SYSTEM ASPECTS OF RENEWABLE ENERGY SOURCES AND PROMOTION SCHEMES

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CONTENT OF LECTURE

- ⇨RENEWABLE (ENERGY) SOURCES
- ⇨ WHAT ? ⇨ RES definition
- ⇨WHY ? ⇨RES significance
- ⇨HOW ? ⇨RES effective support

WHAT

⇨ **WHAT ?** ⇨ **RES definition**

RENEWABLE (ENERGY) SOURCES

DEFINITION:

- different possible definitions
  - *e.g. those sources that – assuming gradual utilization – are able to be fully or partly recovered with or without man assisstance*
- Renewable sources utilization
  - to cover energy needs (power, heat, liquid fuels for transport, cattle)
  - material utilization (houses, matters of daily need, ships and boats, construction materials, etc...)
  - food

RENEWABLE (ENERGY) SOURCES

LEGAL DEFINITION:

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;

Fuzzy border between non-traditional and renewable energy sources

- ⇨ e.g. what is still RES and what belongs to waste category

ORIGIN OF RENEWABLE ENERGIES ?

Solar energy

- ⇨ Primary: solar radiation (solar constant 1 367 W/m^2)
- ⇨ 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 (+residual Earth energy from the Earth formation

CURRENT ROLE OF RES IN EU

EU 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 – power generation
- ⇨ **Climate – energy package to 2020 (4 directives)**
  - ⇨ 20/20/20 target
  - ⇨ 20% GHG reduction (2020 against 1990) – possibly 30% in case of effective world action
  - ⇨ 20% RES energy share on final energy consumption – differs by country
  - ⇨ 10% of biofuels
  - ⇨ **New RES directive 28/2009, NAP for individual countries**

WHY

⇨**WHY ? ⇨RES significance**

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 would increase by at least 5.2 % between 1990 and 2010, if no action is taken.
  - **Major role of transport**
  - 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

- ⇨ **Reduction of classical air emissions** – e.g. SO_2, NO_x
- ⇨ **Reduction of waste** – e.g. solid 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

ADVANTAGES OF RES COMPARED TO FOSSIL FUELS

- **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
  - diversification of activities (reduction of dependency on fluctuating market with agriculture commodities)
- **Decentralized solutions (?reliability, safety)**
- **Increase of energy independency** - RES are generally accessible
- **Diversification of energy sources and reduction of import dependency** - increased importance after September 11, 2001

DISADVANTAGES OF RES

- **(very) low density of energy** - large areas to collect enough energy are needed
  - e.g. can biomass substitute coal (fully) in the Czech Rep.?
- **dependency on external (natural, uncontrolled) conditions**
  - so called dependent production – one cannot mechanically compare kWh from RES and classical sources
  - instant, daily, seasonal fluctuations
- **typically cannot directly compete** with “classical” energy sources

DISADVANTAGES OF RES

Economic implications:

⇨ Potential distortions of opened energy markets

⇨ needs harmonization of support schemes ??

⇨ Energy markets leads to appraisal (evaluation) of electricity based on its features

⇨ kWh from different sources have different value

⇨ cost of backuping, cost of dynamic services

⇨ Higher utilization of RES cause can decrease national economy competitiveness on global markets

⇨ see CZ case with uncontrolled PV boom

DISADVANTAGES OF RES

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

from Green Paper on Security of supply, EC, 2001

GROWING DEMAND FOR ENERGIES

⇨ **Do we have enough energy for mankind ?**

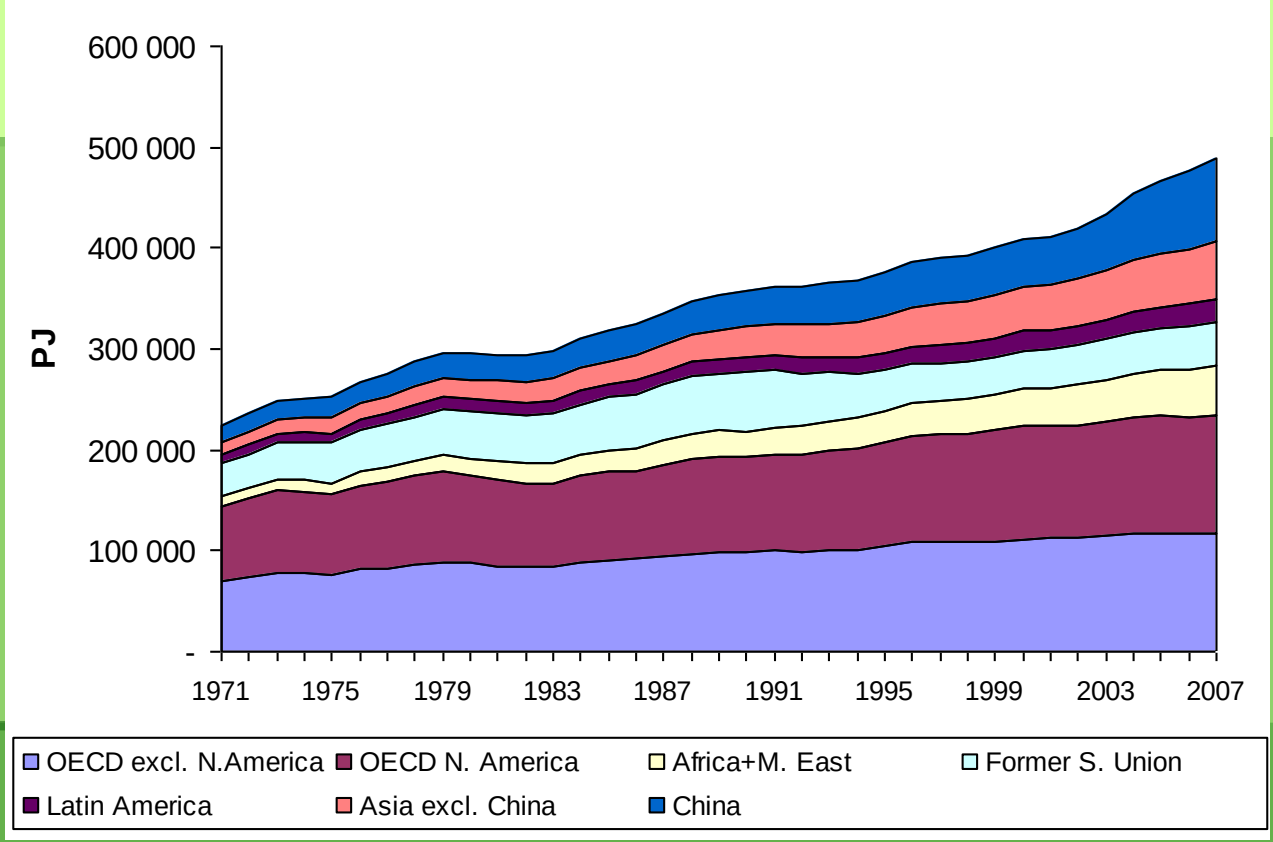
E.g. if potential black-put would exceed 72 hours (CZ analysis) the whole state society infrastructure would collapse

⇨ **What is the current role of RES ?**

⇨ **What are the political aspects ?**

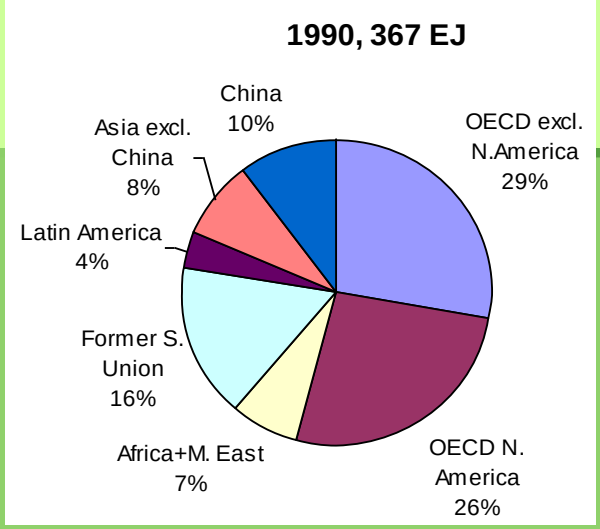
⇨ **Is it safe to be dependent on import ?**

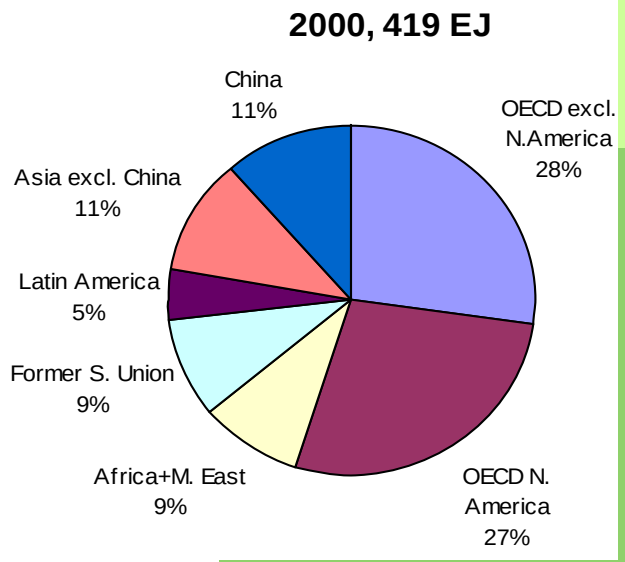
TOTAL PRIMARY ENERGY CONSUMPTION
World and regions

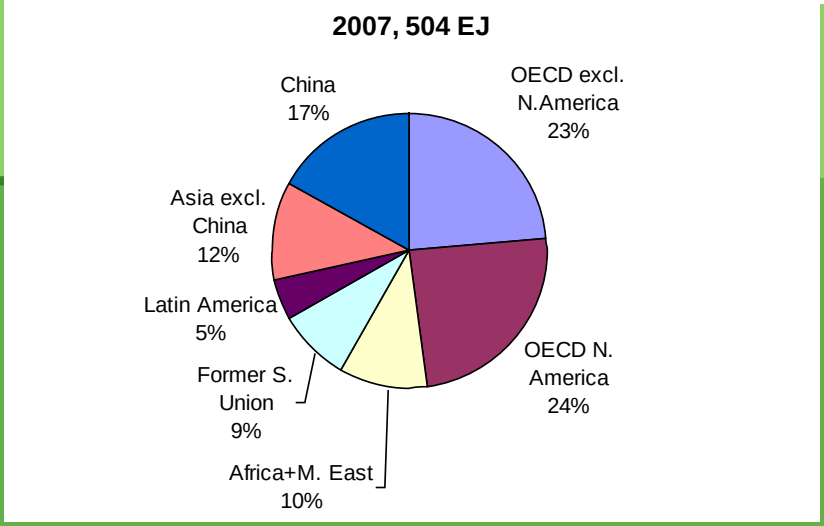


	Growth rate			
	1971/1981	1981/1991	1991/2001	2001/2007
OECD total	1,71%	1,31	1,38	0,85%
Rest of the world	4,29%	3,16	1,13	5,30%
EU 27	-	-	0,51%	0,32%

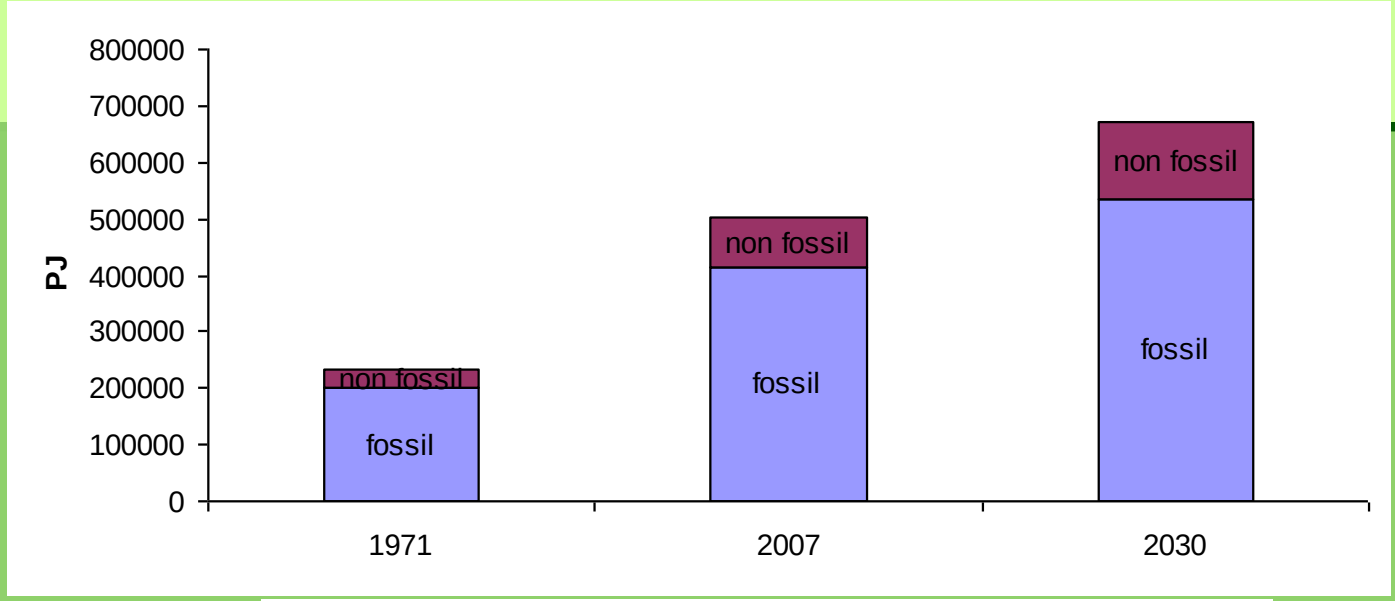
TOTAL PRIMARY ENERGY CONSUMPTION
World and regions

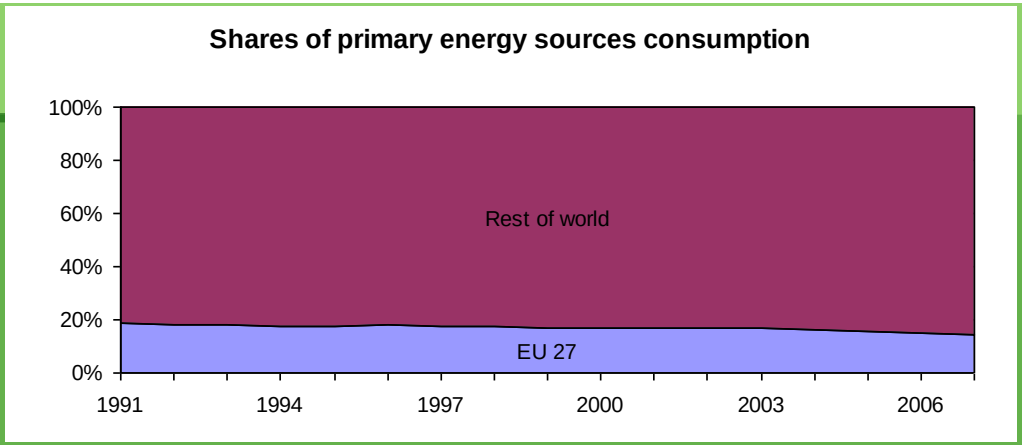




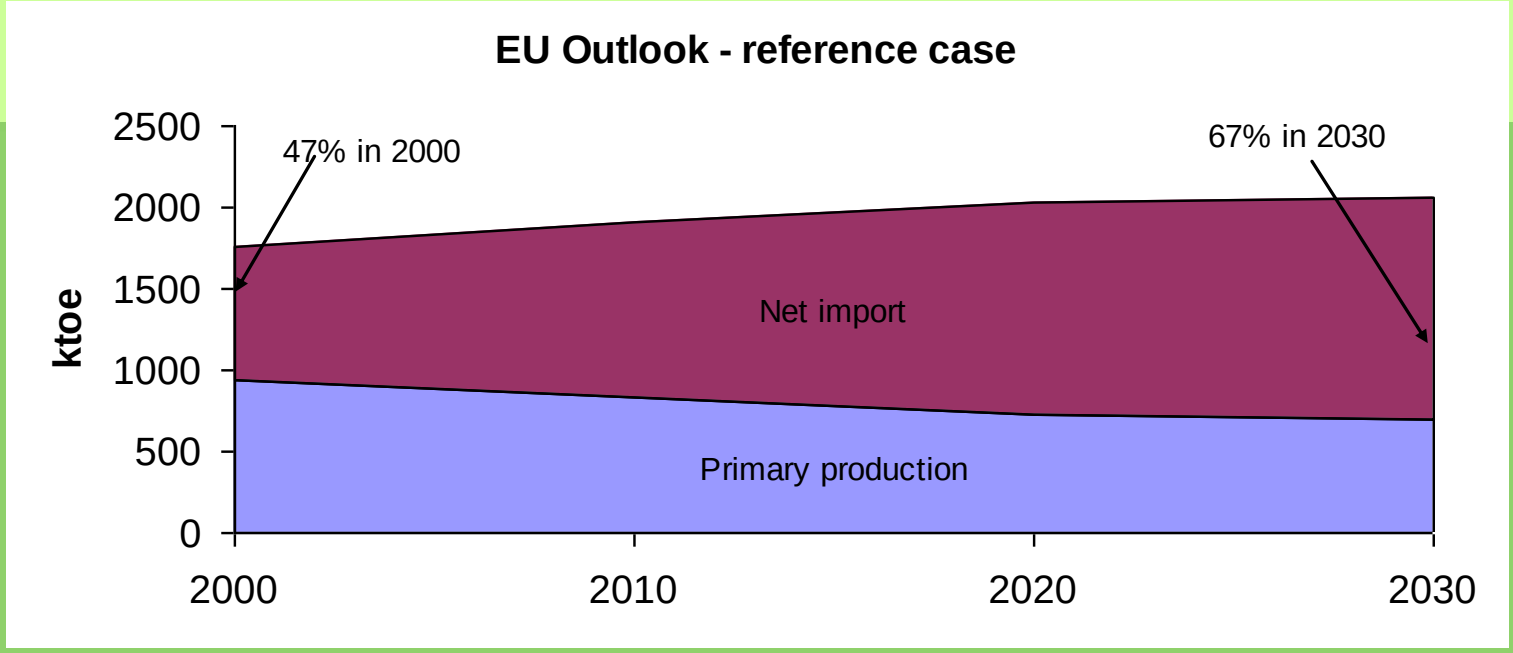


TOTAL PRIMARY ENERGY CONSUMPTION
An outlook – reference scenario





INCREASING DEPENDANCY ON IMPORT

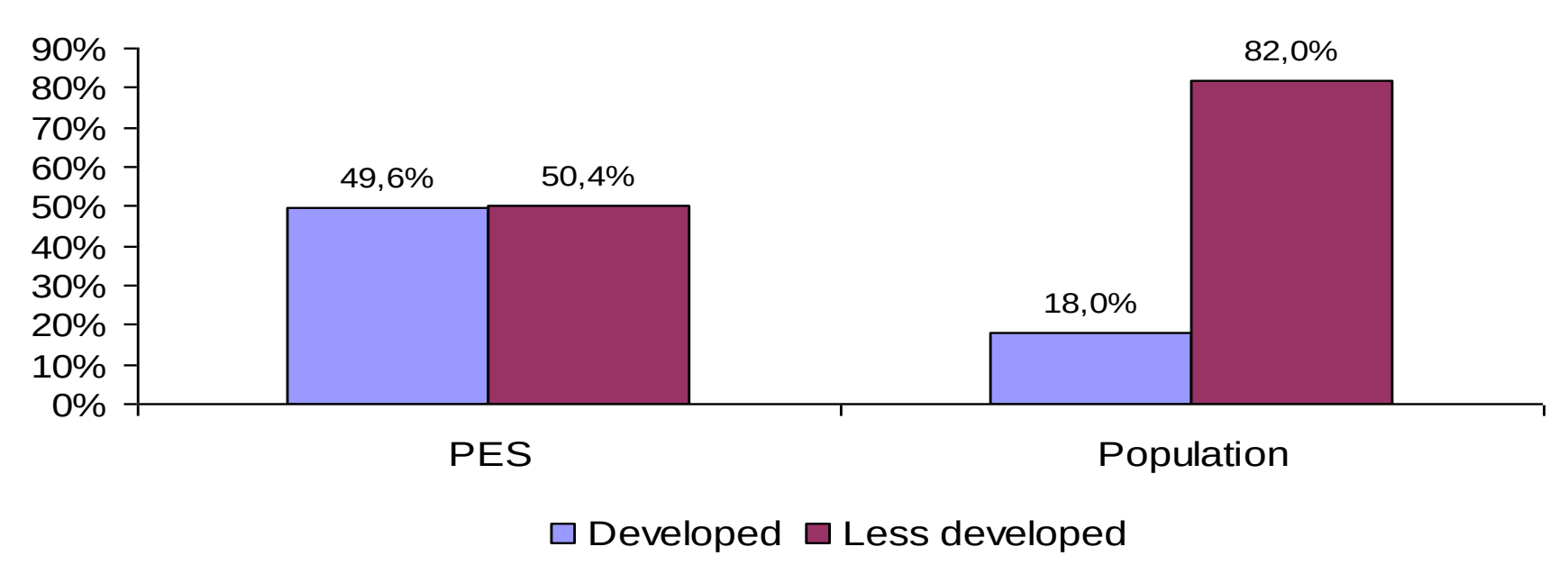


Import of PES plays very sensitive role in EU policy

⇨ EU depends on oil and gas import, from what countries ?

⇨ where are the new possible sources ?

UNEVEN ENERGY CONSUMPTION



⇨share of developed countries on total source consumption differs significantly by source

UNEVEN ENERGY CONSUMPTION

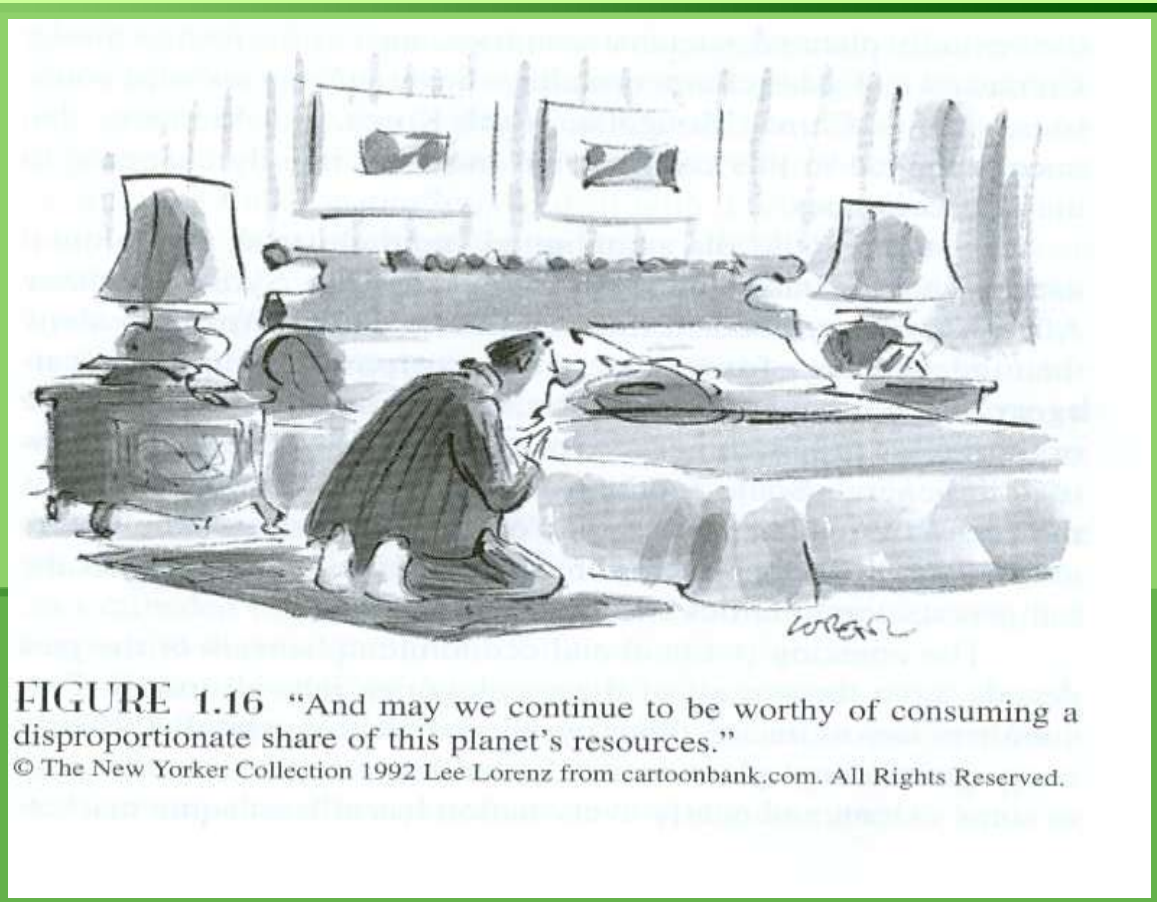
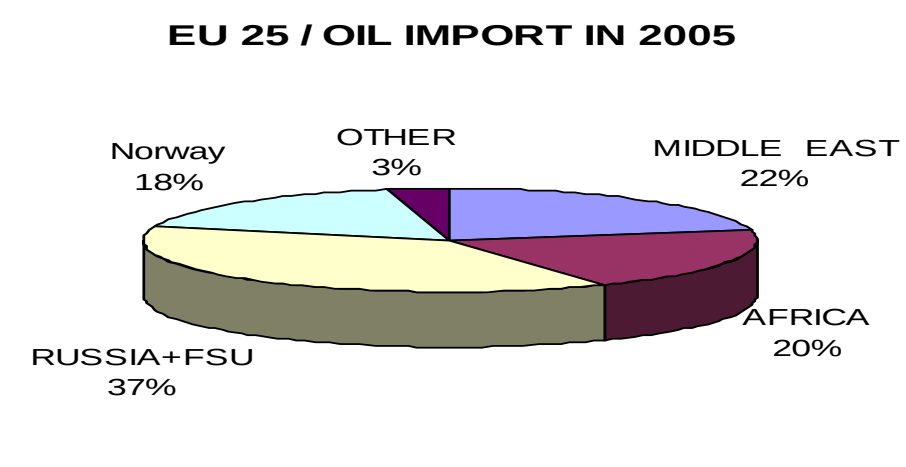


FIGURE 1.16 "And may we continue to be worthy of consuming a disproportionate share of this planet's resources."

WE CANNOT FORGET FOR SECURITY AND RELIABILITY !

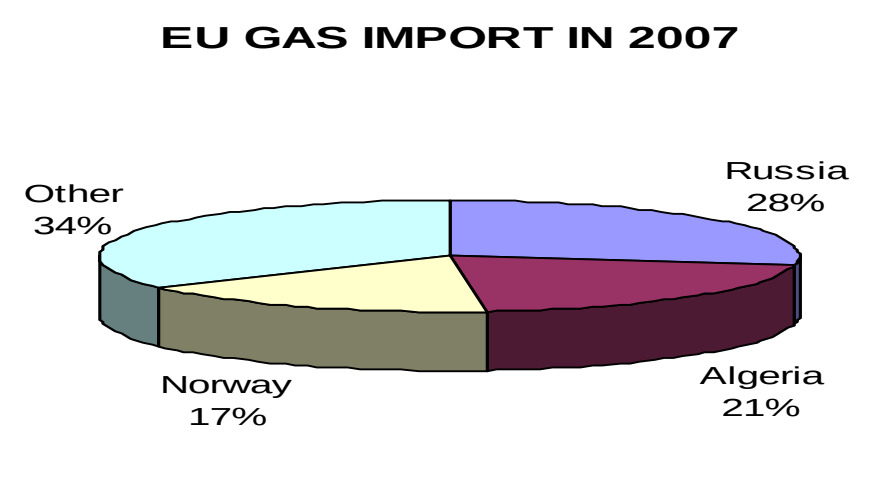
PES - SECURITY ISSUES

- From where do we import oil and gas ? What is political context ?

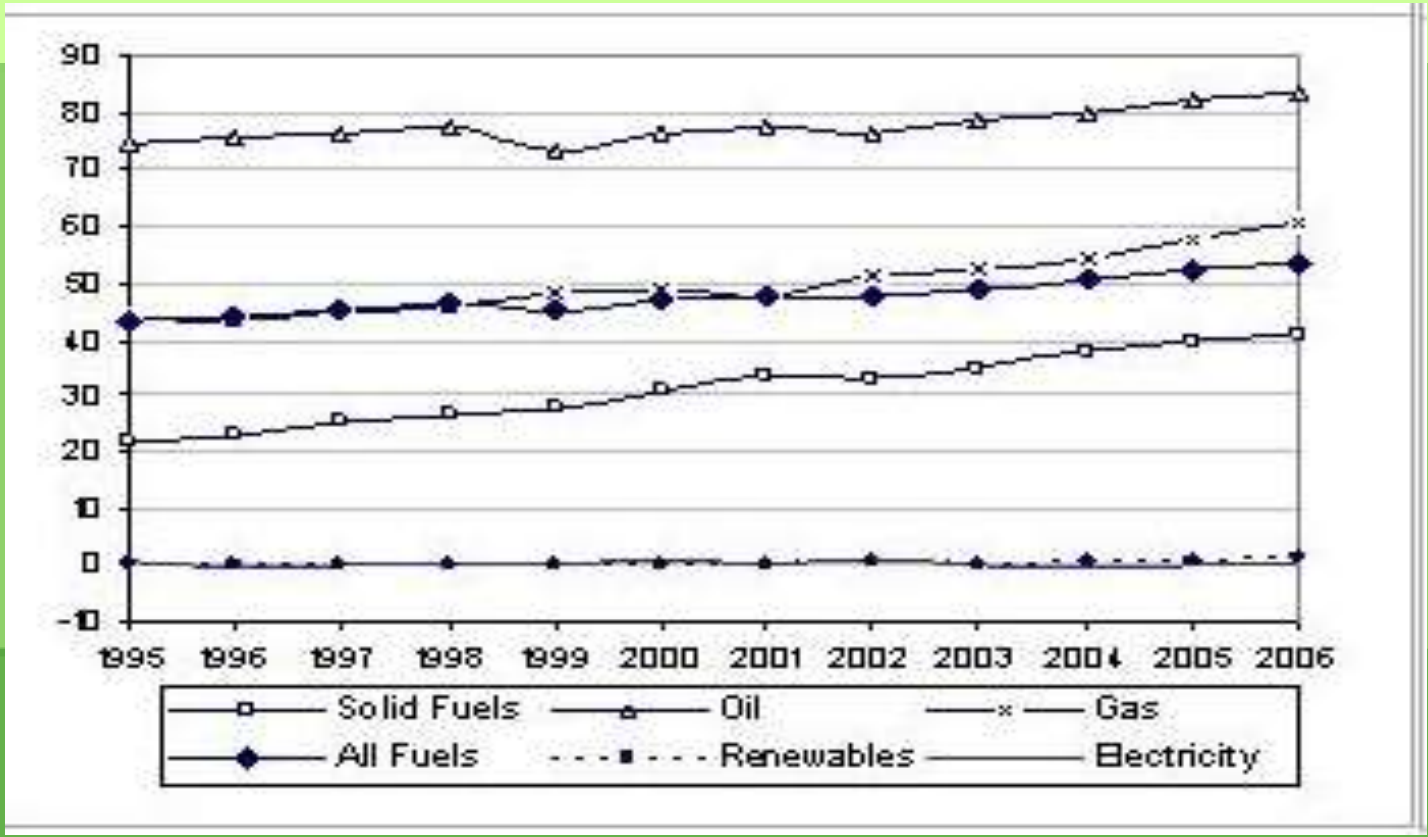


Obligatory emergency oil reserves for 90 days at least

Some countries have significant natural gas storage capacitites – e.g. Czech Republic up to 35% total year consumption



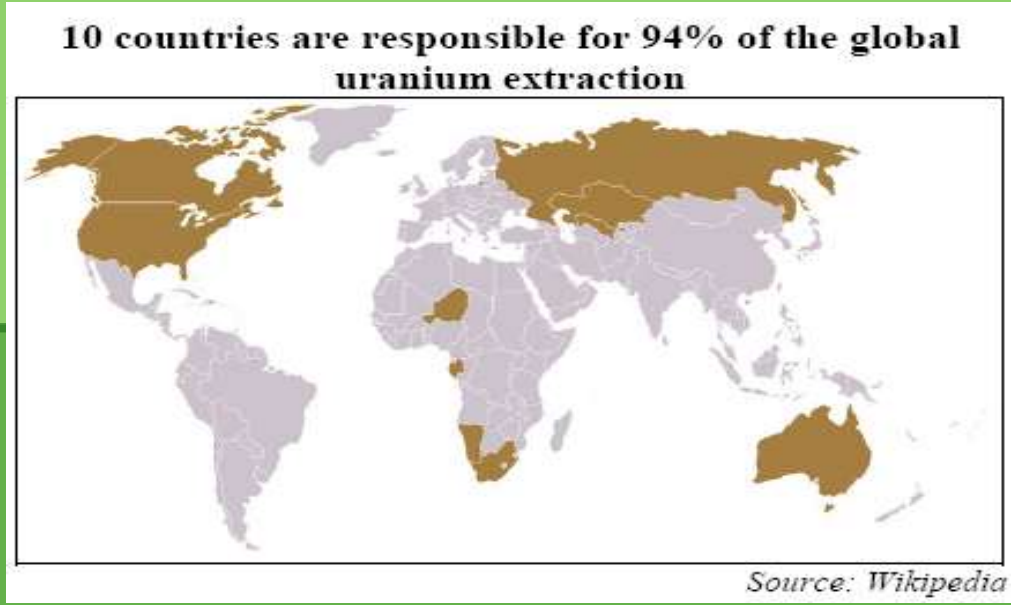
EU 27 IMPORT DEPENDENCY



NUCLEAR FUEL

Where are the reserves of urainum ?

- 1st EU country is on 12th position only (Czech Republic) !
- relatively easier to build strategic reserves



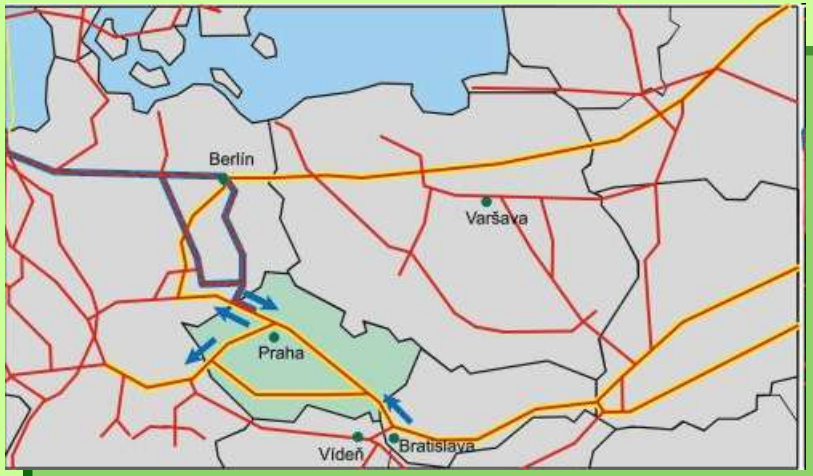
TRANSPORTATION SECURITY AND RELIABILITY

How to get oil and gas from producing sites to the consumers ?

Oil pipelines in Europe

TRANSPORTATION SECURITY AND RELIABILITY

Natural gas pipelines in Europe



Why we had troubles in beg. of 2009 with natural gas from Russia ?

Other discussed projects

- NordStream (from Russia to Germany through Baltic sea)
- SouthStream (from Russia to SouthEast Europe through Black Sea)
- new facilities for LNG

POTENTIALS OF RES – FROM TECHNICAL TO ECONOMIC POTENTIAL

Understanding of different meaning

- **Technical potential** – 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

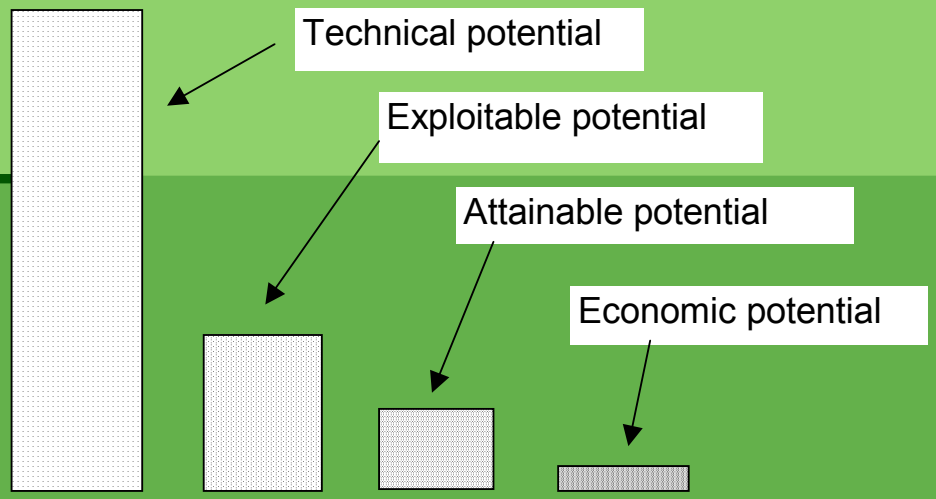
POTENTIALS OF RES – FROM TECHNICAL TO ECONOMIC POTENTIAL - 2

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 !



HOW

⇨HOW ?

⇨RES effective support

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 ?

PRIVATE INVESTORS AND RATE OF RETURN

Rule of scare resources – money for investments are also scarce !

Why do investors invests ?

- ⇨ Profit ?
- ⇨ Rate of return ? (real money ?)

Rational investors compare initial investment with money generated by the project

- ⇨ Basis for decision are cash flows – results of project existence

Why do investors invest into RES (RES-E) projects?

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

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

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

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

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

BASICS ON ECONOMIC EFFECTIVENESS OF PROJECTS - 2

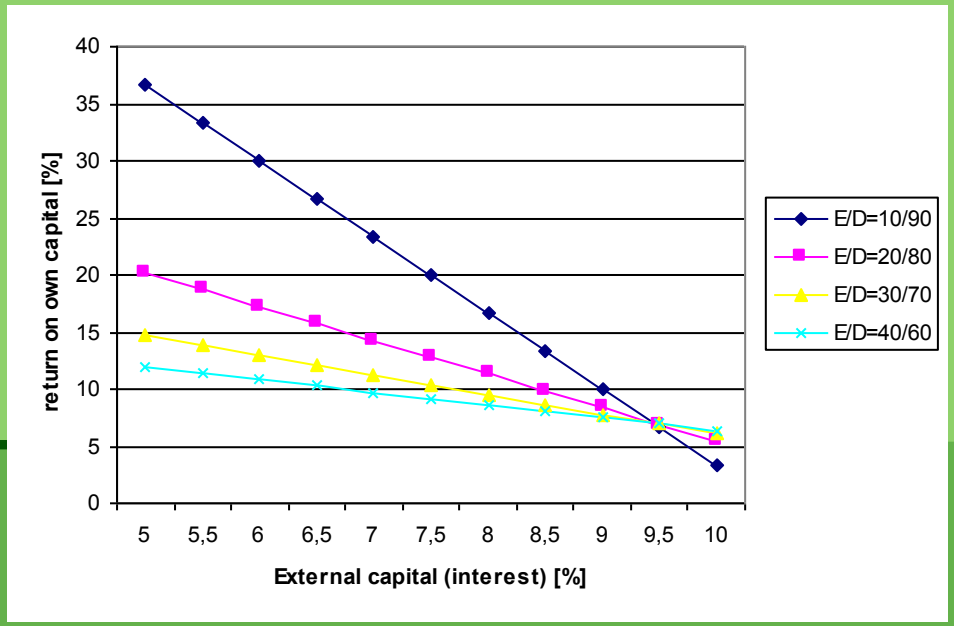
How c_{min} is calculated:

- ⇨ 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 !

DISCOUNT AND RISK

Discount:

- ⇨ Time value of money – opportunity cost
- ⇨ Required rate of return by the investor
- ⇨ Nominal discount: risk free return, risk premium, inflation

$$(1+\text{inf}) \cdot (1+r_f) \cdot (1+r_{pr}) = (1+r_n)$$

Higher risk means higher discount

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

Types of risk:

- ⇨ Technology
- ⇨ Fluctuation of weather conditions, natural effects
- ⇨ Business risk
- ⇨ Political risk

What is the "fair" return on capital in RES-E projects ?
What is the risk in RES-E project ?

TWO POINTS OF VIEW ON ELECTRICITY PRICE

Supply side (investor's point of view):

- Rate on return from invested capital
  - minimum price of production – C_{min}
  - NPV = 0 → rate of return on capital invested equals to applied discount rate

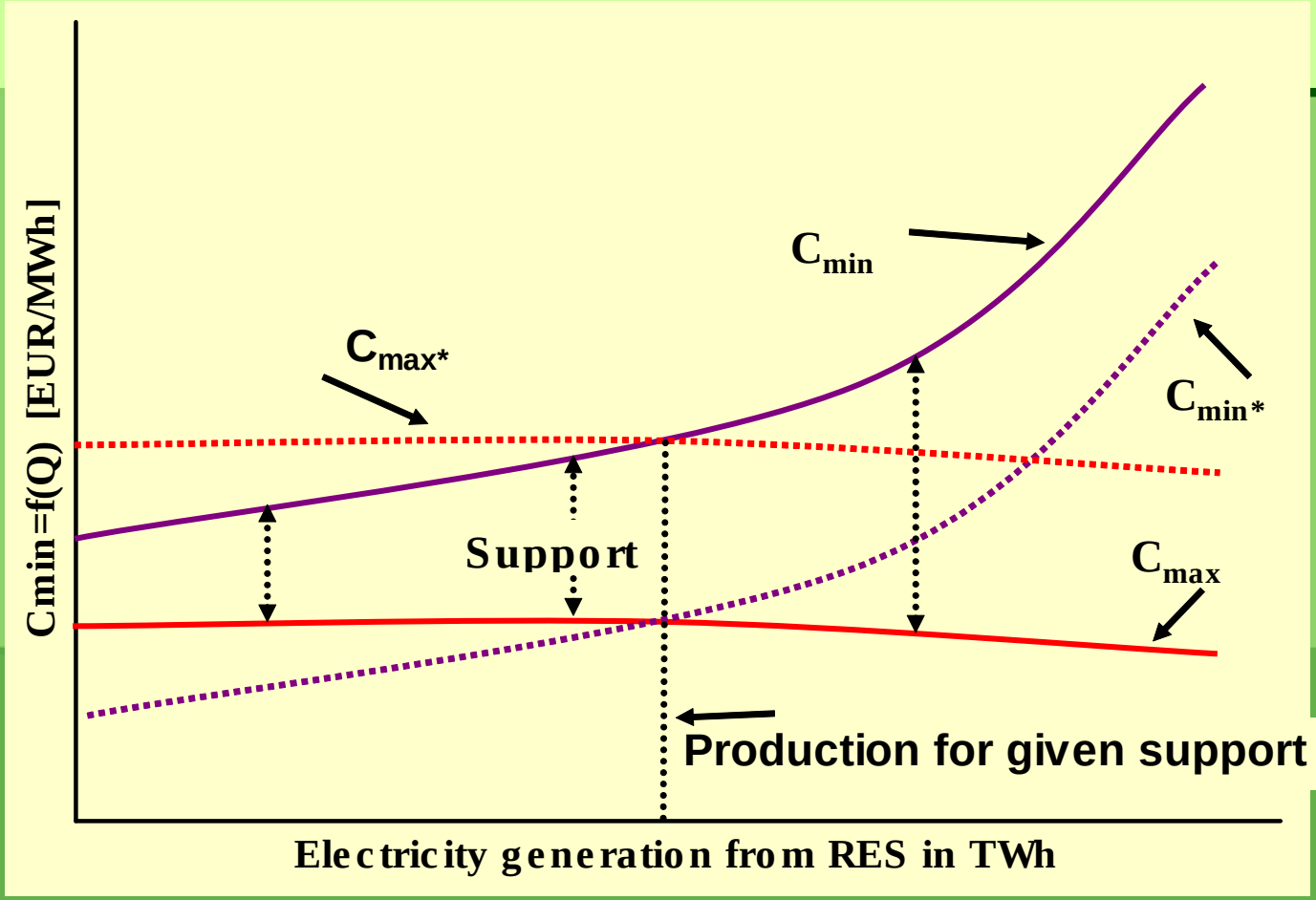
Demand side (purchaser):

- Alternatives for electricity purchase on market with electricity – C_{max}
  - Should respect market rules and technical features of generated electricity

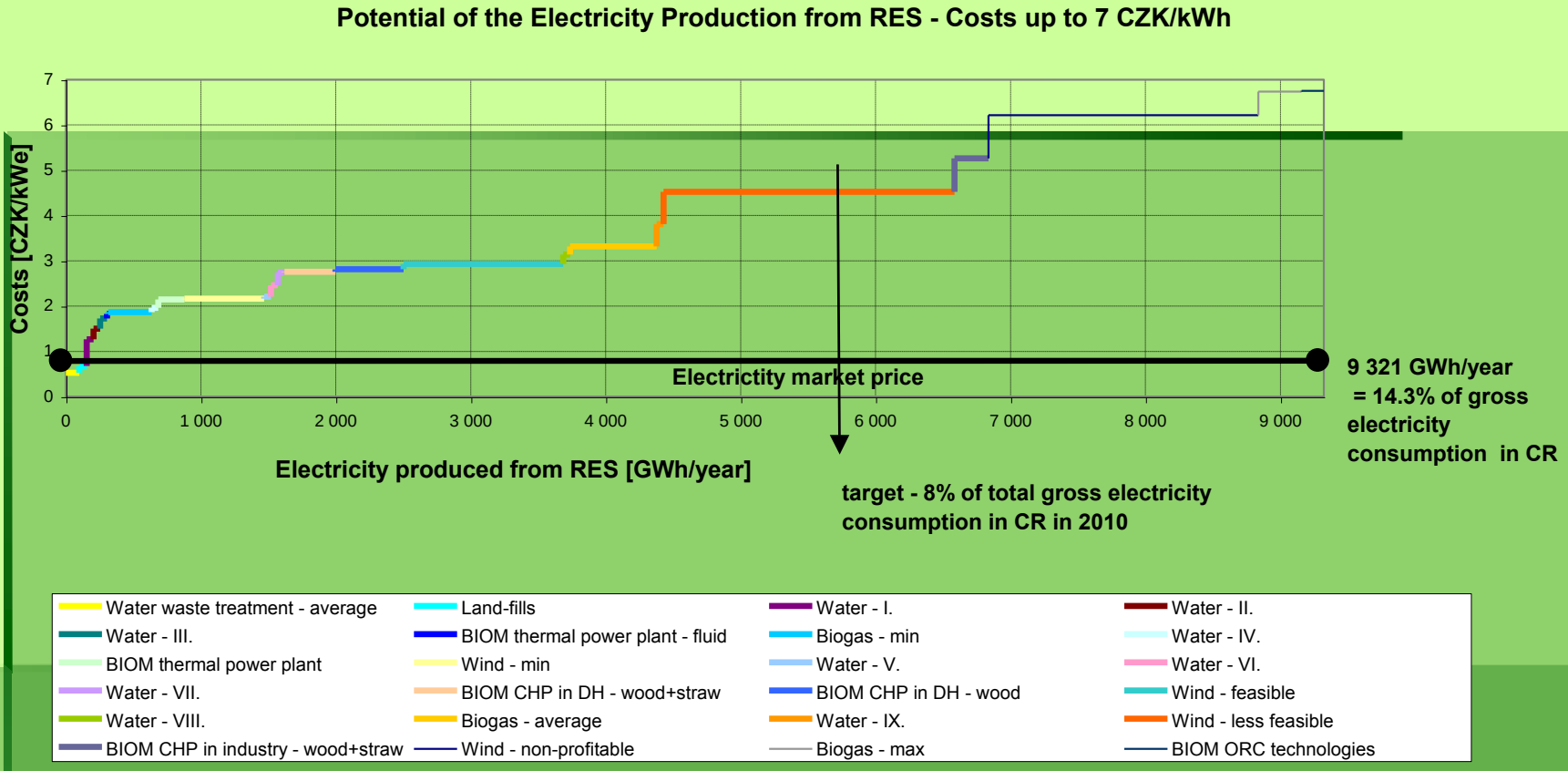
$C_{min} \leq C_{max}$
investor will invest

$C_{min} > C_{max}$
investor will not invest

SUPPLY AND DEMAND CURVES



SUPPLY SIDE – CZ EXAMPLE



DEMAND SIDE

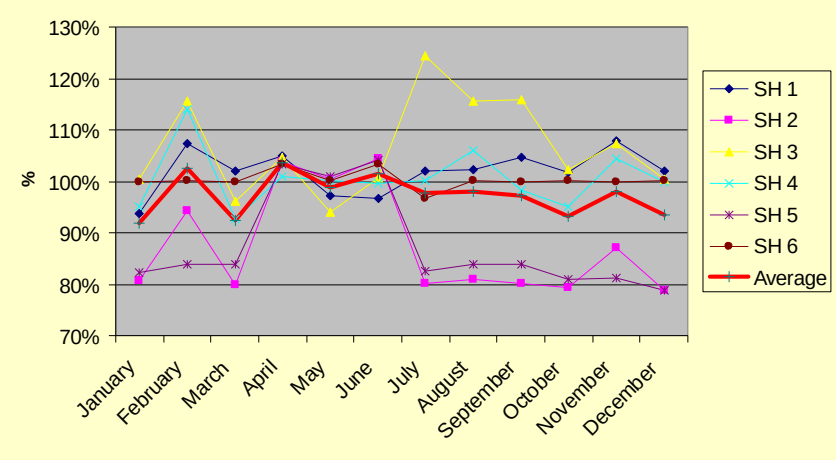
Demand curve – point of view of consumers

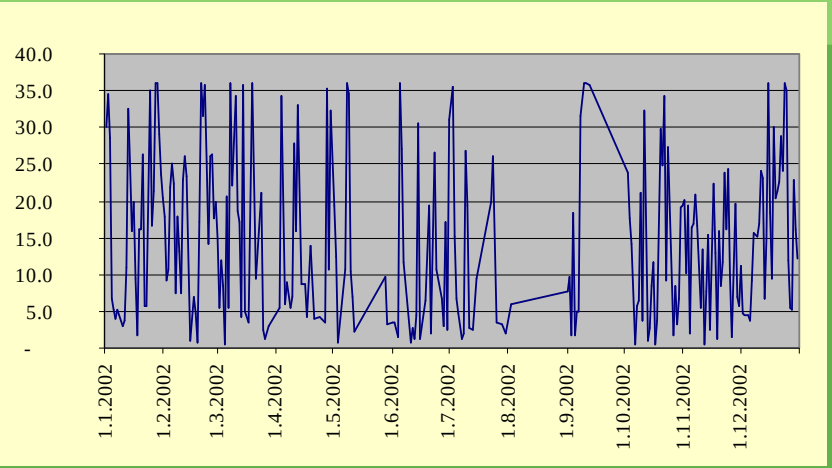
Technical features of production are taken into account

- ⇨ Reliability
- ⇨ Diagram of delivery
- ⇨ Possibility of regulation
- ⇨ Electricity: power and system services

Role of electricity market

Who will pay for system services? Back-up capacity ?





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

- ⇨ but can significantly differ in methodology of calculation

FEED-IN TARIFFS VALUES

Basic decision what RES sources to support

- all
- selected ?
- limit for some kind of RES ?

FEED-IN TARIFFS VALUES

- decision
- calculation
  - assured period
  - degressive
  - constant

FEED-IN TARIFFS CALCULATION

REFERENCE PROJECTS APPROACH

How to define reference projects ?

- it should be representative well prepared projects, market technologies, good locations
- where to find data for reference projects ?
  - statistical analysis of already realized projects ? Do they reflect future state ?
  - to manage lobbyists ?
  - how to reduce extra return for some investors ?
    - time matrix ?
    - individual FT ?
- What is the adequate rate of return on capital invested ?

FEED-IN TARIFFS CALCULATION 2

REFERENCE PROJECTS

⇨ investment cost

⇨ operational cost (typically as % of investment)

⇨ fuel cost (biomass, biogas)

⇨ long term average inflation

⇨ tax depreciation of the investment

⇨ tax rate and tax holidays

⇨ (other support if applicable)

⇨ discount rate that defines rate of return on capital invested

FT is price in first project year assuring NPV=0

Thank you for attention