SYSTEM ASPECTS OF RENEWABLE ENERGY SOURCES AND PROMOTION SCHEMES

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CONTENT OF LECTURE

System aspects of renewable energy sources (RES)
- Pros and cons of RES compared to fossil fuels
- Why RES has increasing importance in energy policies of MDC's
- Potentials of RES – from technical to economic potential

The Czech Energy Policy – the role of RES
- Potentials of different RES in the Czech conditions
- Fossil fuels and RES
- Dominant role of biomass in the Czech Energy Policy
- The current state of RES utilization in ČR – facts and figures

Promotion schemes for RES
- What is the goal of RES support - the different points of view
- Introduction to RES economic - basics on economic effectiveness of projects
- Two views on price of electricity (heat) from RES – supply and demand curves
- Promotion scheme for RES utilization for electricity generation – case example of the Czech Republic

WHAT ARE RENEWABLE ENERGY SOURCES ?

EU Directive 2001/77 definition:
- renewable non-fossil energy sources (wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases);
- 'biomass' shall mean the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste;

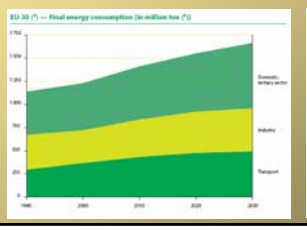
Solar energy
- Primary: solar radiation
- Secondary: Wind energy, wave energy, biomass incl. residual biomass, (potential) energy of water (rivers)

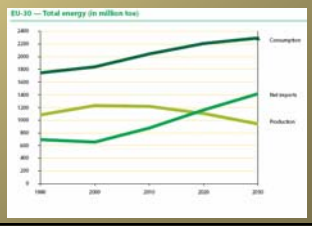
Sun and Moon motion - Tidal energy

Decay of radioactive elements - Geothermal energy

EU AND INCREASING DEMAND FOR ENERGY

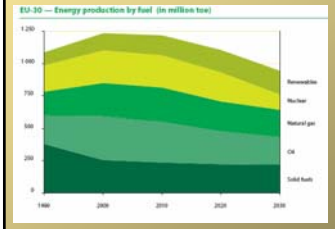
- **EU's demand for energy has been growing at a rate of between 1-2 % since 1986 (esp. transportation, electricity, tertiary sector)**
- **rapid increase o energy consumption in transport sector**
  - 67% of current oil demand (1998: 298 mil.toe, 1986: 203 mil. toe)
  - 1998: 189 mil vehicles, 1985: 132 mil. vehicles)
  - expectation up to 2010:
    - passenger transport + 19% (16% road use, 90% air transport)
    - goods transport +38% (road +50%)



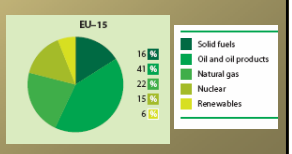


CURRENT ROLE OF RES IN EU FRAMEWORK

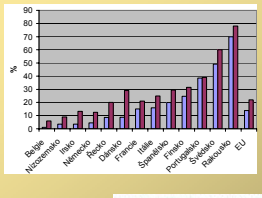
Two targets:
- **White paper:** doubling the share of renewables in global energy consumption from 6 % in 1997 to 12 % in 2010
- **EU Directive 2001/77:** increase of share from 13,9% in 1997 to 22,1% in 2010

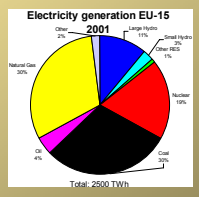


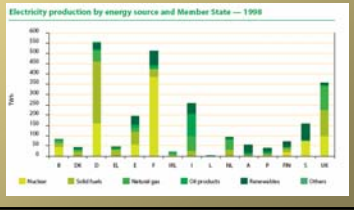
Gross internal consumption in EU15 (1998)



TARGET OF DIRECTIVE 2001/77 FOR SELECTED EU MEMBERS







ADVANTAGES OF RES COMPARED TO FOSSIL FUELS

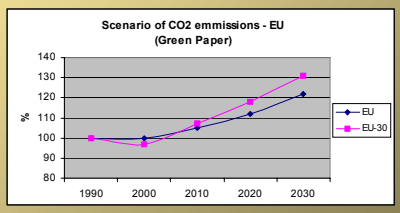
Why RES has increasing importance in energy policies of developed countries ?

- **Non fossil energy sources** – they do not contribute to GHG emissions or can directly contribute to their decrease (e.g. biogas or landfill gas utilization)
  - total emissions of GHG's by the EU15 are expected to increase by at least 5.2 % between 1990 and 2010, if no action is taken.
- **Major role of transport**
  - Although transport accounts for only 28% of total CO_2 emissions, it will be the main reason for the European Union failing to meet the commitments given at Kyoto unless radical changes are made rapidly
  - In particular, 90% of the expected increase in CO_2 between 1990 and 2010 will be attributable to the transport sector.

ADVANTAGES OF RES COMPARED TO FOSSIL FUELS - 2

- **Renewable energy sources can help with Kjoto targets**

BAU scenario without additional policies

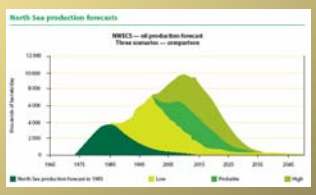


ADVANTAGES OF RES COMPARED TO FOSSIL FUELS - 3

- **Reduction of classical emissions** – e.g. SO_2, NO_x
- **Reduction of waste** – e.g. wastes from burning
- **Saving of non renewable sources** - implication to intergeneration solidarity – concept of sustainable development - contribution towards sustainability
- **Symbol of increasing responsibility** of developed countries in 90's
- **Increases in local employment and income** – dominant role of biomass, biomass can help with solving of agricultural policy of EU – opens new business for countryside and agricultural regions
- **Increase of energy independency** - RES are generally accessible
- **Diversification of energy sources** and reduction of import dependency - increased importance after September 11, 2001

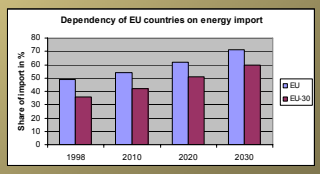
ADVANTAGES OF RES COMPARED TO FOSSIL FUELS - 4

- **EU's primary energy sources are quickly decreasing !**



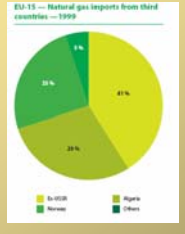
- **EU is highly depend on PES import !**

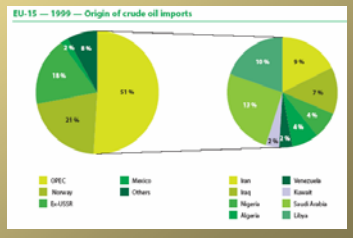
ČR dependency: 2010 – 45%, 2020 – 50%, 2030 – 60%



ADVANTAGES OF RES COMPARED TO FOSSIL FUELS - 5

- **Problem of natural gas and oil import – countries of origin**





DISADVANTAGES OF RES

- **(very) low density of energy** - large areas to collect enough energy are needed
- **dependency on external (natural, uncontrolled) conditions** – so called dependent production – one cannot mechanically compare kWh from RES and classical sources
- **typically cannot directly compete** with "classical" energy sources

Economic implications:

- Potential distortions on opening energy markets
- Energy markets leads to appraisal (evaluation) of electricity based on its features
- Higher utilisation of RES cause can decrease national economy competitiveness on global markets

DISADVANTAGES OF RES - 2

The economic and social system is based on centralised development around conventional sources of energy (coal, oil, natural gas and nuclear energy) and above all, around the generation of electricity

POTENTIALS OF RES – FROM TECHNICAL TO ECONOMIC POTENTIAL

Understanding of different meaning

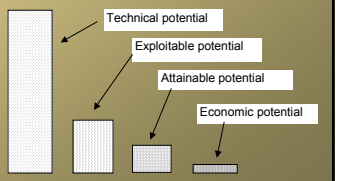
- Technical – done by source presence and by conditions of energy transformation (only theoretical meaning)
- Exploitable (available) potential – part of technical potential that can be used currently available technologies and limitations are done by legal, ecological and other limitations
- Attainable potential – part of exploitable potential that can be used for energy purposes
- Economic potential – part of available potential that can be used based on current economic condition influencing economic effectiveness of project for investors

POTENTIALS OF RES – FROM TECHNICAL TO ECONOMIC POTENTIAL - 2

Understanding of different meaning

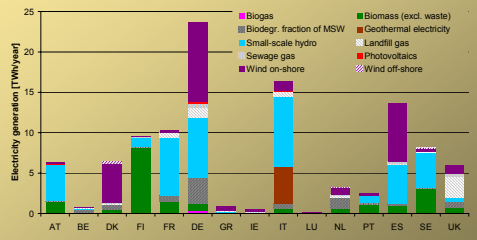
ČR example of potential relation – wind power:
- Technical potential: theoretical figure
- Exploitable potential: app. 3800 MW
- Attainable potential (year 2010): 460 MW
- Economic potential (year 2010): depends on value of feed-in tariff

Potentials depends on natural conditions, availability of tech-nologies, economic power and political strategy of given country !



DOCUMENTATION OF DIFFERENT RES POTENTIALS IN EU COUNTRIES

Electricity generation from various RES in EU-15 countries in 2001



THE CZECH ENERGY POLICY – THE ROLE OF RES

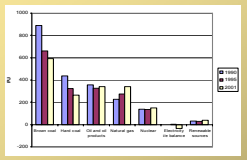
Czech Energy policy (2004)
- basic component of economic policy
- vision – state priorities and concrete targets, outlook up to 2030
- list of instruments and measures for reaching the targets
- basic document for preparation of other related policies

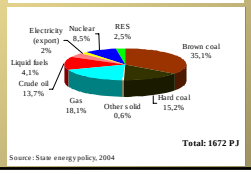
Goals
- Maximization of energy efficiency,
- effective structure of primary energy sources,
- environmental concern,
- accomplishment of transformation and liberalization of energy sector

THE CZECH ENERGY POLICY – THE ROLE OF RES - 2

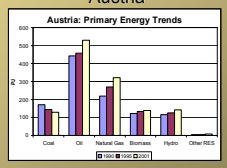
Decreasing role of coal in ČR - from 65% in 1990 to 51% in 2001

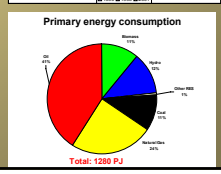
ČR





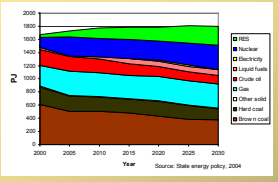
Austria





THE CZECH ENERGY POLICY – THE ROLE OF RES - 3

Expected changes in PES structure

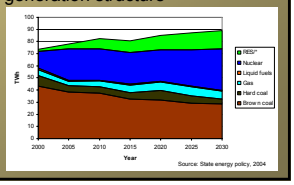


Expected share of RES in PES [MoIT 2003]

2000	2005	2010	2015	2020	2025	2030
2.63%	5.38%	8.96%	10.49%	12.03%	14.86%	15.75%

Great discussion about RES role – can we achieve the targets ?

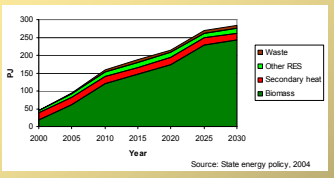
Expected changes in electricity generation structure



Expected share of RES in electricity generation (gross) [MoIT 2003]

2000	2005	2010	2015	2020	2025	2030
2.32%	5.32%	9.92%	12.17%	13.63%	16.23%	16.89%

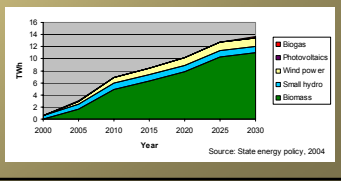
DOMINANT ROLE OF BIOMASS IN THE CZECH ENERGY POLICY



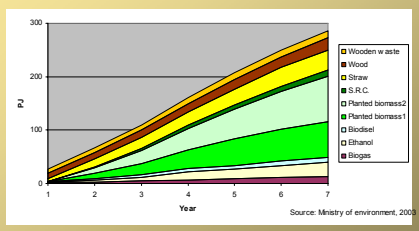
Share of biomass in primary energy sources

(about 85 % share of biomass in target year)

Structure of electricity generation from RES



SOURCES AND TYPES OF BIOMASS



Target cannot be reached without intentionally planted biomass !

THE CURRENT STATE OF RES UTILIZATION IN ČR – FACTS AND FIGURES

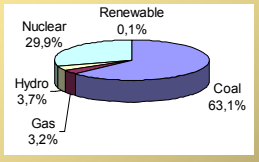
Share of biomass on total RES utilization in ČR, 2003 [MPO statistics]

	Heat production (GJ)	Gross electricity generation (GJ)	Produced energy (GJ)	Share on PES	Share on energy production from RES
Biomass*/	**29 625 688**	**1 342 701**	**30 968 389**	**1,7462 %**	**73,97 %**
Biodegradable part of waste	**2 047 484**	**34 519**	**2 082 003**	**0,1174 %**	**4,97 %**
Biogas	**780 639**	**388 282**	**1 168 921**	**0,0659 %**	**2,79 %**
Hydro power	**0**	**4 980 481**	**4 980 481**	**0,2808 %**	**11,89 %**
Wind power	**0**	**14 040**	**14 040**	**0,0008 %**	**0,03 %**
Liquid fuels **/	**2 660 000**	**0**	**2 660 000**	**0,1500 %**	**6,35 %**
Total/***	**35 113 811**	**6 760 023**	**41 873 835**	**2,3611 %**	**100,00 %**

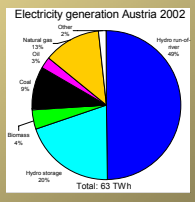
/*production outside household and estimate for households, /** CZSO estimate consumption for driving mechanisms, /*** heat pumps and solar energy not included

THE CURRENT STATE OF RES UTILIZATION IN ČR – FACTS AND FIGURES - 2

Structure of electricity generation in ČR, 2005
Total: 82 TWh



Electricity generation Austria 2002



The Czech Republic and Austria have quite different structure of electricity generation

THE CURRENT STATE OF RES UTILIZATION IN ČR – FACTS AND FIGURES - 3

Electricity generation from RES including expectations for 2005 and 2006 [ERO statistics]

	2001	2004	2005	2006	2010
	[MWh]	[MWh]	[MWh]	[MWh]	[MWh]
Small hydro (<10 MW)	826228	842840	914000	930000	1121000
Photovoltaic	0	19	0	111	15000
Wind energy	591	9901	76000	180000	930000
Geothermal energy	0	0	0	0	15000
Biomass incl. co-combustion	117	355207	665000	660000	2100000
Biogas	5824	90497	99000	160000	250000
TOTAL	832760	1298464	1754000	1930111	4431000

THE CURRENT STATE OF RES UTILIZATION IN ČR – FACTS AND FIGURES - 4

Development of RES-E share on Czech gross electricity consumption [ERO statistics]

RES	2001	2002	2003	2004	2005*	2010**
Electricity generation from supported power plants [GWh]	833	953	785	1299	1754	4431
Electricity generation from non-licensed sources [GWh]	129	19	36	-	-	-
Electricity generation from large hydro power plants [GWh]	1497	1864	967	1619	1600	1600
Total RES-E production [GWh]	2459	2836	1788	2918	3354	6031
Gross national consumption of electricity [GWh]	65108	64961	67014	68616	68522	75382
Share of RES-E on gross national consumption [%]	3,78	4,37	2,67	4,25	4,89	8

*/ expectation ERO, /** possible scenario of meeting Directive 2001/77 target

- EU Directive 2001/77 target up to the year 2010: 8%

THE CURRENT STATE OF RES UTILIZATION IN ČR – FACTS AND FIGURES - 5

Structure of heat generation from RES in ČR, 2004 [MPO 2004]

	Gross production [TJ]	Own consump./* [TJ]	Delivery [TJ]	Share on heat from RES [%]
Solid biomass total	**36480**	**34561**	**1614**	**90.89%**
Biomass industrial/**	**16980**	**15061**	**1614**	**42.30%**
Firewood	387	375	12	0.96%
Wooden chips, sawdust, etc.	8044	6202	1538	20.04%
Pulp extracts	8409	8409	0	20.95%
Plant materials	109	46	62	0.27%
Briquettes and pellets	31	30	2	0.08%
Biomass households	**19500**	**19500**	-	**48.58%**
Biogas total	**968**	**881**	**88**	**2.41%**
Municipal sewage	723	723	0	1.80%
Industrial sewage	74	71	4	0.19%
Biogas from agriculture	68	68	0	0.17%
Landfill gas	104	19	84	0.26%
Solid municipal wastes	**2052**	**570**	**1481**	**5.11%**
Heat pumps	**580**	**580**	**NA**	**1.45%**
Solar thermal collectors	**57**	**57**	**NA**	**0.14%**
Total	**40138**	**36649**	**3183**	**100.00%**

/* consumption for own purposes plus losses in delivery,
/** except households and small consumers

THE CURRENT STATE OF RES UTILIZATION IN ČR – FACTS AND FIGURES - 6

Structure of total biomass utilization, ČR, 2004 [MPO 2004]

Biomass type	Utilization		Total [t]
	electricity [t]	heat [t]	
Wooden chips, sawdust, w. waste etc.	243834	864912	1108747
Firewood	-	36794	36794
Plant materials	11590	11498	23087
Briquettes&pellets	1227	2251	3478
Pulp extracts	157203	862042	1019245
TOTAL	413854	1777497	2191351
Estimate of wood consumption in households			1500000
Biomass export (suitable for energy purposes)			322955
TOTAL			**4014306**

PROMOTION SCHEMES FOR RES

What is the goal of RES support - the different points of view

- **Similar effects of different tools**
  - RES for electricity generation
  - RES for heat production and delivery (industrial, households)
  - Energy savings
  - Energy efficiency (e.g. cogeneration)
- **One cannot concentrate only at EU Directive 2001/77 targets !**
- What are the system goals ? Just RES support ?
- Economic rule about scarce resources – invest into fields with highest marginal effects !
- Is it rational to use biomass for electricity generation ?

INTRODUCTION TO RES ECONOMIC - BASICS ON ECONOMIC EFFECTIVENESS OF PROJECTS

- **Private investors run RES projects**
- Investors expects (fair, adequate, required) rate of return on capital invested – they need to sell at least for the minimum price cmin

$$NPV = \sum_{t=1}^{T_n} CF_t \cdot (1+r_n)^{-t} = 0 \qquad \sum_{t=1}^{T_n} c_{\min 1} \cdot Q_t \cdot (1+r_n)^{-t} = \sum_{t=1}^{T_n} V_t \cdot (1+r_n)^{-t}$$

$$c_{\min 1} \cdot \sum_{t=1}^{T_n} (1+\inf)^t \cdot Q_t \cdot (1+r_t)^{-t} \cdot (1+\inf)^{-t} = \sum_{t=1}^{T_n} V_t \cdot (1+r_n)^{-t}$$

$$c_{\min 1} = \frac{\sum_{t=1}^{T_n} V_t \cdot (1+r_n)^{-t}}{\sum_{t=1}^{T_n} Q_t \cdot \left[\frac{(1+r_n)}{(1+\inf)}\right]^{-t}} = \frac{\sum_{t=1}^{T_n} V_t \cdot (1+r_n)^{-t}}{\sum_{t=1}^{T_n} Q_t \cdot (1+r_r)^{-t}}$$

- NPV=0 means that production is sold for c_{min} price and investor gains rate of return equal to discount rate !

INTRODUCTION TO RES ECONOMIC - BASICS ON ECONOMIC EFFECTIVENESS OF PROJECTS - 2

How c_{min} is calculated:

- data of reference projects are necessary
- decision on discount rate value

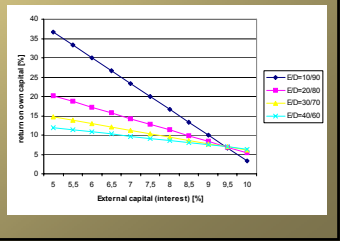
Meaning of discount – WACC

$$WACC = r_{ed} * \frac{E}{E+D} + i * (1-d) * \frac{D}{E+D}$$

E ... equity (own capital)
D ... debt (external capital)
i ... cost of external capital
d ... tax rate
red... return on own capital

What is the "fair" return on capital ?

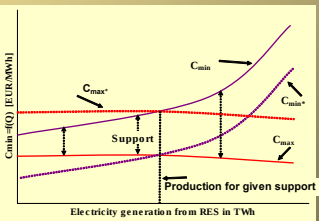
Higher risk - higher return,
lower risk – lower return !



TWO VIEWS ON PRICE OF ELECTRICITY (HEAT) FROM RES – SUPPLY AND DEMAND CURVES

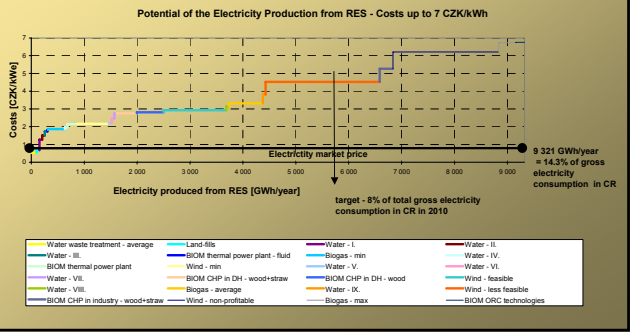
Price of production (e.g. electricity from RES)

- **point of view of producers** – c_{min} price
  - supply curve
- **point of view of consumers** – c_{max} price
  - demand curve
  - derived from prices of competitive products on market



TWO VIEWS ON PRICE OF ELECTRICITY (HEAT) FROM RES – SUPPLY AND DEMAND CURVES - 2

Supply curve of RES reflects different cost of production for different RES



TWO VIEWS ON PRICE OF ELECTRICITY (HEAT) FROM RES – SUPPLY AND DEMAND CURVES - 3

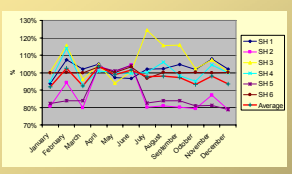
Demand curve – point of view of consumers

- Technical features of production are taken into account
  - Reliability
  - Diagram of delivery
  - Possibility of regulation
  - Electricity: power and system services
- Competition of different producers
- Role of electricity market

TWO VIEWS ON PRICE OF ELECTRICITY (HEAT) FROM RES – SUPPLY AND DEMAND CURVES - 4

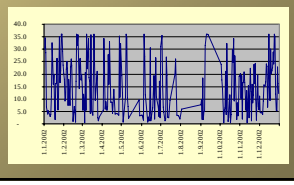
RES and electricity generation

- typical problem of dependency on actual external conditions



Example of utilization of available capacity for selected small hydro power plants

Example of fluctuation of power generation in wind power plant



MEASURES FOR CHANGING POSITION OF SUPPLY AND DEMAND CURVES

How support renewables – case example of electricity generation

- **affection of supply or demand curves**

Moving supply curve down

- investment subsidy
- operational subsidy related to power generation – green bonus
- reduction of investors risk – investment to R&D, good conditions for investors
- reduction of cost of financing – preferential loans (zero or reduced interest)
- tax exemptions (income tax holidays, real estate tax)
- green certificates – sale of emission reduction
- combination of quota system and sale of certificates

MEASURES FOR CHANGING POSITION OF SUPPLY AND DEMAND CURVES - 2

Moving demand curve up

- feed-in tariff and obligation of purchase
- quota system
- information campaigns (voluntary purchase of green electricity for higher price)
- ecological taxation imposed to classical electricity generation (carbon tax)
- emission allowances

Feed-in tariffs – widely used instrument

PROMOTION SCHEME FOR RES UTILIZATION FOR ELECTRICITY GENERATION IN ČR

- **up to the year 2002** – no system approach
  - electricity sold at market conditions
  - only not guaranteed investment support from State environmental fund and Czech energy agency
- **2002-2005:** regulatory authority set up feed-in tariffs on yearly base (price decisions of ERO) – no specific legislation
- **2003-5:** discussions on legislation, several major changes
- **from 2006:** systematic support according to Act 180/2005

PROMOTION SCHEME FOR RES UTILIZATION FOR ELECTRICITY GENERATION IN ČR - 2

Main logic of Act 180/2005

- deals only with electricity generation
- feed-in tariffs and green bonus scheme – producer choose for each year
- tariffs and bonuses are set up by ERO
- **feed-in tariff scheme:**
  - obligation of purchase for distribution company
  - tariffs differentiated according to type of RES
  - fixation of tariff for 15 year (annual adjustment by PPI)
  - tariff should be set up for 15 year of payback time
  - principle of time matrix – tariffs are related to the year of placing into operation (next year tariffs – max. possible decrease 5%)

PROMOTION SCHEME FOR RES UTILIZATION FOR ELECTRICITY GENERATION IN ČR - 3

- **green bonus scheme**
  - electricity is sold for market price
  - distribution company pays green bonus
  - necessity to solve responsibility for deviations in electricity generation
  - higher market risk is reflected in volume of bonus
  - co-firing of biomass and coal can use only green bonus scheme

Open questions of Act 180/2005

- utilization of heat in combustion processes (ERO applied logic of "reasonable" utilization of originated heat)
- doesn't solve problem of parallel support
- differentiation of (solid) biomass utilization
- what will happen after 15 year

PROMOTION SCHEME FOR RES UTILIZATION FOR ELECTRICITY GENERATION IN ČR - 4

Logic of feed-in tariff

- C_{min} (from NPV=0) is base for feed-in tariff setting

Logic of green bonus

- green bonus=c_{min}* - market price
- c_{min}* is recalculated for adequate discount (level of risk)

Higher risk in green bonus scheme

- business risk
- depends on share of market price in c_{min}

PROMOTION SCHEME FOR RES UTILIZATION FOR ELECTRICITY GENERATION IN ČR - 5

Feed-in tariffs for the year 2006

Type of RES	F. tariff	G. bonus
	cE/kWh	cE/kWh
Small hydro (<10 MW)	8.21	5.02
Photovoltaic	46.32	44.18
Wind energy	8.63	7.09
Geothermal energy	15.79	12.77
Biomass	8.04-10.28	4.63-6.88
Biomass co-firing	-	1.89-4.14
Biogas stations	10.46	7.05
Landfill gas	7.82	4.42
Biogas - sewage plants	7.82	4.42

Note: Valid for new plants, 1 EUR=28.5 CZK, tariffs and bonuses are differentiated according to type of solid biomass used

PROMOTION SCHEME FOR RES UTILIZATION FOR ELECTRICITY GENERATION IN ČR - 6

Green bonuses calculation needs:

- c_{min}* (recalculation of c_{min} for given discount rate)
  - three categories of RES – increase of discount by 0,5-1,5%
  - wind, photovoltaic, geothermal/biomass and biogas applications/small hydro
  - modification of discount rate by share of revenues from electricity sale on total revenues
- estimates of market price
  - depends of price and diagrams of electricity at electricity market (for given year)
  - wind 18,95 EUR/MWh
  - photovoltaic 28,42 EUR/MWh
  - all other RES 37,26 EUR/MWh


Thank you for attention