow and switchgrass, grown specially for energy (electricity or liquid fuels)
- other natural resources (such as straw and peat)
- organic wastes (such as animal manure and food processing wastes)

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Biomass sources in Albania

- Forestry biomass resources were calculated to be approximately 460 millions of GJ in1995;
- The energy potential from agricultural residues was calculated at approximately 43000 GJ in 1995
- The energy potential from animal residue's was calculated at approximately 12 740 GJ in 1995
- These numbers should be considered estimates; a more comprehensive study should be carried out for real validation.

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Biomass sources in Bosnia and Herzegovina

- Forests and forestland include around 53 percent of Bosnia and Herzegovina's territory or around 2.7 million hectares. Average annual volume growth of all forests is around 10.5 million m3.
- **Krivaja factory in Zavidovici** as a success story of biomass based combined heat and power generation;
- Krivaja factory: while manufacturing furniture and timber houses, wood waste is converted into electrical energy in steam power plants with a maximum thermal output of 15 MW, peak electricity outputs of 4.5 MW generated for the factory's on-site power needs.

Biomass sources in Croatia

- Almost 44 percent of Croatia is covered by woods and forests;
- National bio-energy programme has set the goal of at least 15% of the total energy consumed from the biomass by the year 2030;
- Sawmill Krašić is the first demonstration project for biomass utilisation in Croatia: a new 1 MW wood waste boiler and two drying chambers with a combined volume of 170 m3 have been installed;
- Cogeneration plant is under consideration in t*he Spačva* wood and lumber facility generating 30,000 m3 of wood waste per year and located in Vinkovci.

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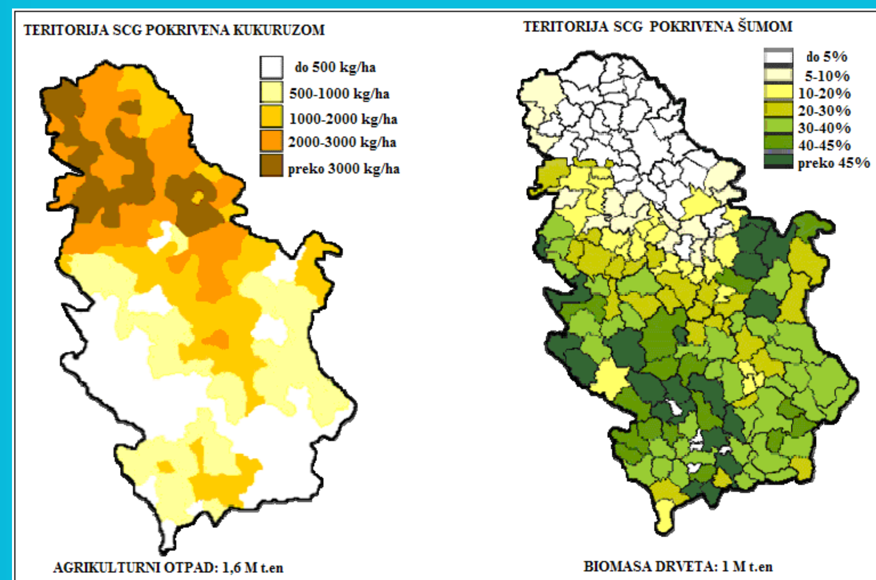
Biomass potential in Serbia and Montenegro

- Biomass resources represent a significant potential energy source for Serbia and Montenegro;
- Forests occupy nearly 30,000 km^2, containing over 300 million m^3 of wood biomass. The estimated renewable biomass potential is about 1.8 Mtoe.
- Projects for biofuels production under development



Biomass potential in FYR of Macedonia

- Forests cover over one million ha of which 90% is owned by 30 major forestry companies
- Each year, the wood processing industry utilizes 150,000 m3 of wood and produces nearly 70,000 m3 of waste (45,000 tons);
- An additional 150,000 m3 of wood waste, equal to 100,000 tons of wood waste (density 650kg/m3), is produced during the logging process
- The theoretical potential for forests and forest residues utilization is estimated on: theoretical Potential 6000 GWh and Technical Potential 2660 MWh;

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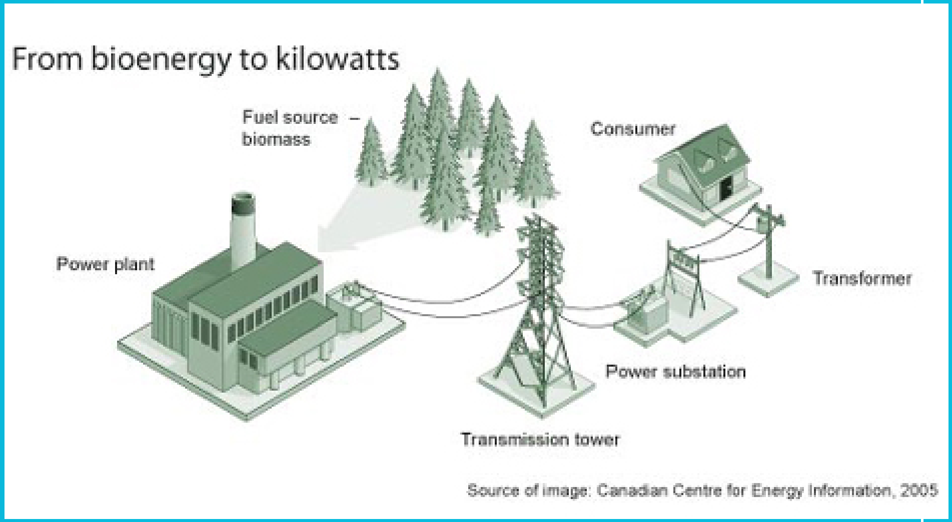
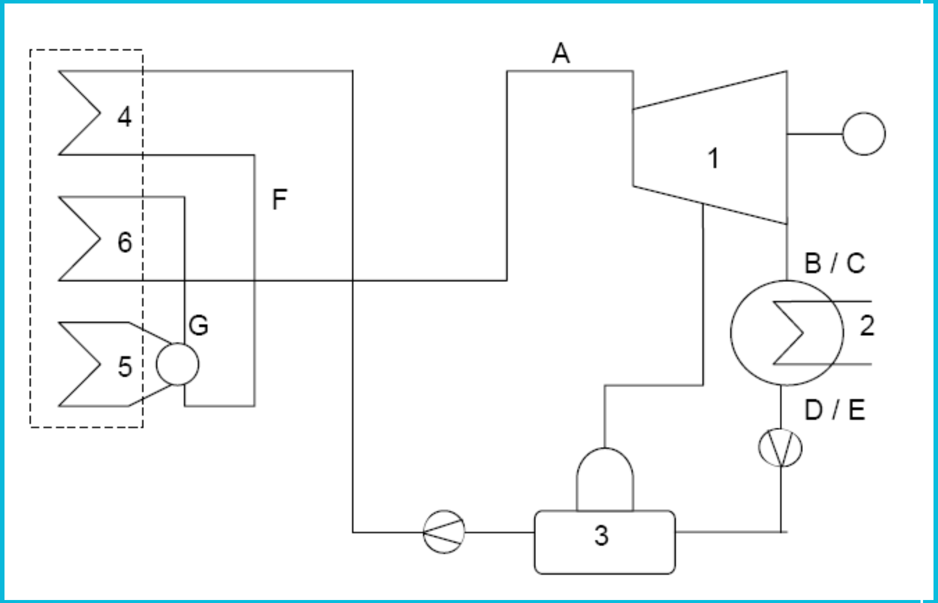
How to convert biomass energy into electricity?

- Through: direct combustion, co-firing, gasification, pyrolysis and anaerobic digestion
- With gasification the biomass is converted to gaseous fuels by the under stoichiometric addition of air: this fuel can feed Oto gas engine or gas turbine;
- Most of the electricity generating concepts specified above are not yet available or very expensive



Direct combustion process is proven technology

- The simplest way, and oldest way, of generating electricity from biomass is to burn it
- The burn gives thermal energy in form of the flue gas heat
- The heat is used in a boiler, following the firing, for heating up water and for the production of steam;
- This steam turns a turbine or an engine connected to electrical generator

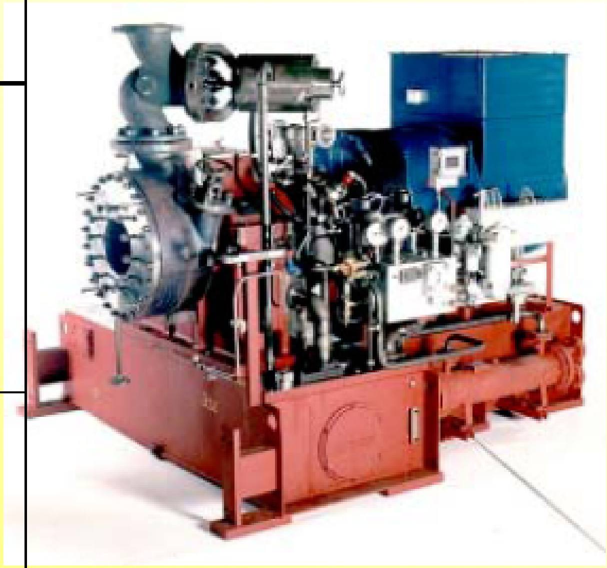


Main features of the Steam Turbine generation

source of image: Biomass Information Centre – Stuttgart

Steam Turbine

Advantages	Disadvantages
➢ Mature, proven technology	➢ Small steam turbines < 1 MW_{el} offer only limited efficiencies
➢ Broad power range available	➢ Low efficiency at partial load
➢ For large installations: high efficiencies can be obtained by high steam temperatures and pressures	➢ High specific investment costs for small turbines
➢ Separation between combustion and power generation enables the use of ash containing fuels	➢ For biomass application: limited super heater temperature because of risk of high temperature corrosion



Main features of the Steam Engine generation

source of image: Biomass Information Centre - Stuttgart

Steam Engine

Advantages	Disadvantages
➢ Suitable for lower power ranges	➢ Maximum power output is limited to about 1.2 MW_{el}
➢ Saturated steam can be used	➢ High maintenance costs
➢ Very good performance at partial load	➢ Electrical efficiency is limited due to low steam pressures (< 25 bar)
➢ Steam extraction at various pressures possible due to modularity	➢ Heavy vibration and noise production
➢ Oil free construction avoids steam contamination	

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ORC plants: the recent break-through in the biomass power generation

- The on Organic Rankine Cycle (ORC) is a thermodynamic cycle that uses an organic working fluid (rather than steam) to generate electricity;
- Chemicals used in the ORC include freon, butane, propane, ammonia and the new environmentally-friendly "refrigerants" and as well as different oils;
- The selected working fluid for biomass fired ORC plants is silicone oil;
- This approach allows exploiting efficiently low temperature heat sources to produce electricity in a wide range of power outputs (from few kW up to 3 MW electric power per unit)

Biomass fired ORC co-generative district heating plant in Lienz, Austria

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The ORC advantages over conventional steam plant technology for small and medium scale biomass fired power generation

- ➢ high cycle efficiency;
- ➢ very high turbine efficiency (up to 85 percent);
- ➢ low mechanical stress of the turbine, due to the low peripheral speed;
- ➢ low RPM of the turbine allowing the direct drive of the electric generator;
- ➢ no erosion of blades, due to the absence of moisture - long life;
- ✓ Steam turbine Rankine cycle – feasible for large plants (above 5000 KW)
- ✓ ORC is emerging and feasible technology for capacity range 500 – 1500 KW;

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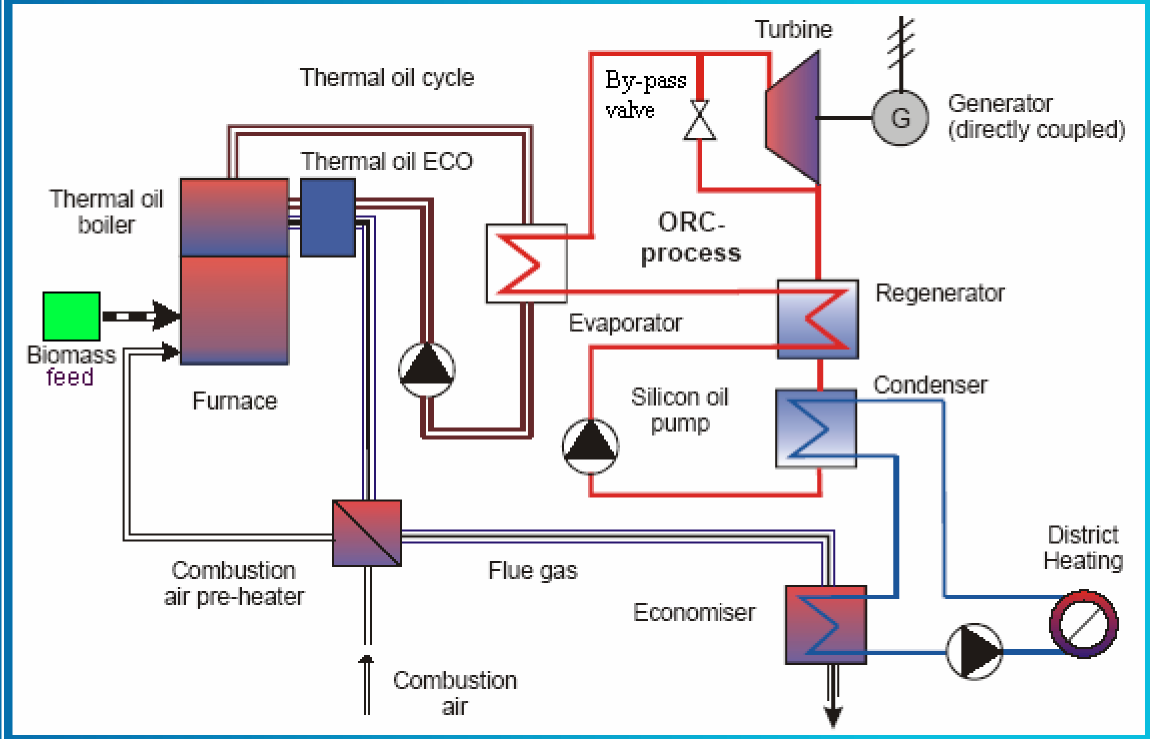
Biomass fired ORC plant basic design features



- Virgin wood is burned in thermal oil boiler;
- The heat is transferred from the boiler to the evaporator of the ORC unit by a thermo-oil circuit;
- Two stage axial turbine drives directly coupled generator;
- The condenser is cooled by district heating water;
- The ORC unit is heat controlled

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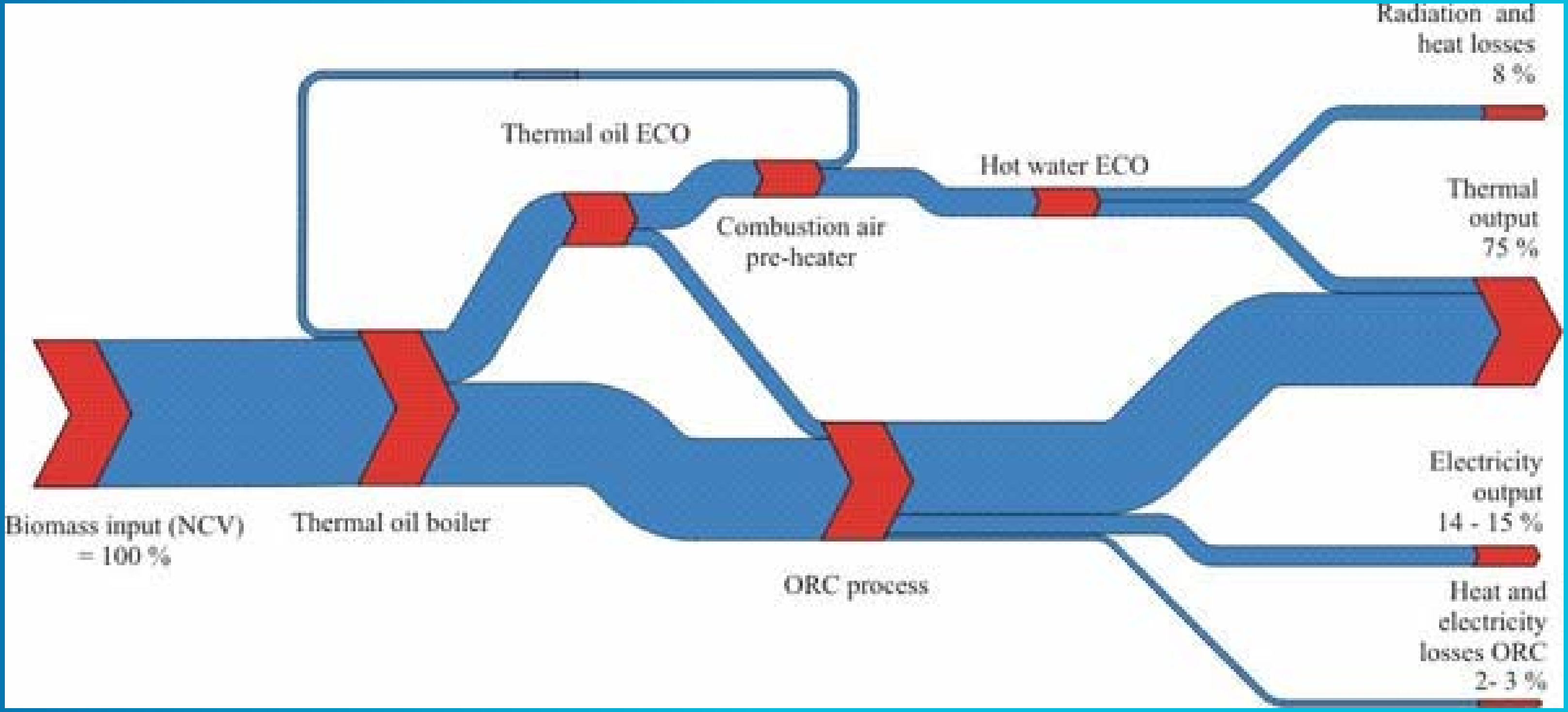
ORC process: the whole module fixed in container

- **The ORC turbo-generator (up to about 800 kW) consists of a single skid-mounted assembly, containing all the equipment required for the turbo-generator to be operated (i.e. heat exchangers, piping, working fluid feed pump, turbine, electric generator, control and switch-gear).**

Energy balance of the biomass fired ORC-combined heat and power plant (Lienz case)



ORC technology implementation

- After several successful demonstration projects biomass fired ORC process is already mature technology

Country	ORC units in operation	ORC units under construction	Total number of ORC units
Austria	6	11	17
Czech Republic	0	1	1
Italy	2	1	3
Germany	3	7	10
Switzerland	2	0	2
Total number of ORC units	13	20	33
Total ORC plants capacity	12050 KW_{el}	21500 KW_{el}	33550 KW_{el}

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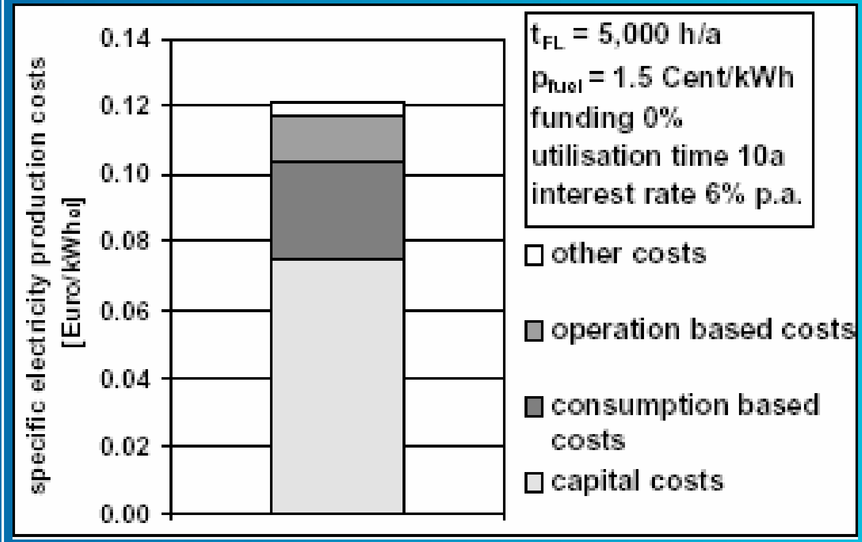
Biomass fired ORC Plant - Economic aspects



- Electricity production cost (Lienz case)
- ✓ The capital costs are based on additional investment costs, and consider only surplus investment costs of ORC plant in comparison to a conventional biomass fired plant with a hot water boiler and the same thermal output
- ✓ The average fuel price is set at 15 Euro/MWh.;
- ✓ The capacity utilization of the ORC plant is set at 5000 h/a;

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RENEWABLE ENERGY SOURCES IN WESTERN BALKANS

Conclusions 1- ORC is available on the market

- **Advantages**
- ✓ **Excellent partial load behavior**
- ✓ **Mature technology**
- ✓ **Atmospherically operated boiler reduces personal costs**
- ✓ **High degree of automation**
- ✓ **Low maintenance costs**

- **Weak points**
- ✓ **Relatively high investment costs (single manufacturer)**
- ✓ **Low experiences of biomass based ORC plants available**
- ✓ **Thermo-oil cycle necessary**

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Conclusion 2 – biomass power generation in WB countries

- All West Balkan countries have got huge untapped biomass potential;
- Power plants based on Organic Rankine Cycle (ORC) are very promising solution for biomass co-generation in woody and agriculture remote areas
- There are important number of economic and social (job creation) benefits to be gained from increased use of biomass energy technologies in WB countries
- institutional barriers need to be removed in order to utilise the existing potential;
- The importance of government policy support in this respect can hardly be overestimated

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Thank you for your attention!

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Financing of Renewables
Case of Small Hydro Power

Borut Del Fabbro

Key issue

- Characteristics of Renewables
- Project Financing
- Risk Management
- Capital Structure

Characteristics of Renewables

- **High Up-Front costs (investment)**
- **Low cost O&M**
- **Relatively Stable Output:**
  - **Small HPP, Wind, Photovoltaics – possible high variations between years**
  - **Geothermal – extremely constant**

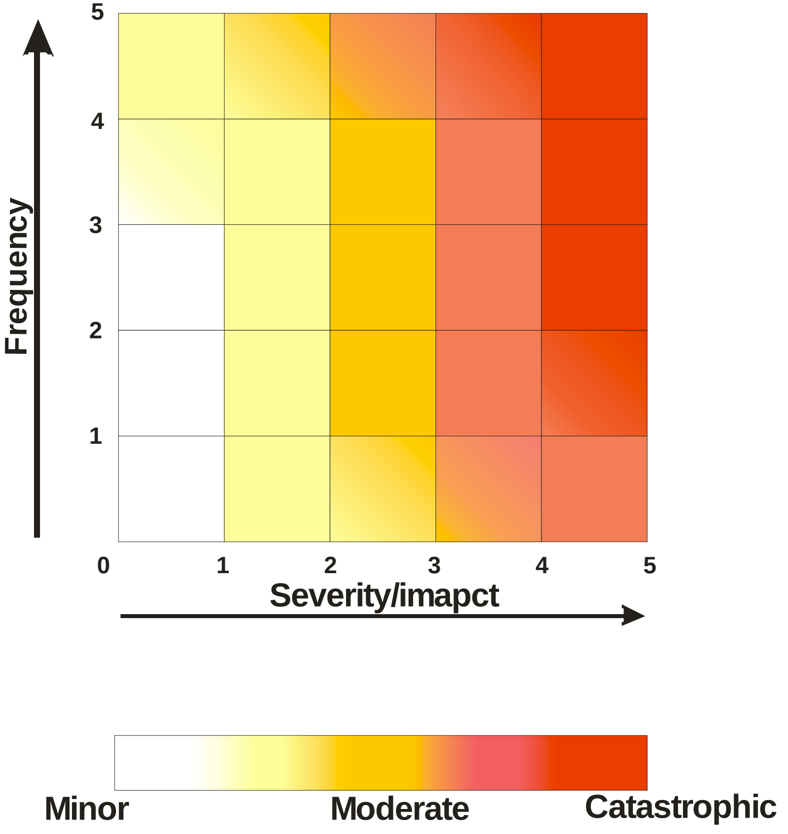
Project Financing

- is an approach to isolate the risk of the project and to rise additional finance without impacting the debt capacity of the investor
- A new special purpose company is established
  - used as a means to obtain financing for the project (equity investors, loan givers, etc)
  - more transparent
- Non-Recourse financing
  - Owners of the project (=Project sponsors) have no obligation towards lenders)

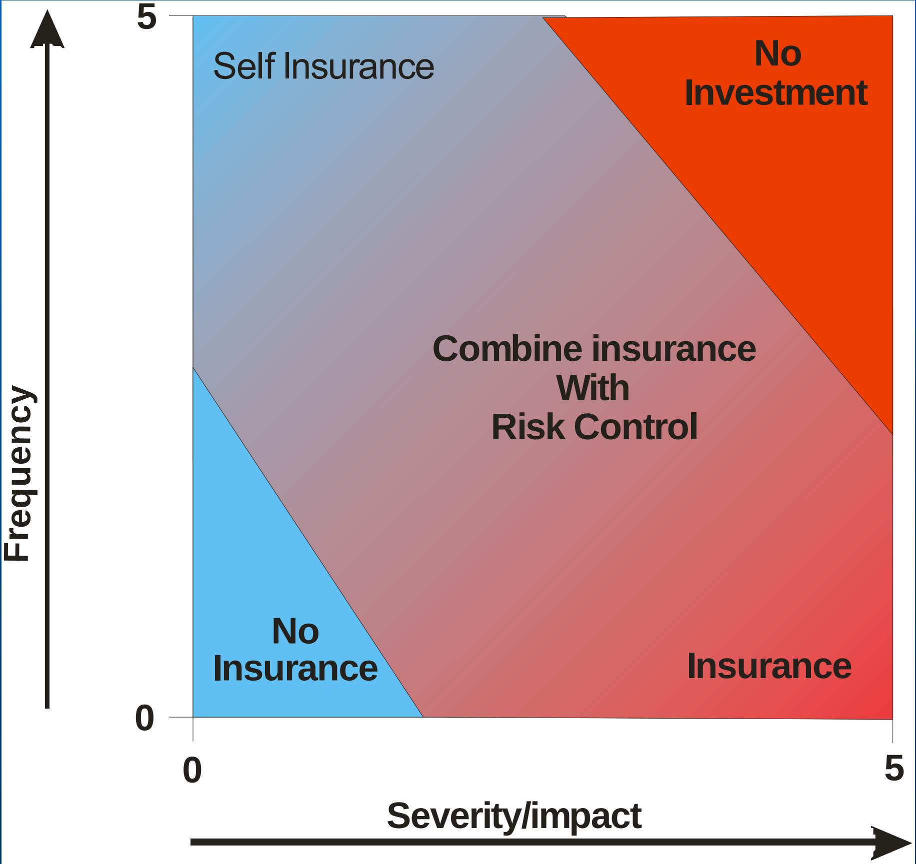
Risk - definition

- Risk is always connected to future uncertainties
- Pure Risk
  – possibility of occurrence of an event that has a negative impact on the cash flow
- Speculative Risk
  – possibility of occurrence of an event that can have a negative or positive impact on the cash flow

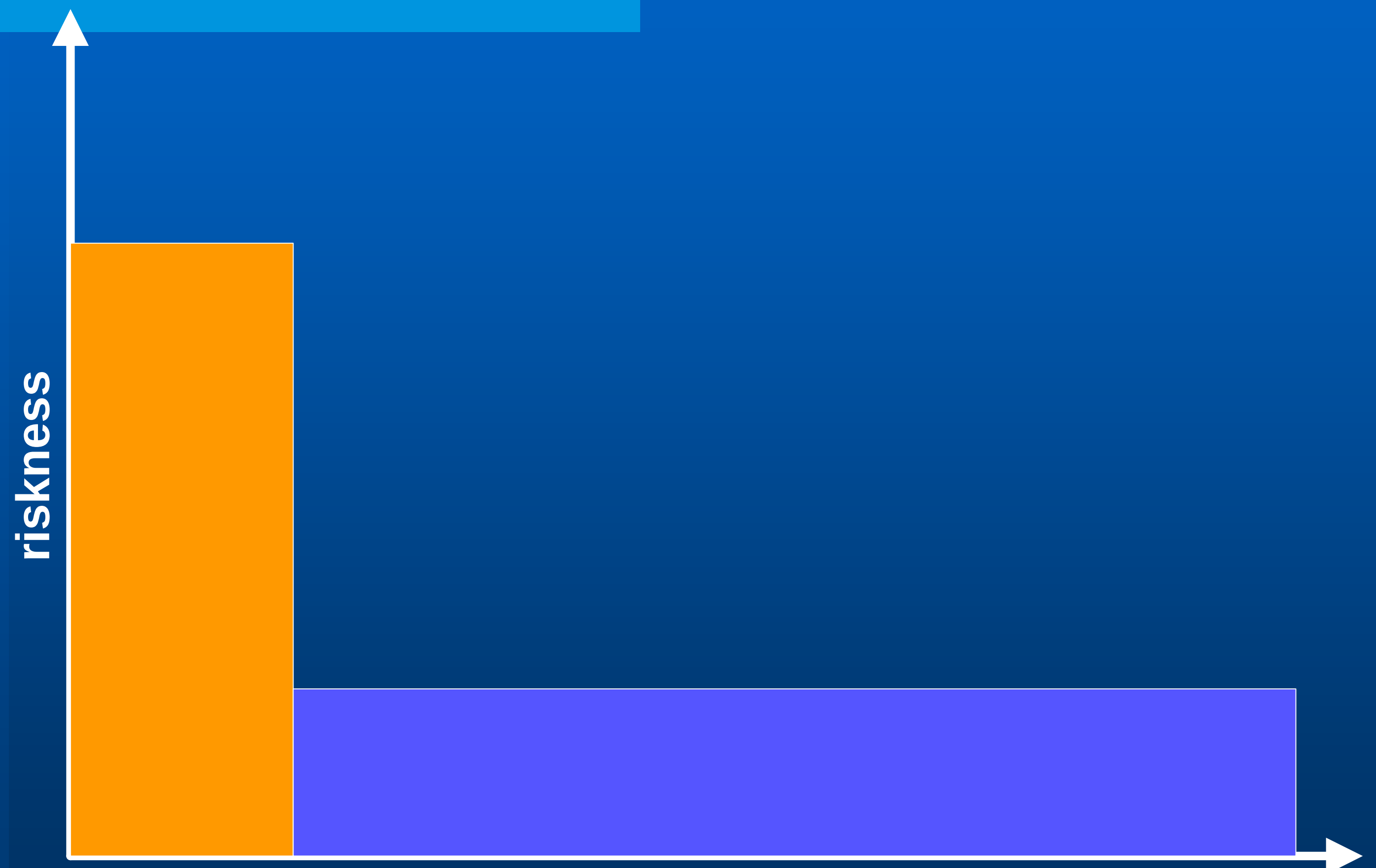
Classification of Risk Events



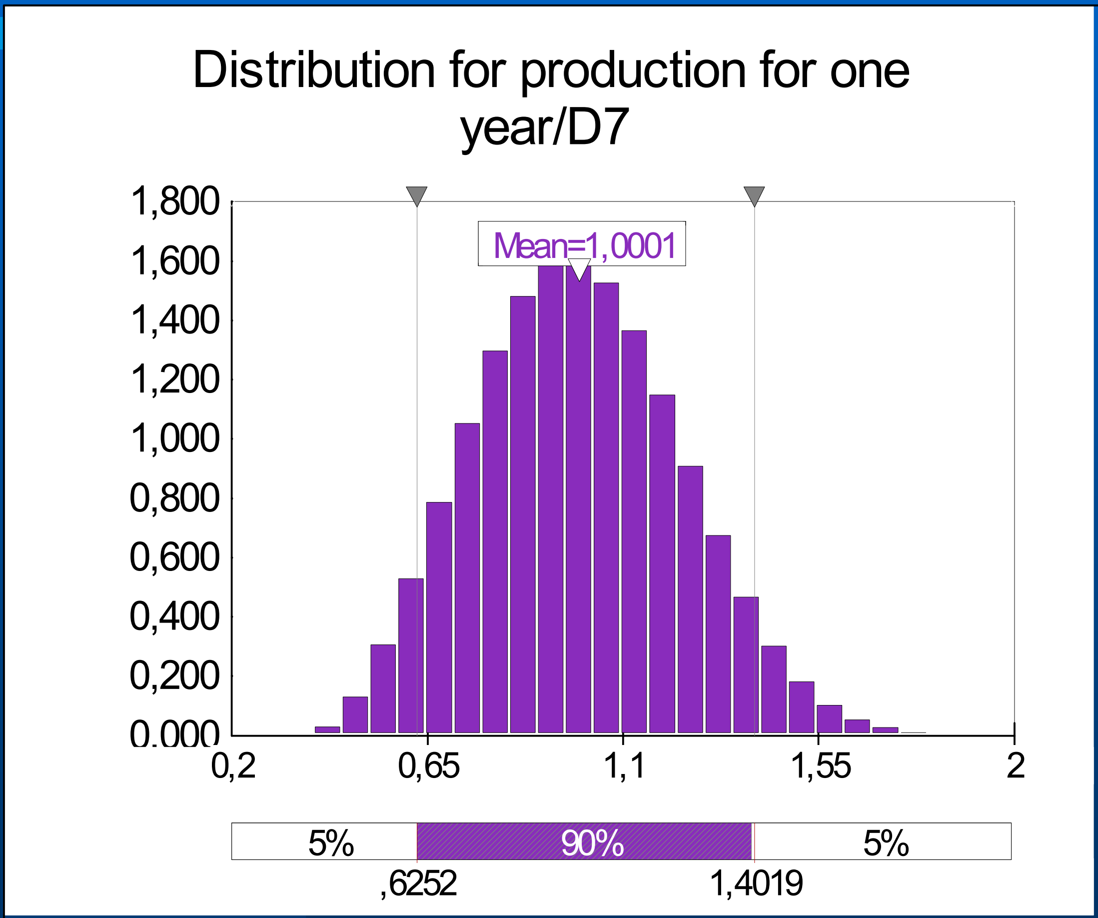
Risk Management



Two Phase approach

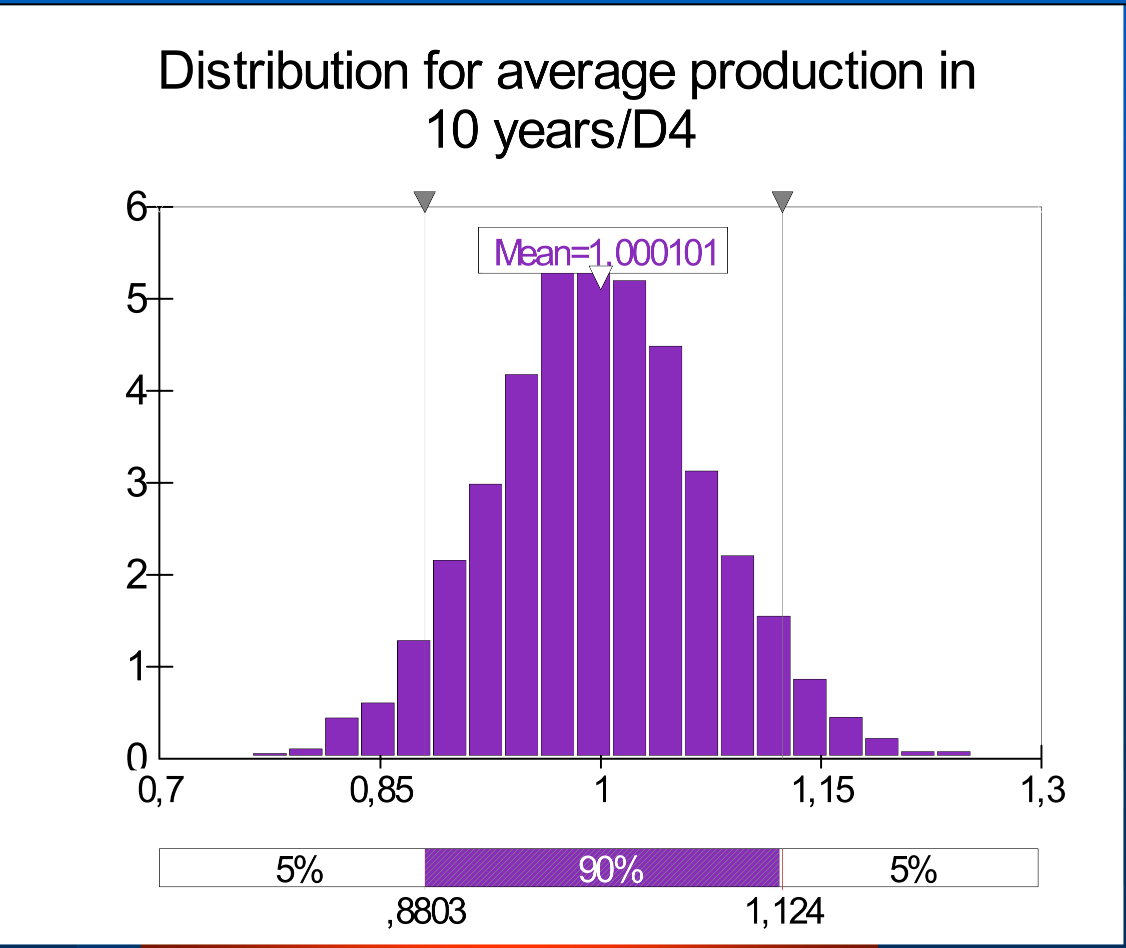


Production uncertainty



%tile	Value
5%	63%
10%	70%
15%	75%
20%	79%
25%	83%
30%	87%
35%	90%
40%	93%
45%	96%
50%	99%
55%	102%
60%	106%
65%	109%
70%	112%
75%	116%
80%	120%
85%	125%
90%	131%
95%	140%

Production uncertainty – effect of "bad luck"



%tile	Value
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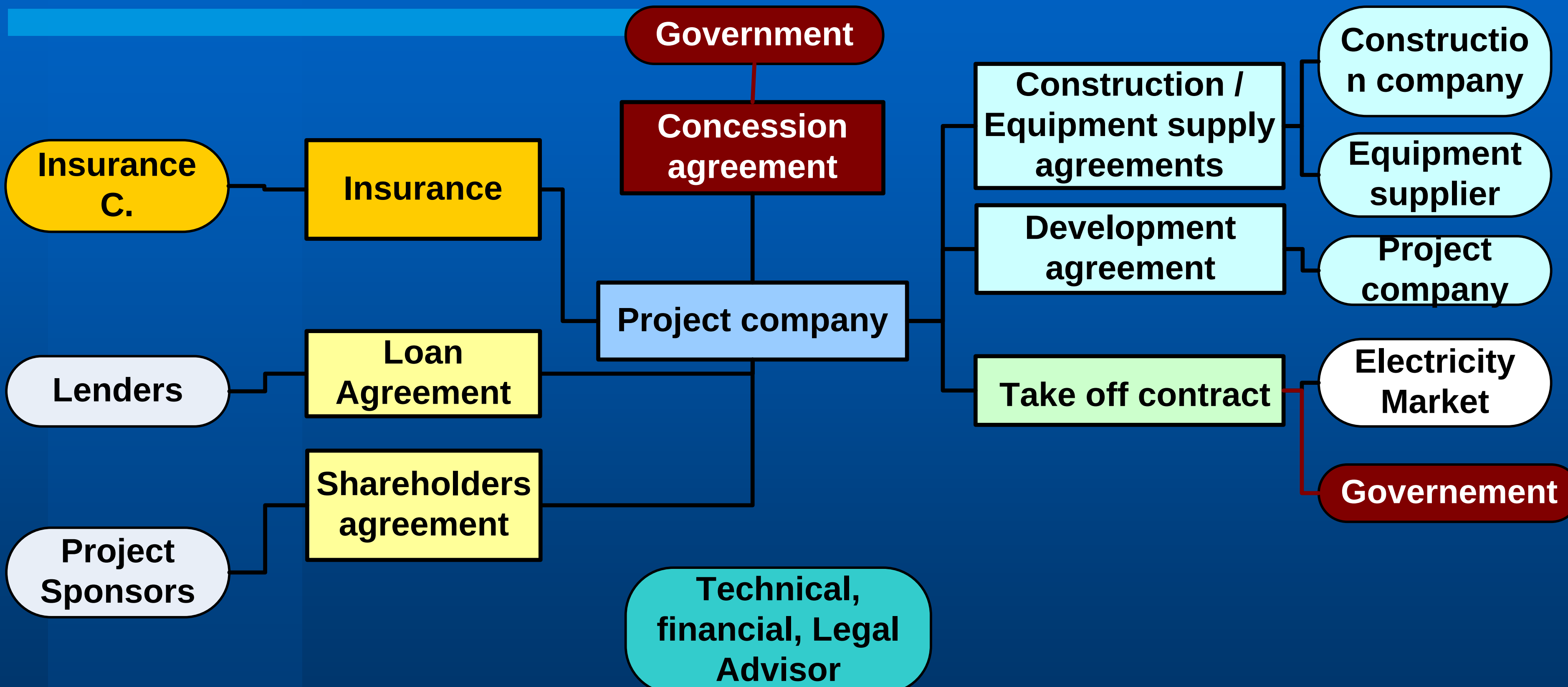
25%	95%
30%	96%
35%	97%
40%	98%
45%	99%
50%	100%
55%	101%
60%	102%
65%	103%
70%	104%
75%	105%
80%	106%
85%	108%
90%	110%
95%	112%

Risk Allocation

- Risk should be borne by the party who can manage it in the most efficient way (at the lowest costs)

- Risk must be allocated to one of the following:
  - Sponsors = Capital investors
  - Lenders
  - Contractors (construction company, equipment suppliers)
  - Insurance company
  - Government

Project Scheme



Risk Allocation

- Government
  - electricity price risk
- Insurance company
  - physical damages
  - catastrophic events (storms, earthquakes)
- Contractors
  - underperformance of equipment
  - delays in construction
- Lenders
  - investment cost overruns (partially)

Risk Allocation (2)

- Sponsors
  - investment cost overruns
  - underperformance of operation (lower electricity production than expected, higher costs)

Capital Structure

- The more debt you take, the higher the return on your invested capital, but also the higher the risk
- Usually the debt ratio is from 70% to 90%:
  - Depends on
    - Risk of the project
    - The financial capabilities of the sponsors

Capital Structure

- alternate capital strategy:
  - first finance with capital
  - after the high risk phase refinance with cheap loans

Recommendations

- Make a list of all risks
- Find a way how to manage the risks
- Capital structure:
  - Take as much debt as possible at a reasonable cost, but not more than the limit in the worst case scenario of production
  - Use own capital to reduce the risk of bankruptcy

Thank you very much for your attention!

Techniques for maximizing the wind power penetration in autonomous power systems

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RENEWABLE ENERGY SOURCES IN WESTERN BALKANS

Contents

- Introduction
- Wind Penetration
- Method for calculation of wind penetration limit
  - Objectives
  - Principles
  - Method
- Case study
- Conclusions

Introduction

- The cost of electric energy in islands is generally higher than in the mainland
- In many islands there are favorable conditions for wind power production
- The wind power penetration in islands is limited due to operational problems raised from the parallel operation of the wind generators with the conventional power units
- In order to maximize the wind penetration, a proper planning of the wind power that can be installed and the adequate schedule of the operation are needed

Wind penetration (1)

- *Instantaneous penetration* (or *power penetration*) is mainly a technical measure

$$\text{Ins tan tan eous (power) penetration} = \frac{P_{wind}}{P_{load}}$$

- *Average penetration* (or *energy penetration*) is mainly an economic measure

$$\text{Average (energy) penetration} = \frac{E_{wind}}{E_{load}}$$

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Wind penetration (2)

- On average wind energy penetration represents only 1-2% of the total power generation in the Central European System
- The wind penetration levels in the USA are even lower

	Area	
	Tamil Nadu (India)	Eltra (Denmark)
Wind capacity (MW)	750	1.900
Conventional capacity (MW)	7.804	4.936
Total capacity (MW)	8.554	6.836
Wind power penetration (%)	8,8	27,8
Wind production (GWh)	1.157	3.398
Consumption (GWh)	37.159	20.604
Wind energy penetration (%)	3,1	16,5

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Methodology for the calculation of wind penetration limits (1)

Objectives

1. Estimation of wind energy that can be absorbed annually by an autonomous power system that is composed of diesel generators and wind parks
2. Determination of the maximum permissible wind power that can be connected with the power system (maximum penetration), without reducing the system security or causing inadmissible contingencies during the system operation

Methodology for the calculation of wind penetration limits (2)

Principles

1. Securing the right operation of the system and the supply of satisfactory power quality, aiming at maximizing the wind energy penetration in the energy balance of the island
2. The technical part of the problem is studied
3. The characteristics of the conventional power station and the annual load curve are taken into account
4. It is considered that the total produced wind power can be controlled
5. The wind conditions of the island are taken into account through the Weibull curve

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Methodology for the calculation of wind penetration limits (3)

Principles (2)

6. The conventional units of the stations must not be loaded under their technical minimum load limits
7. 100% running reserve of conventional power is considered, which completely secures the load supply even in case that the total wind power is lost
8. The estimation of the wind energy that can be absorbed is done with probabilistic analysis, where the probabilistic variables are the wind speed and the load demand, which are considered as completely independent each other

Methodology for the calculation of wind penetration limits (4)

Principles (3)

9. A limit is set for the *instantaneous wind power penetration*. This limit, also called *dynamic operational limit* (C_D), depends on:
   i. The conventional station characteristics, e.g. response rate of the speed governor of each unit
   ii. The wind power parameters, e.g. total wind power installed, the characteristics of the wind generators (e.g. tenacity in under/over-frequency, and under/over-voltage control, power smoothing capability)
   iii. The dispersion of the wind parks on the island
   iv. Many other factors related with the dispatching philosophy, the operators capabilities, the existence of control systems (e.g. CARE and MORE CARE) in the dispatching center

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Methodology for the calculation of wind penetration limits (5)

Method

- The total wind energy that can be absorbed by the system annually is:

$$E_w^{max} = \sum_{i=1}^{8760} E_w^{max}(t)$$

where

$$E_w^{max}(t) = \min\left\{P_{w\,max}^{C_T}(t), P_{w\,max}^{C_D}(t)\right\}$$

$$P_{w\,max}^{C_T}(t) = P_L(t) - \sum_i C_{Ti} \cdot P_{Di}(t)$$

$$P_{w\,max}^{C_D}(t) = C_D \cdot \sum_i P_{Di}^{nom}(t)$$

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Methodology for the calculation of wind penetration limits (6)

Method (2)

- A discrete frequency distribution of the *capability of wind power absorption* is calculated
- A discrete frequency distribution of the *wind power that can be generated* is calculated
- A discrete frequency distribution of the *absorbed wind power* is calculated

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Methodology for the calculation of wind penetration limits (7)

Method (3)

- The economic viability of the investment is based on the value of the capacity factor (CF):

$$CF = \frac{E_w}{8760 \cdot P_w}$$

- According to the estimations of the Greek Regulatory Authority for Energy (RAE), a wind park investment in a Greek island is considered as economic viable if the wind park can achieve a CF over 27,5%

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Case study – Crete power system at 2003

- Total nominal power of conventional units: 628 MW
- Wind parks : 70 MW
- Maximum demand : 514 MW
- Total produced energy : 2.467 GWh
- Wind park production : 207 GWh (8,4%)

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Case study – Wind penetration limits at 2003

C_D	Installed wind power 70 MW Production (GWh)	70 MW CF (%)	95 MW Production (GWh)	95 MW CF (%)	130 MW Production (GWh)	130 MW CF (%)	160 MW Production (GWh)	160 MW CF (%)
100	228	36,3	302	36,3	414	36,3	509	36,3
40	221	35,9	290	34,9	371	32,6	417	29,8
35	220	35,9	288	34,6	355	31,2	391	27,9
30	218	35,5	278	33,4	330	29,0	357	25,5
25	213	34,7	259	31,2	297	26,0	317	22,6
20	198	32,3	230	27,6	255	22,4	271	19,3

Case study – Wind penetration limits at 2003 (2)

1. Existing situation: 70 MW wind parks installed
   i. CF varies for 32,3% (for C_D=20%) to 35,9% (for C_D=40%)
   ii. From the measured data, the real CF was 33,76%, which corresponds to a C_D=23%. This is in accordance to the restrictions applied by the Public Power Corporation (PPC), since a maximum wind penetration of 25% is permitted and exceptionally, during low load conditions, it can be reduced up to 15%
   iii. The spilled (not produced) wind energy is 228-207=21 GWh, i.e. less than 10% of the capable to be produced wind energy
   iv. The method gives approximately credible results
2. The maximum CF is obtained for C_D=100% (no restrictions in the absorption of wind power)

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Case study – Wind penetration limits at 2003 (3)

3. The economic viable wind power (CF>=27,5%) is:
   i. 95 MW (~18% of the peak), for C_D=20%
   ii. 130 MW (~25% of the peak), for C_D=27,5%
   iii. 160 MW (~31% of the peak), for C_D=35%

Case study – Crete power system at 2010

- Total nominal power of conventional units: 909 MW
- Maximum demand : 817 MW
- Wind parks
  - 130 MW (15,9% of peak)
  - 160 MW (19,6% of peak)
  - 200 MW (24,5% of peak)
  - 260 MW (31,8% of peak)
- Total produced energy : 3.826 GWh

Case study – Wind penetration limits at 2010

	Installed wind power							
	130 MW		160 MW		200 MW		260 MW	
C_D	Production (GWh)	CF (%)	Production (GWh)	CF (%)	Production (GWh)	CF (%)	Production (GWh)	CF (%)
100	414	36,3	509	36,3	636	36,3	827	36,3
40	414	36,3	499	35,6	589	33,6	680	29,9
35	410	36,0	484	34,6	558	31,8	629	27,6
30	399	35,0	460	32,8	516	29,5	569	25,0
25	377	33,1	422	30,1	461	26,3	502	22,0
20	340	29,9	369	26,3	397	22,7	428	18,8

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Case study – Wind penetration limits at 2010 (2)

1. The economic viable production at 2010 will be 160 MW, if PPC will follow the same operating policy as at 2003 (C_D=23%)
2. The economic viable production at 2010 will be 260 MW, if a C_D=35% will be applied

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Conclusions

1. The method, used by RAE for the assessment of economic viable wind power that can be installed on an island, gives credible results
2. The accuracy of the method strongly depends on the correct choice of the dynamic operational limit (C_D)
3. A high value of C_D results in a high wind penetration
4. Especially for the operation stage, software like CARE and MORE CARE can considerably help the system operators in order to increase the wind energy production and reduce the operation cost of the system

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Conclusions (2)

5. In general, the wind power penetration can be considerably increased by two main ways:
   i. By the installation of more wind power, so that a part of it could be switched off when it is not possible to be absorbed by the system (the disadvantage is that a large part of wind energy that could be produced is spilt, i.e. a part of the installed wind energy is not properly used)
   ii. By the installation of energy storage systems of different types (the advantage is that almost the whole spilt wind energy can be exploited for electrical energy production)

Techno-economic characteristics of SHPP use – case of BiH

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Introductory remarks about water resources and (S)HPP-s

- Waterpower has been, and still is the leading, renewing source for the electric power production;

- The electric energy produced by waterpower represents 13% in the European Union Countries; (in Bosnia and Herzegovina cca 30%)

- The annual emission of CO_2 is reduced for more than 67 mio. tons;

- Well-designed small hydro power plant represents good alternative, for it easily fits into local eco-systems;

Introductory remarks about water resources and (S)HPP-s

- Electricity generation in Western Europe is projected to grow from 2300 TWh in 1995 to 3800 TWh in 2015;

- Demand in BiH within 10 years will be doubled;

- 60% not used hydro-capacity in BiH;

- Hydro potential in Bosnia and Herzegovina (HPP):
  Total: 3.940 MW
  Annual production: 12.635 GWh

- Already used (in HPP):
  Total: cca 2.000 MW
  Annual production: cca 6.000 GWh

Introductory remarks about water resources and (S)HPP-s

- Possibility to construct up to 700 SHPP

- Range from 50 kW up to 5 MW

- Total installed capacity up to 1000 MW

- Total annual production up to 4500 GWh

- Techno-economical useful cca 65%

- Potential Investment cca 550 million of Euro

Main characteristics of SHPP-s

- Small dimension;

- Standardized;

- Easy to install;

- Short construction period (8 - 12 months);

- (Almost) Maintenance free;

- Fully automated;

Reasons why SHPP-s (especially in countries like BiH)

- Local initiative;
- Local participation;
- Private sector;
- Small projects with low risk;
- Increasing environmental concerns;
- Renewable energy options;

Steps to realization of SHPP project

- Preparation of project documentation;

- Tender announcement and selection of constructors, supplier and assemblers of equipment;

- Construction and performing of works during construction;

- Commissioning and trial run

Preparation of project documentation

1. Feasibility Study

2. Basic design or project

3. Main project

(4. Tender documentation)

5. As-built project

Each step in making project documentation can be divided into few parts:

- Hydrological part;

- Geological part;

- Hydropower part with hydropower facilities.

As result we have documentation for:

- Civil works including geological analyses;

- Electro-mechanical equipment;

- Other necessary documentation (environmental study...)

Feasibility Study – Elaborate of hydropower utilization

- First step in preparation of investment-technical documentation

- Rough estimation of hydropower utilization of some watercourse

- Estimation of hydrological potential,

- Visual recording of terrain

- Rough estimation of necessary type and amount of equipment.

Basic design - project

To obtain concession, as the first actual step toward realization of small hydro power plant construction project, it is necessary to submit adequate technical - investment documentation to the responsible authority that issues the concession. In Bosnia and Herzegovina that documentation is Basic design, i.e. project.

Basic design also serves for submitting applications for issuing all permits necessary before start of construction.

Main project

During preparation of this documentation it is recommendable to perform geological investigations at the site of construction of the water-intake building, powerhouse, and parts of pressure pipeline route.

Quantities of material, dimensions of construction grips with all necessary parameters are led to the level of precision of ±5%.

Regarding electrical-mechanical equipment, it is necessary to give principal solution of the powerhouse, while real dimensions and resulting quantities of materials and works will be known after tender announcement and selection of the electrical-mechanical equipment.

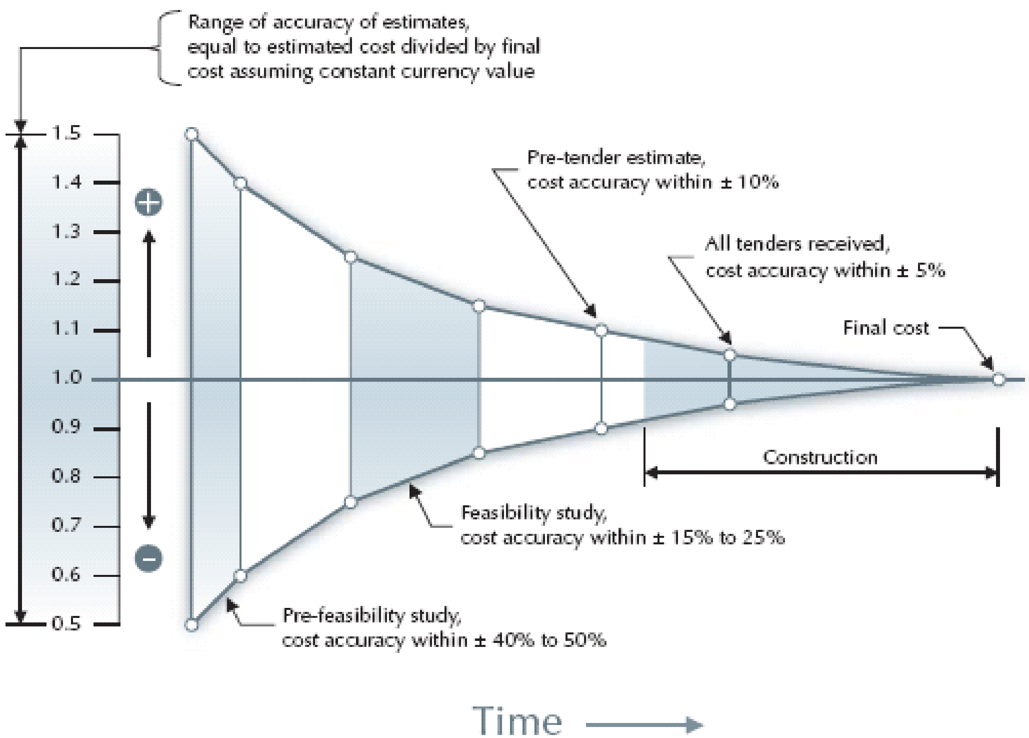
Tender documentation

After preparation of the Main project, the following step is its revision.

This level of documentation in construction part of the project presents shortened version where are emphasized basic features of the project with precisely defined priced bill of quantities.

Priced bill of quantities has preciseness of ±5%.

For each Bidder is left freedom also to offer different solution based on its experience as well as new technical knowledge and achievements.



Accuracy of project cost estimates vs. actual costs

Construction and performing of works during construction - Commissioning

- Usually the construction time from 8-12 months;

- Supervision on performing of construction works, delivery and erection of equipment;

- Supervision on commissioning

Economical aspects

- Legislative in energy sector presents (laws, decisions...):

    - Energy law;
    - Concession Law;
    - Decision on Methodology for Establishing Redemption Prices from Power Plants Based on Renewable Resources with the Installed power up to 5 MW;

- Regulatory agency

Economical aspects

According to "Decision on Methodology for Establishing Redemption Prices from Power Plants Based on Renewable Resources with the Installed power up to 5 MW" correction coefficients:

- Small hydro power plants 0,80
- Power plants on biogas from waste depots and biomass 0,77
- Power plants on wind and geothermal sources 1,00
- Power plants on solar energy 1,10

Economical aspects

- The correction coefficients in relation to price on 10 kV distributive connection, higher tariff, daily tariff.

- In case of decreasing of amount of the valid tariff system, the correction coefficients are increased for the percent of decreasing.

- In case of increasing of amount of the valid tariff system, the correction coefficients are not subject to modifications.

Stimulative measures

The electricity redemption price levels established according to the item III of the Decision could be subject of correction within the limits up to +10%, in cases when construction of power plants based on renewable resources of installed power up to 5 MW, contributes to decreasing of costs of development and construction of the network, thereof Federal Ministry of Energy, Mining and Industry gives approval on the basis of "Elektorprivreda" proposal.

Techno-economic characteristics of wind energy use

Case of Croatia

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Contract: INCO-CT-2004-509205

The aim of the presentation

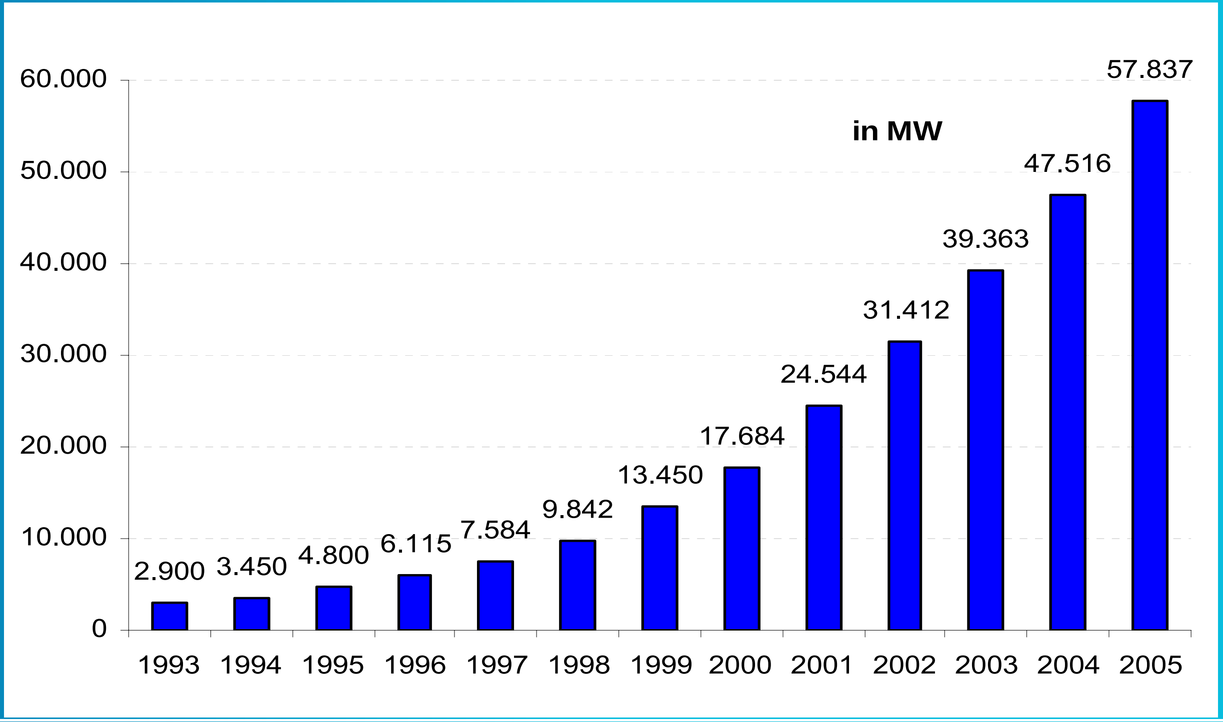
- To give a general and comprehensive overview of techno-economic characteristics of wind energy use
- Why?
  - Rapid increase in installed capacities world wide
  - Strong technology development
  - Specificities related to the operation and control
  - Economic feasibility
  - Strong interest of investors and good potentials for exploitation in Croatia
  - Benefits from wind energy use

Contents

- Status of wind energy use
- Technical characteristics
  - Wind characteristics
  - Wind turbine characteristics
  - Electricity production
  - Electric generators concepts
  - Power system impacts
- Economic characteristics
  - Expenditures and revenues
  - Specific costs and electricity production costs
- Environmental characteristics
- Wind energy status in Croatia
- Benefits from wind energy use

Status of wind energy use

- the installed world capacities have grown in time period 1993-2005 from 2,900 MW to 57,837 MW (annual average growth rate of 28.4%)



Status of wind energy use, II

- In 2005 installed capacity in the EU has reached 40,455.4 MW
- Wind energy origin electricity production in the EU was equal to 69.5 TWh in 2005 → a little over 2% of total EU electricity production
- The EU share in total world installed wind power capacities at the end of 2005 was equal to 70.6% and the share in market for generating equipment was equal to 60.3%
- Constant growth and development directed towards increase of wind turbine sizes, improved operation and control procedures and off-shore applications

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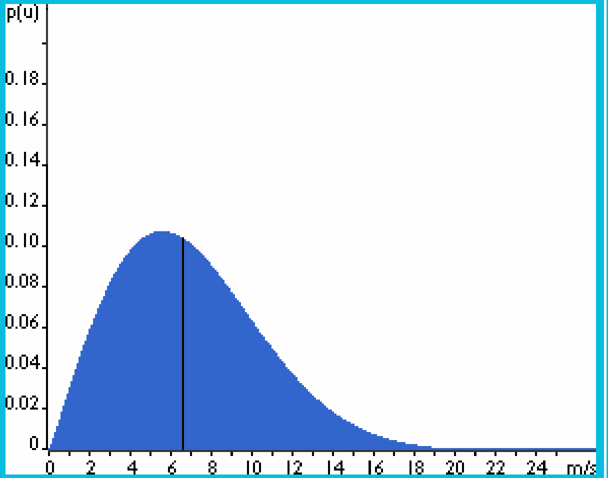
Technical characteristics of wind energy use

- **Wind characteristics**
  - Intermittent energy source
  - Long-term distribution of observed wind speeds conforms well to the Weibull probability density function
  - Development of wind prediction tools!
    - System reliability → managing power reserves from conventional power plants for ensuring real-time demand supply
    - In some countries (Spain) to avoid costs of deviations



Technical characteristics of wind energy use

➢ Wind turbine characteristics

- Wind power proportional with the cube of the wind velocity

$$P = \frac{1}{2}\rho A v^3$$

- Wind turbine design
  - Orientation of the axes → vertical or horizontal
  - Number of blades → three-bladed, less often one- or two-bladed
  - Rotor power regulation
    - Stall controlled→ passive and active
    - Pitch controlled

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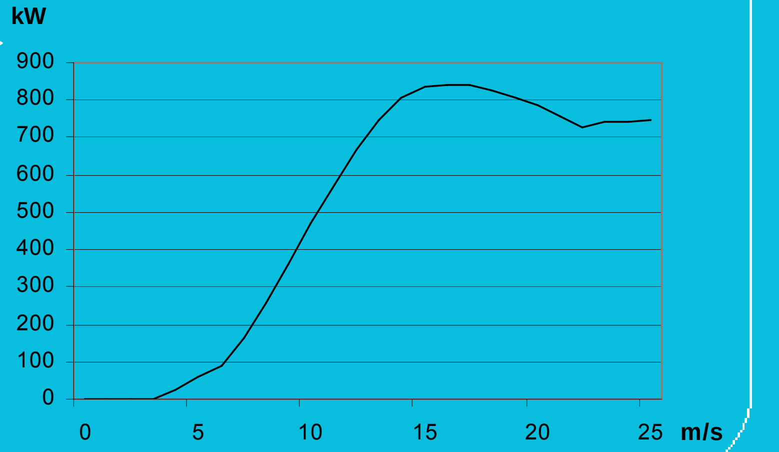
Technical characteristics of wind energy use

➢ Electricity production

- wind turbine turns the kinetic energy of the wind into mechanical energy → conversion of mechanical to electrical energy
- the amount of electricity delivered is dependant on the **Weibull parameters** and the **power curve**
- power curve of a wind turbine → electrical power output at different wind speeds



$$E_T = T\int_0^{\infty} P_v\, p(v)\, dv$$

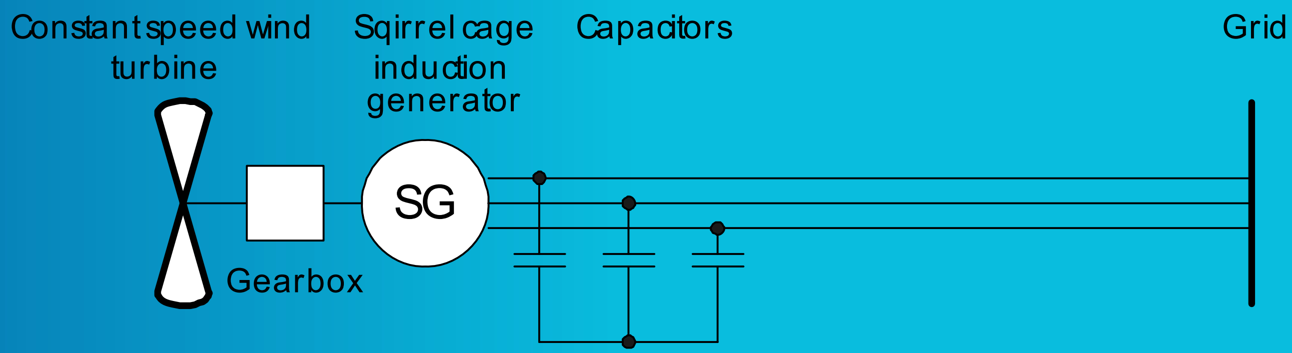
Technical characteristics of wind energy use

➢ Electric generator concepts

- generating systems different from conventional synchronous generator:
  - constant speed turbines
    - squirrel cage induction generator
      - » directly coupled to the grid
  - variable speed turbines
    - doubly fed induction generator
      - » rotor is connected to the grid through a back-to-back voltage source converter which controls the excitation system in order to decouple the mechanical and electrical rotor frequency and to match the grid and rotor frequency
    - direct drive synchronous generator
      - » completely decoupled from the grid by a power electronics converter connected to the stator winding

Technical characteristics of wind energy use

➢ Squirrel-cage induction generator system



- the power converted is limited by designing the turbine rotor in such a way that its efficiency decreases in high wind speed
- always consumes reactive power
- not able to control and regulate the voltage level
- capacitors close are necessary to avoid a voltage decrease

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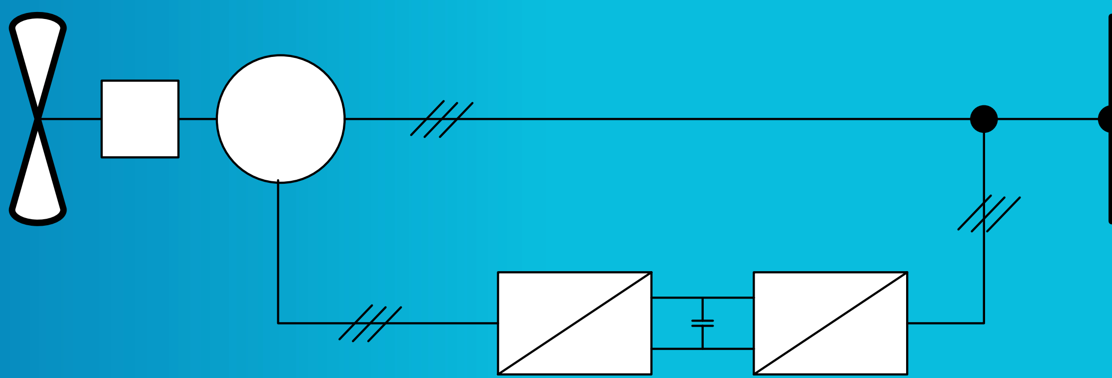
Technical characteristics of wind energy use

Doubly fed induction generator



- due to power electronics regulation, generator operates over a relatively large speed range
- electrical power is independent from the speed
- the concept allows turbine operation at the aerodynamically optimal point for a certain wind speed range

Variable speed wind turbine

Doubly fed induction generator

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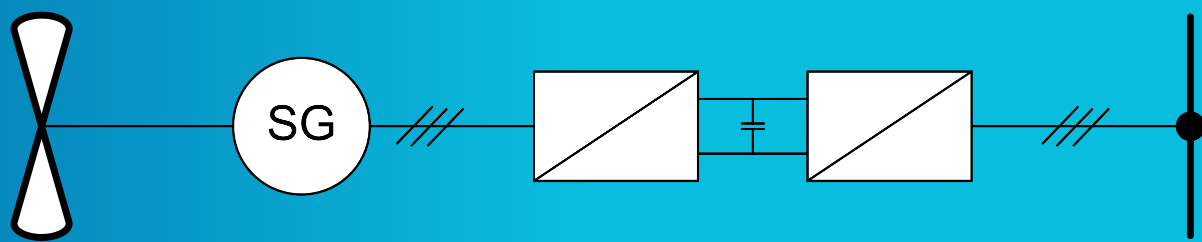
Technical characteristics of wind energy use

➢ Direct drive synchronous generator



- turbine and generator are directly coupled, without gearbox
- generator used in such systems is high-pole synchronous generator designed for low speed – large generator, thus large nacelle
- solution is in direct drive concept but with single stage gear box with low ratio – lower number of poles required and smaller generator

Variable speed wind turbine

Direkt-drive synchronous generator

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Technical characteristics of wind energy use

- **Power system impacts**
  - local impacts – occur in the electrical vicinity of the wind farm and can be attributed to a specific turbine or farm
    - branch flows and node voltages
    - protection schemes, fault currents, and switchgear ratings
    - power quality: harmonic distortion and flicker
  - system-wide impacts
    - power system dynamics and stability
    - reactive power and voltage control
    - frequency control and load following/dispatch of conventional units.
  - TSO requests → improved wind prediction and ability of WPPs to deal with voltage dips without disconnection from the network

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Economic characteristics of wind energy use

- The main parameters governing wind power project economics:
  - Investment costs;
  - Operation and maintenance (O&M) costs;
  - Electricity production/average wind speed;
  - Turbine lifetime (economic lifetime of the project);
  - Discount rate (cost of capital).

Investment costs and O&M costs: Expenditures
Electricity production/average wind speed: Revenues
Turbine lifetime and discount rate: Economic parameters

- Selecting the right site is critical to achieving economic viability!

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Economic characteristics of wind energy use

- **Wind power project expenditures**
  - Investment costs
    - up to 80% are wind turbine costs
  - Operation and maintenance costs
    - no fuel costs
    - land lease, insurance, transmission lines maintenance, parts and labour, administrative costs
    - approx. 2% of total costs
  - Cost of capital
    - strong influence of discount/interest rate
  - Depreciation
  - Profit tax
    - in Croatia 20%

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Economic characteristics of wind energy use

Wind power project revenues

- Revenues from electricity sales
  - amount of electricity produced
  - purchase price of electricity produced
    - guaranteed in its full amount
    - prescribed as a price cap on the electricity market price
    - aimed at reflecting the environmental benefits of the technology

$$E_T = T \int_0^{\infty} P_v \, p(v) dv$$

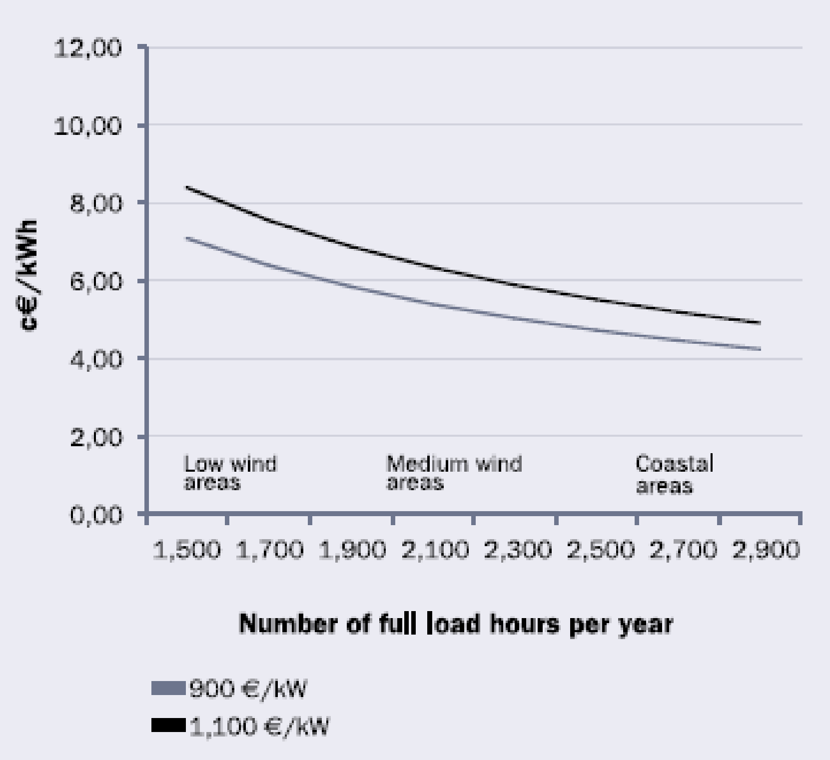
- Revenues from possible tax relieves for WPP construction and delivered kWh
- Revenues from possible financial support for produced kWh

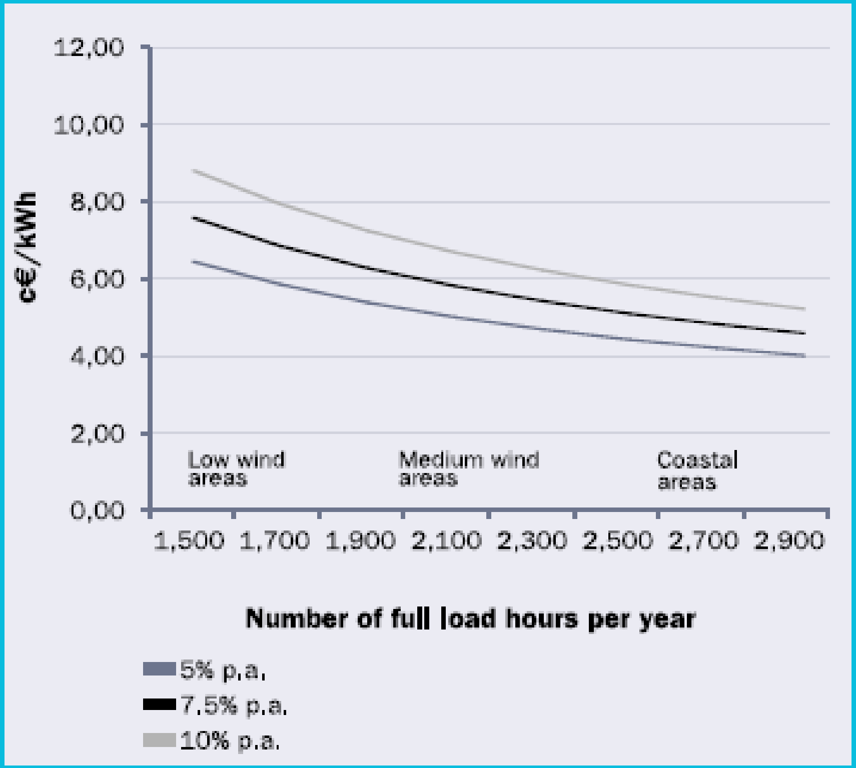
Economic characteristics of wind energy use

- **Generated electricity costs**
  - Calculated by discounting and levelising investment and O&M costs over the lifetime of wind turbine, divided by the annual electricity production.
  - Approx. 4-5 €cents/kWh at sites with very good wind velocities; 6-8 €cents/kWh at sites with low wind velocities
  - Cost reduction of over 50% in the last 15 years
  - With a doubling of total installed capacities, the cost of production per kWh from new wind turbines will fall by between 9% and 17 %

Economic characteristics of wind energy use

➢ Generated electricity costs, II





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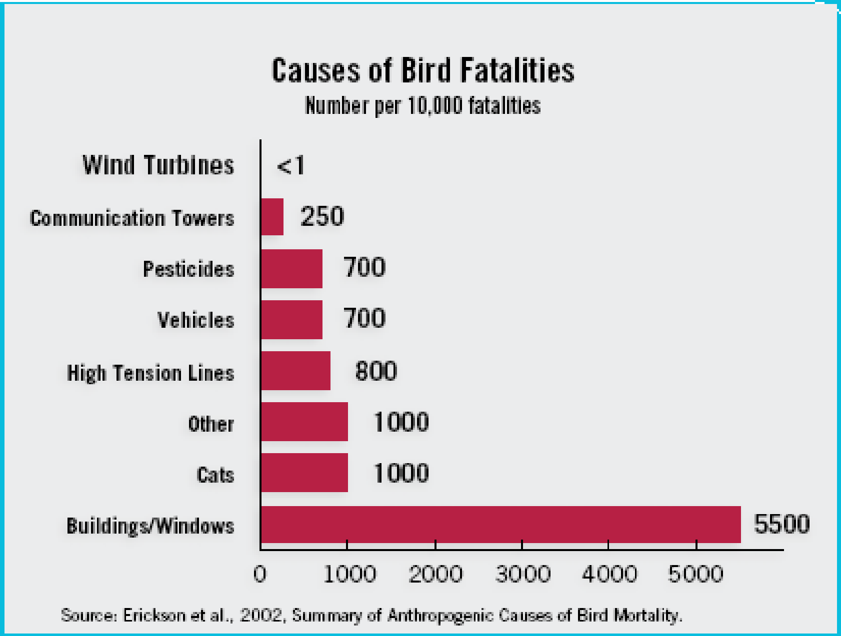
Environmental characteristics of wind energy use

noise	modern turbines are seldom heard at distances further than 300 m
visual impacts	care should be taken in the siting and design of the turbines
atmospheric emissions during the materials processing and components production	insignificant in comparison to those from fossil fuels
birds	collision in flight with turbines (3,1 bird per installed kW) and behavioural disturbance from blade avoidance
electromagnetic interference	minimised by careful siting of a wind facility

Environmental characteristics of wind energy use

- Bird mortality →



- Noise level on 300 m distance: 35 - 45 dB

  Quiet bedroom 35 dB
  Busy office 60 dB
  Pneumatic hammer (7 m) 95 dB
  Pain limit 140 dB

- Atmospheric emissions (energy chain):
  - Emissions are two orders of magnitude lower then from fossil fuel power plants
  - CO_2 equivalent emissions:
    - Wind power plant 6-9 g/kWh
    - Coal power plant 800 g/kWh
    - Natural gas power plant 260 g/kWh

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Wind energy status in Croatia

- Strong interest for wind energy use in Croatia
- National wind energy programme ENWIND established in 1998 → assessment of potentials, wind mapping, proposals for pilot projects → 29 locations → 400 MW installed capacities and 800 GWh electricity production per year
- Update of ENWIND in 2003 → 104 locations → 1300 MW installed capacities and 3000 GWh electricity production per year
- Currently only one wind power plant operating – 5.95 MW WPP Ravne on the island of Pag → private (foreign) investor and power purchase agreement with Croatian power utility
- Several projects in preparation → 11.2 MW WPP Trtar-Krtolin near Šibenik

Wind energy status in Croatia, II

- Development of domestic industry
  - Development of own 750 kW and 1 MW wind turbine in energy equipment production company Končar
  - Commissioning of the first 1MW wind turbine in 2006
  - Commissioning of the 14 1MW wind turbines in 2007 – WPP Pometeno Brdo
- Maintaining existing and creating new jobs!
- Apart from grid-connected facilities, possibilities exist for off-grid applications, especially see water desalinisation on the Adriatic islands, water pumping and irrigation systems → development of isolated areas

Wind energy status in Croatia, III

- Main barriers and problems
  - Lack of complete regulatory framework in Croatia → tariff system for RES and CHP
    - prescribed purchase price for every RES type
    - differentiation according to the installed power
    - for WPP over 1 MW → 0,57 HRK/kWh (7,6 €cents/kWh)
  - Jurisdiction of different ministries → Ministry of Environmental Protection, Physical Planning and Construction has brought out the Ordinance which forbids the construction of WPP on the islands and in the area 1000 m away from coast line
  - Long and complicated administrative procedure and permit issuing

Benefits from wind energy use

- Improved security of energy supply → reduced energy dependence through reduced energy imports
- Environmental benefits → emission reductions due to less energy produced from fossil fuel fired power plants
- Improvement of overall economic situation in the country → development of small and medium-size enterprises and creation of new jobs

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Thank you for your attention!

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LOW ENTHALPY (T<150ºC) GEOTHERMAL POWER GENERATION

by

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Centre for Renewable Energy Sources

June 2006

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1. Introduction

- started with a pilot unit of 10 kWe installed in Larderello of Italy, in 1904
- today amounts to 8.771 MWe spreaded in 25 countries
- 94% corresponds to high enthalpy geothermal energy of temperature 150-350 ºC with wet water vapour cycle (H_2O)
- 6% to Rankine cycle (organic or ammonia) units also called binary cycle units

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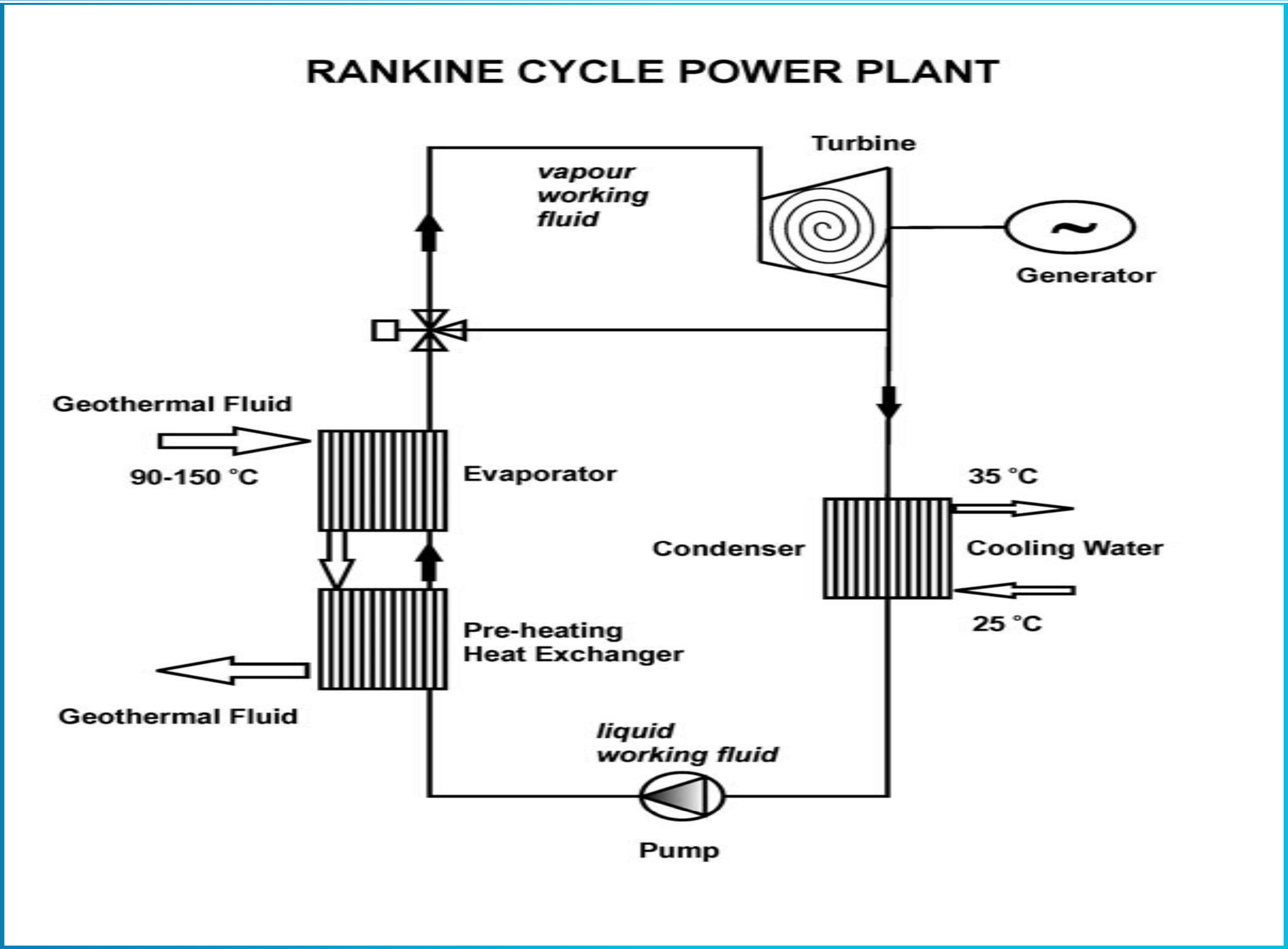
2. Technology

- Hydrocarbon (isobutane or isopentane) or fluoro-hydrocarbon (ORC) or Ammonia (KALINA).
- Cost effective operation with entering geothermal fluid temperature of 90°C+ .
- Can operate without supervision, with tele-monitoring and control through phone or satellite.
- Only part time semi-skilled personnel needed.
- Can cover both base or peek load, as well as fluctuating load, including load between 0 and 25% of installed power.
- Conversion efficiency depends on temperature:
  - 6,6% for geothermal fluids of 90ºC, to
  - 12% for 120ºC geothermal fluid and to
  - 15% for 150ºC.



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3. Energy costs

Overall geothermal power generation costs:

- **average : 5,7 Eurocents per kWh(e)**
- **maximum : 7,7 Eurocents per kWh(e)**

including the present value of capital costs discounted during the life time of the unit (20 years period and 5% discount rate)

Capital costs:

- **large binary plants (1-5 MW_e) : 850-1400 Euro/kWe**
- **smaller units (400-500 kW_e) : 1800 Euro/kWe**

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4. Installed units

Manufacturers:

- ORMAT (USA): market leader
- TURBODEN (Italy): first EU manufacturer
- SIEMENS (Germany): KALINA cycle

Global Market:

- EU, Romania & Iceland : 32 MWe
- USA: 294 MWe
- Other countries: 207 MWe
- World, total: 533 MWe

Annual Market Growth:

- 5,6% or 30 MWe

Combined with downstream direct heat uses for reduced energy costs and improved efficiency:

- Svartsengi & Husavik (Iceland),
- Neustadt Glewe (Germany),
- Altheim & Bad Blumau (Austria),
- .....

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Country	Field	MW_e	year	source, ºC
Austria	Altheim	1,00	2001	106
	Bad Blumau	0,25	2001	110
Germany	Neustadt-Glewe	0,21	2003	98
Iceland	Svartsengi, Reykjanes	9,10	1989-92	103
	Husavik	2,00	2000	120
Italy	Travale	0,70	1991	115
	Castelnuovo	1,30	1992	110
	Latera	2,00	2004	100+
Portugal	S.Miguel, Azores	14,00	1994-98	149
EU & Iceland		30,56		
World		533,35		

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5. Geothermal Potential of Europe

- Hot dry rock resources abounding everywhere at 3-5 km depth, but their exploitation is still at pilot stage.
- Water permeable horizons of major sedimentary basins at depths between 1 km and 3 km, having temperatures between 90ºC and 120ºC and locally up to 150ºC:
  - 90-120 ºC : 5.600 MW_e
  - 120-150 ºC : 300 MW_e
- High enthalpy geothermal fields associated with recent volcanic activity (Tuscany, Iceland, Azores, Canaries, Guadeloupe, Martinique, La Reunion, Milos, Nisyros, and others).
  - 90-150 ºC range for Rankine plants: 2.850 MW_e

6. Conclusions

- Geothermal power generation with Rankine cycle, is an internationally accepted technology.
- Cost effective and reliable.
- Unique for geothermal fluids of temperature 90 - 150ºC.
- In Europe, Rankine cycle power plants can be used for the exploitation of the geothermal potential of water permeable formations available in major basins at depths 1 km to 3 km.

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