Feasibility Study for NPP Mochovce Units 3 and 4 Completion

CENTER FOR NUCLEAR SAFETY

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CAN SLOVAKIA SECURE ENERGY SUPPLY AND SUSTAINABLE DEVELOPMENT WITHOUT NUCLEAR?

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CENS

- **NGO&TSO supported by Swiss Government**
- **Established in July 2002**
- **The main pillars**
  - Management decisions support
  - Training
  - Knowledge management
  - Networking
  - Independent expertise

Feasibility study of Mochovce 3&4 units completion

- The study was elaborated according to the order received january 7 2004 from Ministry of Economy of the Slovak Republic
- This study focuses on the increased use of nuclear power as a viable alternative for generation of electricity to meet the emission reduction targets that are set forth in the Kyoto Protocol “commitment period 2008-2012”.
- Delivered on 31 January 2004

NUCLEAR POWER: PERSPECTIVE

- There is a need to reduce environmental impacts of electricity production and to avoid unacceptable impacts on the climate system due to the greenhouse gases, primarily carbon dioxide emission. The concept of sustainable development as a model of environmentally compatible and socially acceptable development of human activities has gained wide spread acceptance. Sustainability also implies efficient utilization of natural resources.

- There is a great opportunity for Slovakia to play a leading role in achieving CO2 emission reductions in the enlarged EU, and to set an example for social and economic development, that is in turn, dependent on the energy sector.

- The EU 25 baseline forecast indicates a 44% growth in electricity consumption between 2000 and 2020

Global Warming and Its Consequences

- The main problem is the ever increasing atmospheric concentration of all greenhouse gases (GHG) as a direct result of human activities and consequentially, leading to global warming of about 1.4 to 5.8 degrees C by 2100, which would threaten and adversely affect the habitant and economy of virtually all countries.
- Without the implementation of emissions control policies, atmospheric concentrations of CO2 are expected to rise from today's level of about 370 ppm to the range of 490 to1260 ppm by the year 2100, depending on the scenario.
- By the "2008-2012 Kyoto Protocol commitment period" the EU must actually reduce emissions to at least 8% below the level of the year 1990. The Protocol contains legally binding emissions targets for Annex I countries (Slovakia included) requiring them to reduce their collective emissions of six key GHG by at least 5.2% by the commitment period of 2008-2012. The GHG are carbon dioxide, methane, nitrous oxide, hydro fluorocarbons, per fluorocarbons and sulphur hexafluoride.

Potential Contribution of Nuclear Power to a Sustainable Energy Mix to Combat Climate Change

- ***"With the current state-of-the-art, giving up the nuclear option would make it impossible to achieve the objectives of combating climate change. Paradoxically, the contribution of nuclear energy to the stabilization of CO2 emissions is often underestimated***

  Loyola de Palacio, Vice President of the European Commission and Commissioner for Transport and Energy clearly indicates the priority in the EU,

Nuclear energy in Slovakia

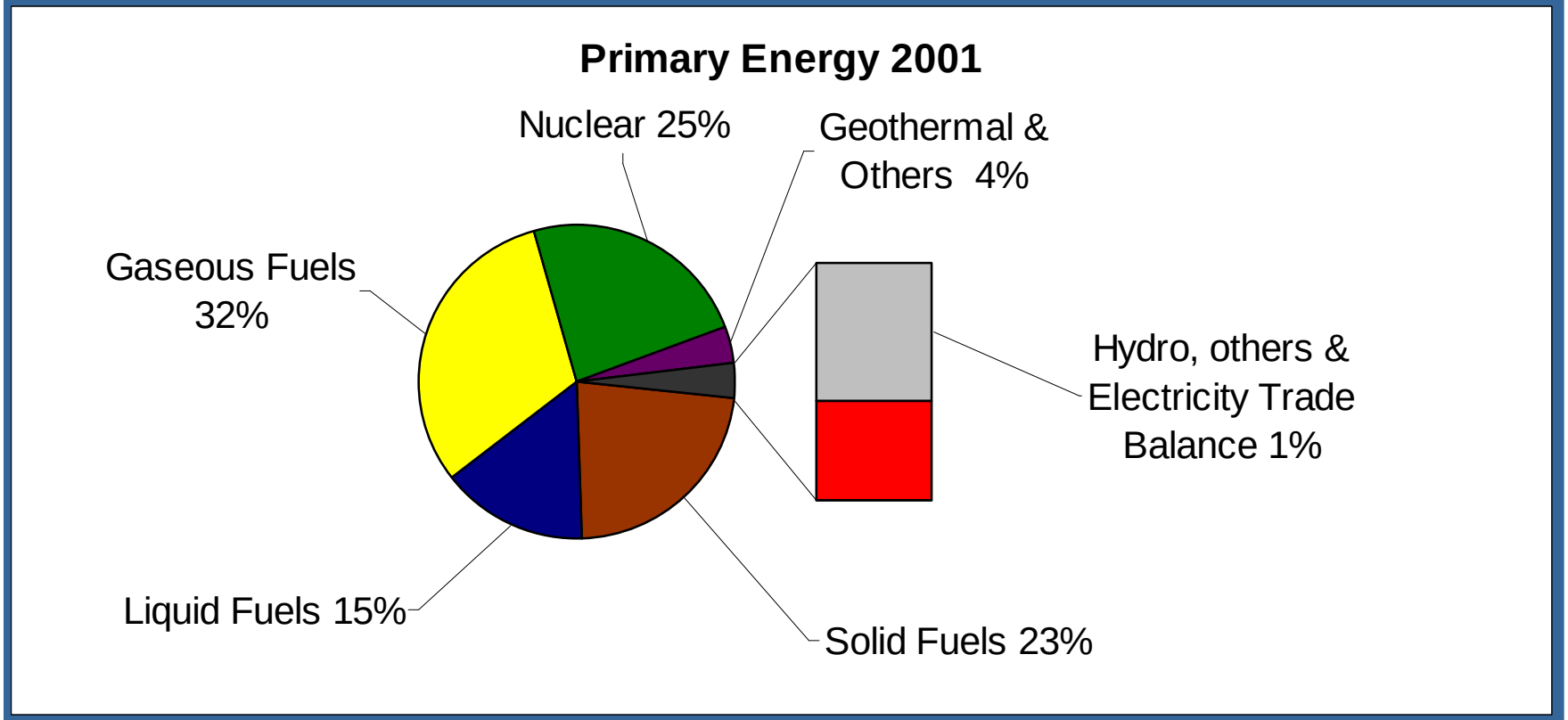
- **Nuclear energy sources in Slovakia are closely related to the general economic and social policy. They have a real potential to contribute to sustainable development and economic growth.**
- **Environment protection is also playing crucial role in the future establishment of the energy concept for the SR. Specific focus to:**
  - Minimize exhalations to environment
  - Minimize exhalations of CO2 equivalent
  - Minimize ecological debts for future generations

Based on this energy policy the Slovak republic must reflect all EU emission limits in 2010.

  - Commitments from Kyoto protocol
  - Preparation and realization of CO2 limits trade according to the EU directive

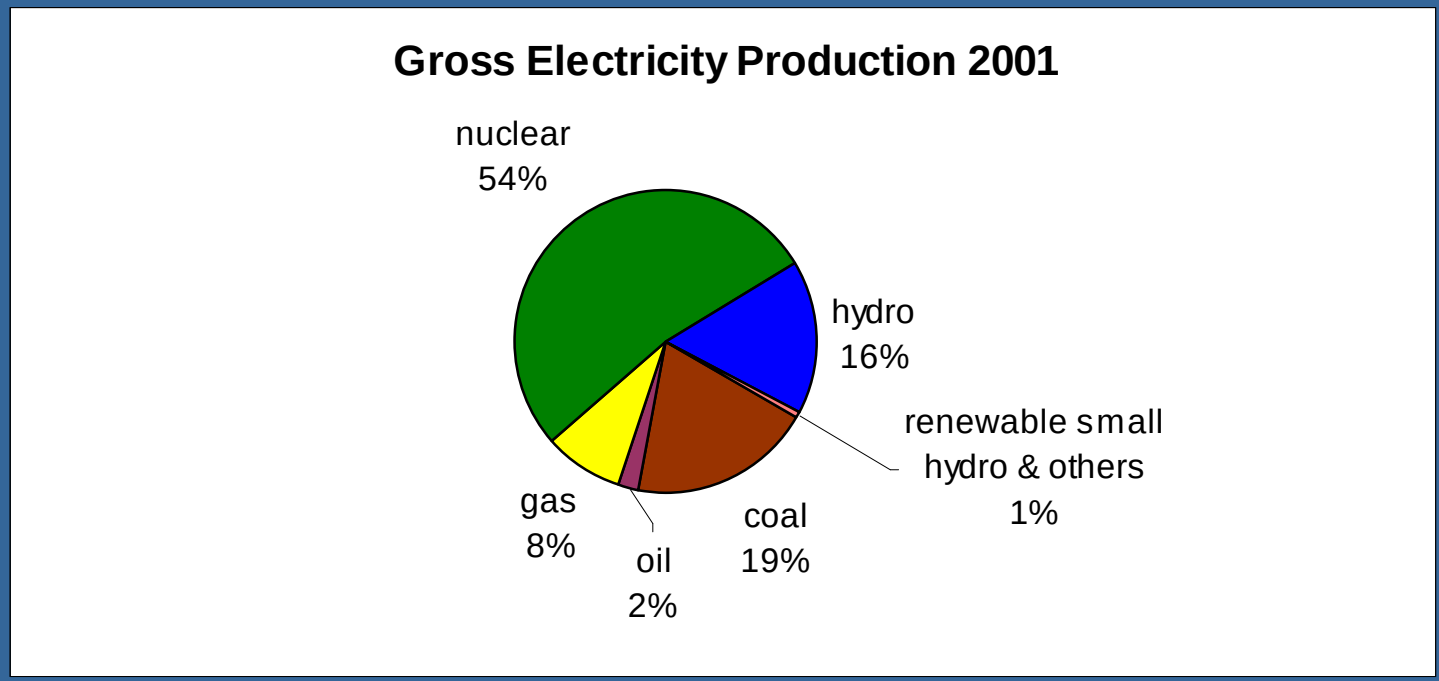
Share of primary energy sources in Slovakia

- **Primary energy sources generated 813208 TJ in Slovakia in 2001. As shown in fig.1, the gaseous fuels (mostly natural gas) have the most significant share of primary energy sources (32%), followed by nuclear energy (25%), solid fuels (23%) and liquid fuels (15%).**



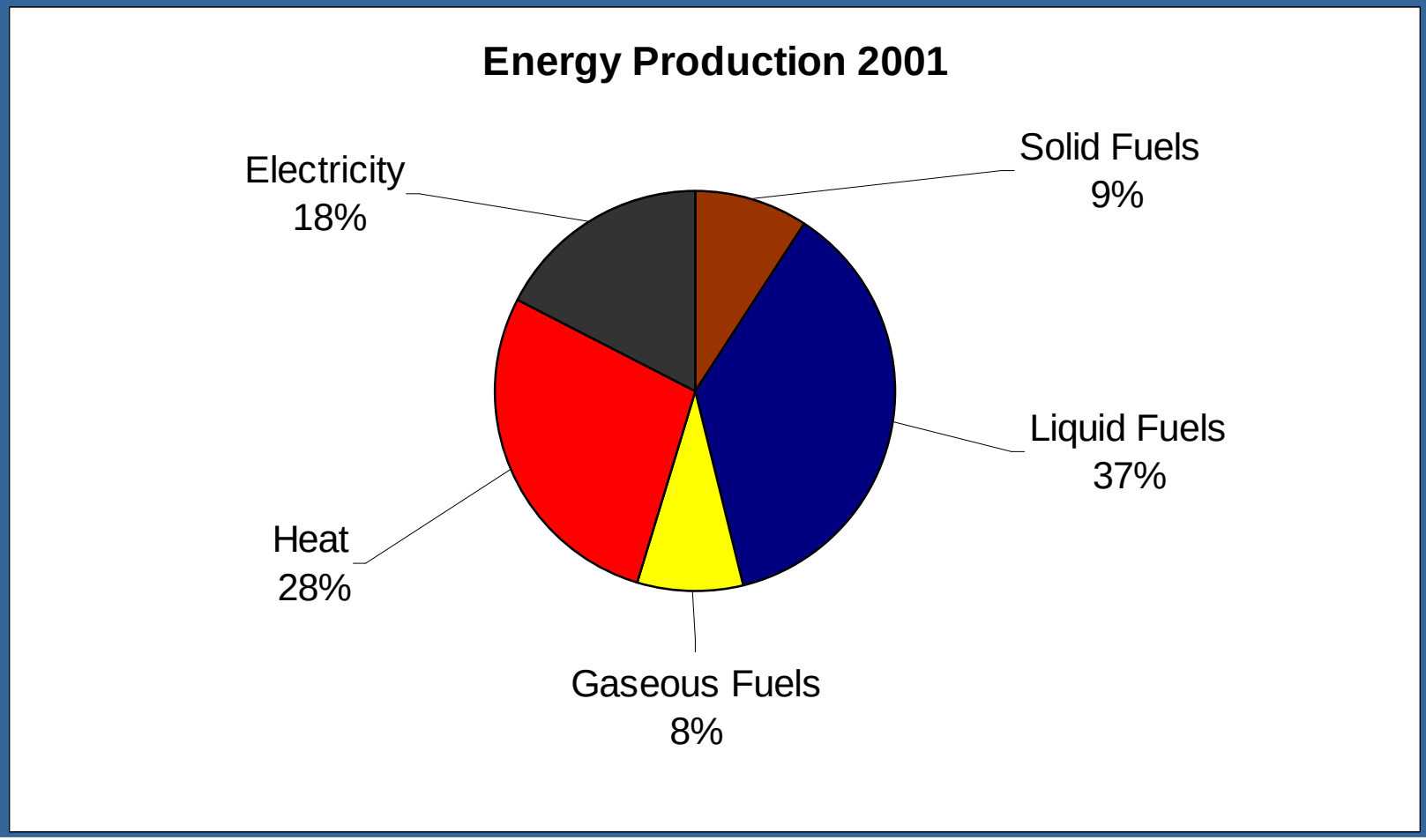
Gross Electricity Production

- The gross electricity production in Slovakia in 2001 was 115365 TJ, the major contributor being electricity from nuclear energy

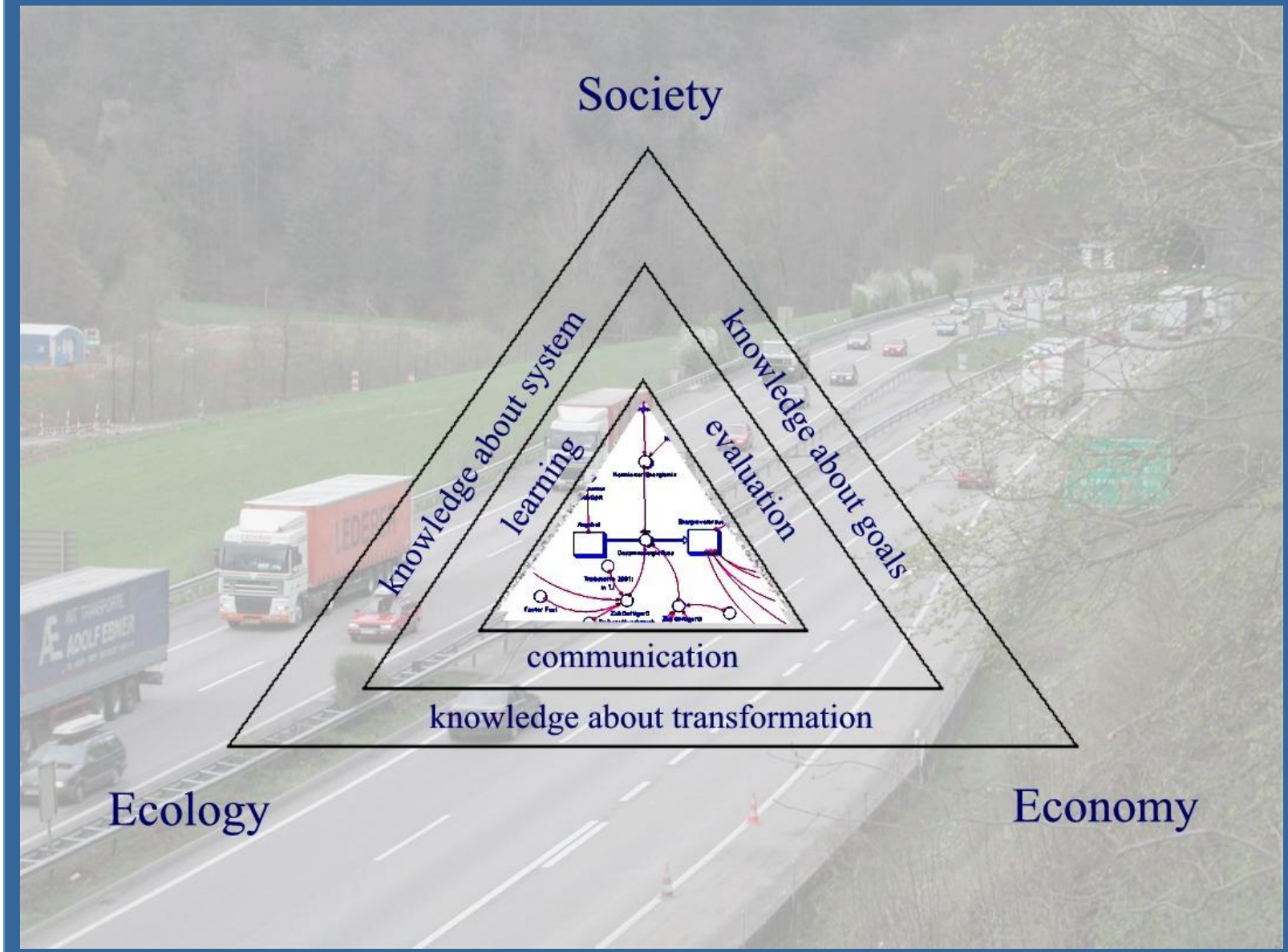


Energy production in SR

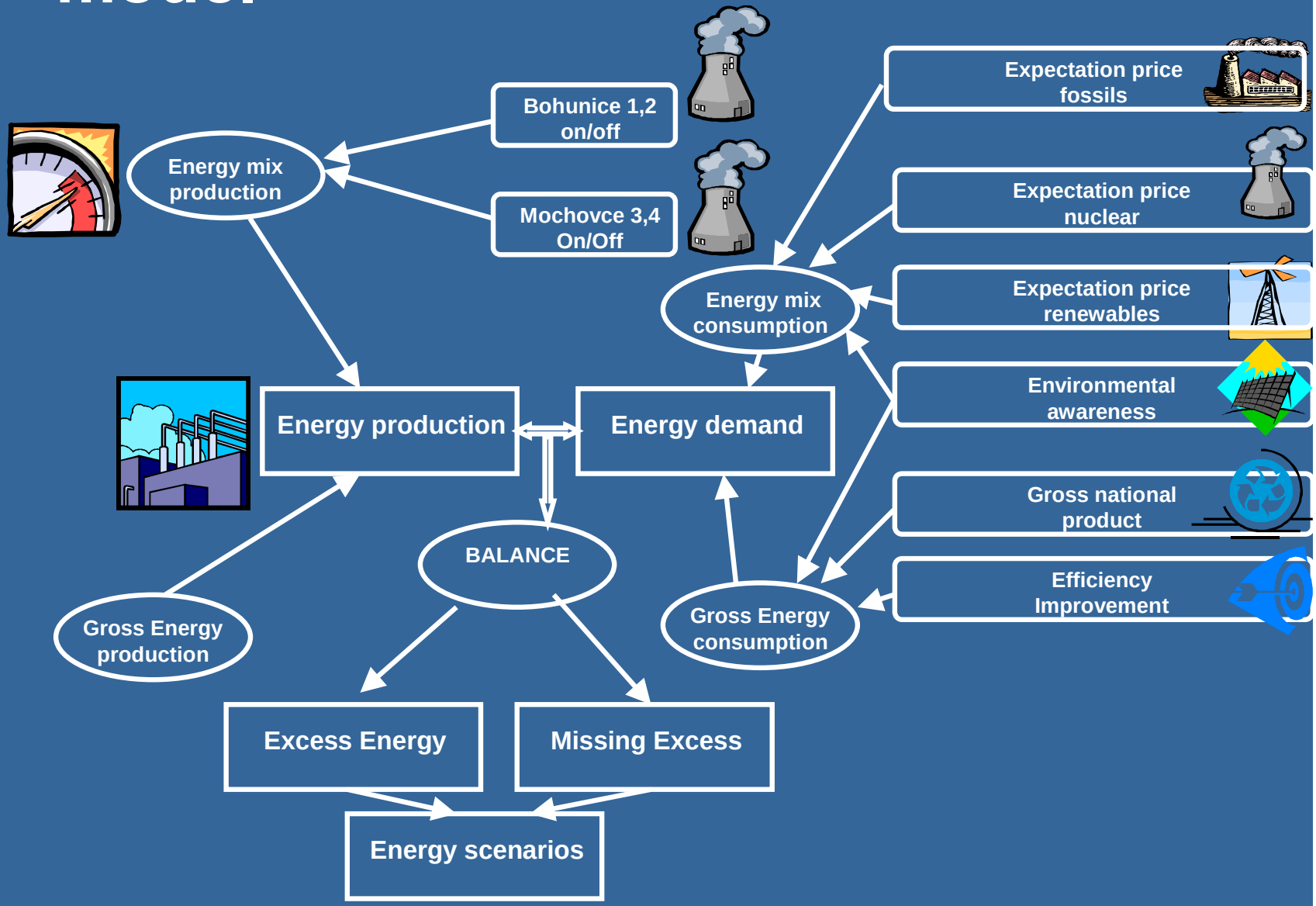
The main contributor to energy production in 2001 are liquid fuels with 37% (fig.2), followed by heat (28%), electricity (18%), solid fuels (9%) and gaseous fuels (8%).



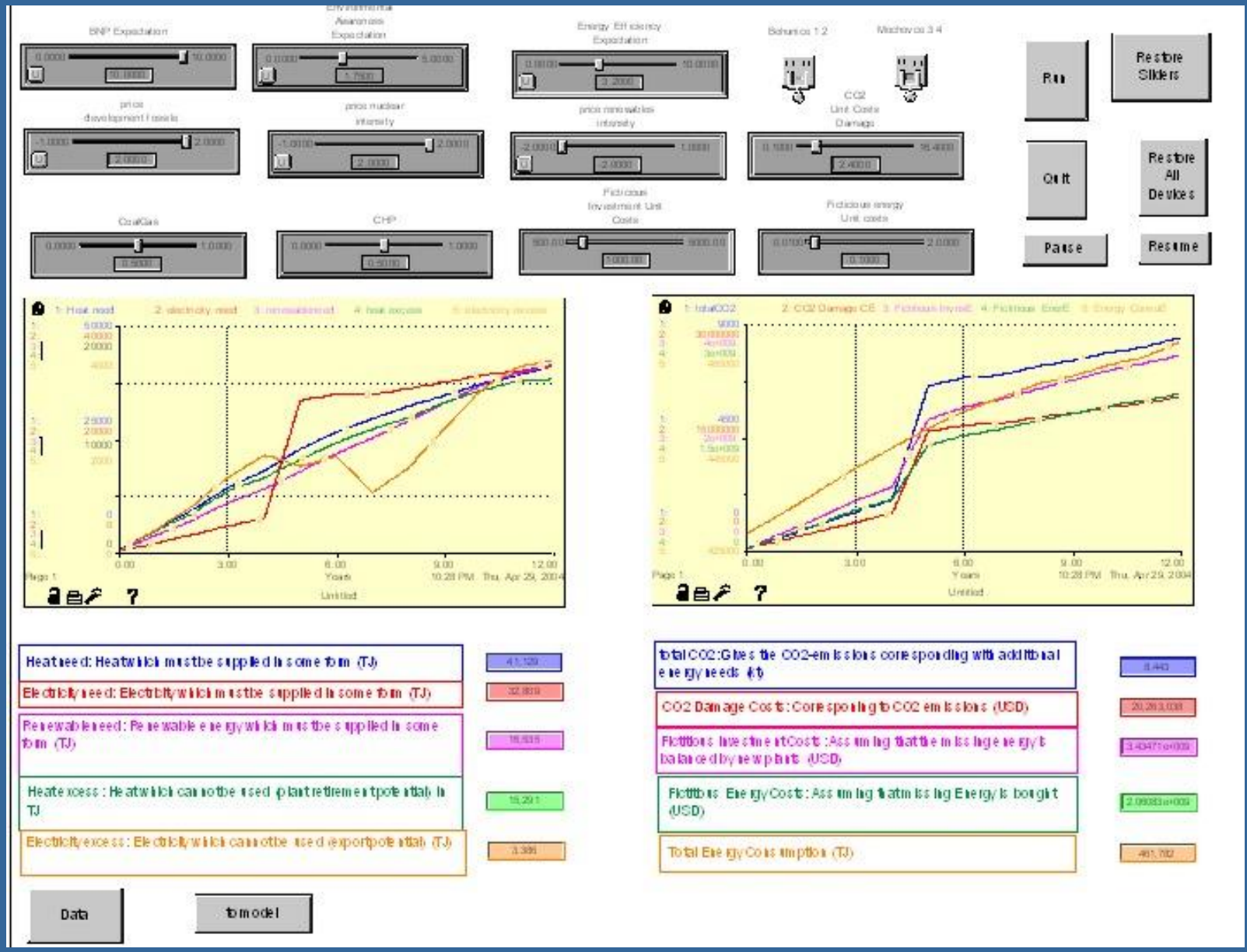
sustainable development deals mainly with complex systems

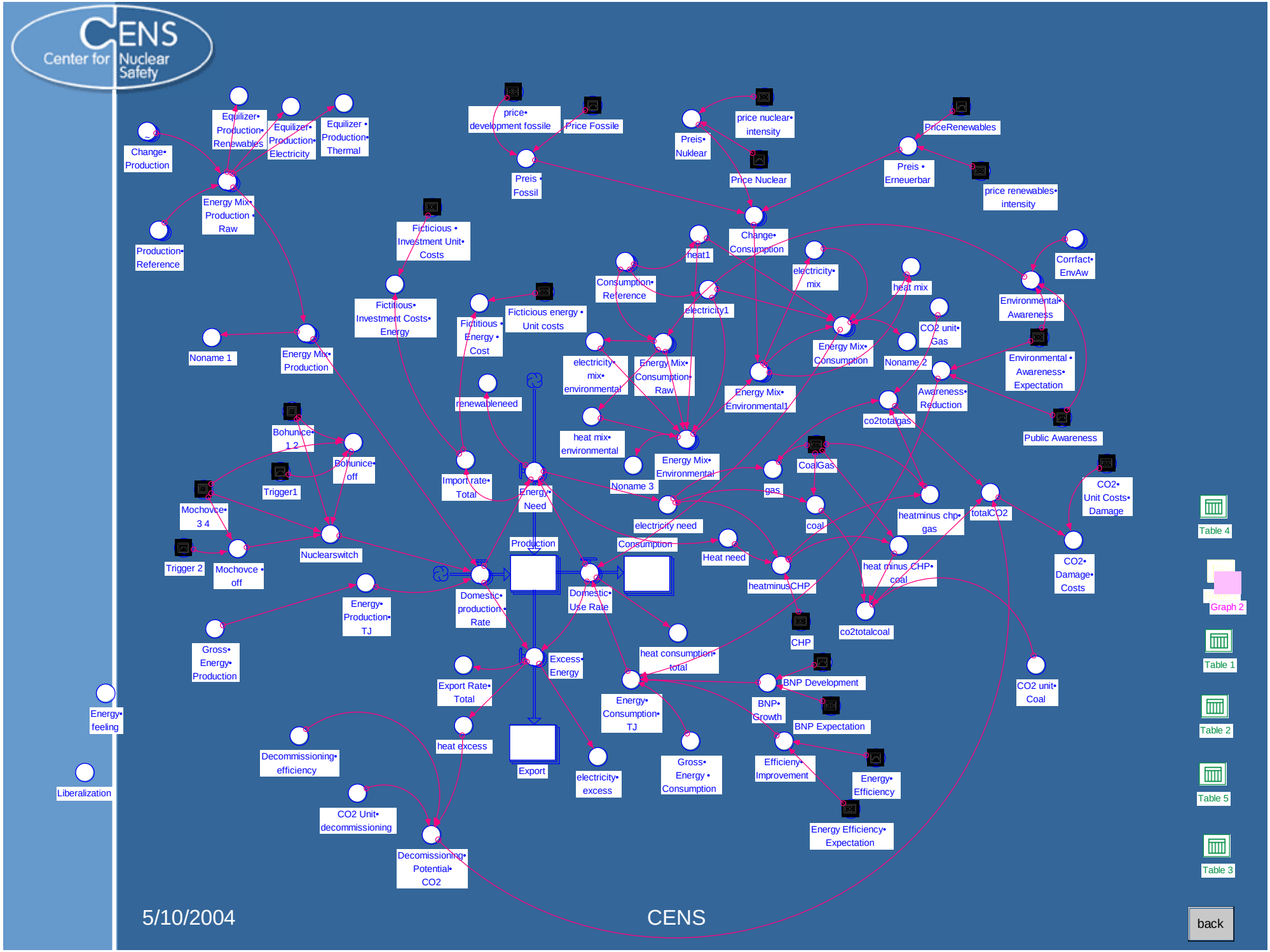


Flow Sheet of the system dynamic model



User interface of the model

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Center for Nuclear Safety
Change• Production
Equilizer• Production• Renewables
Equilizer• Production• Electricity
Equilizer • Production• Thermal
Energy Mix• Production • Raw
Production• Reference
price• development fossile
Price Fossile
Preis • Fossil
Preis• Nuklear
price nuclear• intensity
Price Nuclear
PriceRenewables
Preis • Erneuerbar
price renewables• intensity
Change• Consumption
Ficticious • Investment Unit• Costs
Fictitious• Investment Costs• Energy
Noname 1
Energy Mix• Production
Fictitious • Energy • Cost
Ficticious energy • Unit costs
heat1
electricity1
Consumption• Reference
electricity• mix
heat mix
Corrfact• EnvAw
Environmental• Awareness
Environmental • Awareness• Expectation
Energy Mix• Consumption
Noname 2
CO2 unit• Gas
Awareness• Reduction
Public Awareness
co2totalgas
Energy Mix• Environmental1
electricity• mix• environmental
Energy Mix• Consumption• Raw
heat mix• environmental
renewableneed
Bohunice• 1 2
Bohunice• off
Trigger1
Mochovce• 3 4
Trigger 2
Mochovce • off
Nuclearswitch
Import rate• Total
Energy• Need
Noname 3
Energy Mix• Environmental
electricity need
CoalGas
gas
coal
heatminus chp• gas
totalCO2
CO2• Unit Costs• Damage
CO2• Damage• Costs
Production
Consumption
Domestic• production • Rate
Domestic• Use Rate
Heat need
heatminusCHP
heat minus CHP• coal
co2totalcoal
CHP
Energy• Production• TJ
Gross• Energy• Production
Excess• Energy
heat consumption• total
Export Rate• Total
heat excess
Export
Energy• Consumption• TJ
BNP Development
BNP• Growth
BNP Expectation
CO2 unit• Coal
Energy• feeling
Liberalization
Decommissioning• efficiency
CO2 Unit• decommissioning
Decomissioning• Potential• CO2
electricity• excess
Gross• Energy • Consumption
Efficieny• Improvement
Energy• Efficiency
Energy Efficiency• Expectation
Table 4
Graph 2
Table 1
Table 2
Table 5
Table 3
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Model Parameters Setting

	No	BNP expectation	Environmental Awareness	Energy Efficiency	price fossil	price nuclear	price renewables	coal gas	CHP	investment	price energy	CO2-costs	Bohunice	Mochovce
reference	1	0	0	0	0	0	0	0,5	0,5	200	0,05	2,4	0	1
ref+mochovce not on	2	0	0	0	0	0	0	0,5	0,5	200	0,05	2,4	0	0
ref+ bohunice on +mochovce on	3	0	0	0	0	0	0	0,5	0,5	200	0,05	2,4	1	1
1 +moderate growth	4	3	0	0	0	0	0	0,5	0,5	200	0,05	2,4	0	1
2+ moderate growth	5	3	0	0	0	0	0	0,5	0,5	200	0,05	2,4	0	0
3+ moderate growth	6	3	0	0	0	0	0	0,5	0,5	200	0,05	2,4	1	1
1+strong growth	7	10	0	0	0	0	0	0,5	0,5	200	0,05	2,4	0	1
2 + strong growth	8	10	0	0	0	0	0	0,5	0,5	200	0,05	2,4	0	0
3+strong growth	9	10	0	0	0	0	0	0,5	0,5	200	0,05	2,4	1	1
7+moderate efficiency	10	10	0	3	0	0	0	0,5	0,5	200	0,05	2,4	0	1
8+moderate efficiency	11	10	0	3	0	0	0	0,5	0,5	200	0,05	2,4	0	0
9+moderate efficiency	12	10	0	3	0	0	0	0,5	0,5	200	0,05	2,4	1	1
7+ high efficiency	13	10	0	10	0	0	0	0,5	0,5	200	0,05	2,4	0	1
8+high efficiency	14	10	0	10	0	0	0	0,5	0,5	200	0,05	2,4	0	0
9+high efficiency	15	10	0	10	0	0	0	0,5	0,5	200	0,05	2,4	1	1

Model Calculations

		heat need	electricity need	Renewable need	excess heat	excess electricity	CO2	CO2 damage	Fictitious invest	Fictitious energy costs	total energy consumption
1		0	0	0	0	0	0	0	0	0	427 774
2	before 2006	0	0	0	0	0	0	0	0	0	427 774
	after 2006	939	20 312	0	0	0	5 439	13 053 203	196 774 000	295 160 000	427 774
3	before 2006	0	0	0	0	0	0	0	0	0	427 774
	after 2006	0	0	0	690	20 318	0	0	0	0	427 774
4	after 12 years	11 522	4 123	395	0	0	2 158	5 180 102	144 931 000	217 397 000	443 174
5	after 3 years	3 080	1 033	103	0	0	552	13 247 778	37 380 198	56 070 297	431 565
	after 12 years	12 214	24 437	395	0	0	7 804	18 729 725	339 431 000	509 147 000	443 174
6	after 3 years	3 050	1 023	103	0	0	552	13 247 778	37 380 198	56 070 297	431 565
	after 12 years	11 445	1 909	395	615	18 100	1 574	3 778 659	123 718 000	185 577 000	443 174
7	after 12 years	37 830	13 751	1 300	0	0	7 131	17 113 453	477 833 000	716 750 000	479 107
8	after 3 years	9 594	3 417	329	0	0	1 776	4 262 371	119 329 558	178 994 338	440 410
	after 12 years	38 521	34 065	1 300	0	0	11 385	27 327 409	672 333 000	1 008 500 000	479 107
9	after 3 years	9 594	3 417	329	0	0	1 776	4 262 371	119 329 558	178 994 338	440 410
	after 12 years	37 577	6 366	1 300	439	12 929	5 498	13 194 597	407 111 000	610 666 000	479 107
10	after 12 years	26 555	9 624	912	0	0	5 000	11 999 160	335 161 000	502 741 000	463 707
11	after 3 years	8 808	3 129	302	0	0	1 628	3 907 899	109 440 104	164 161 416	439 343
	after 12 years	27 247	29 939	912	0	0	9 255	22 213 116	529 661 000	794 491 000	463 707
12	after 3 years	8 808	3 129	302	0	0	1 628	3 907 899	109 440 104	164 161 416	439 343
	after 12 years	26 377	4 456	912	514	15 145	3 816	9 159 195	285 657 000	428 485 000	463 707
13	after 12 years	0	0	0	0	0	0	0	0	0	427 774
14	after 3 years	6 849	2 413	234	0	0	1 275	3 060 413	85 798 803	128 698 000	436 791
	after 12 years	939	20 312	0	0	0	5 439	13 053 203	196 774 000	295 160 000	427 774
15	after 3 years	7 010	2 471	240	0	0	1 306	3 133 220	87 829 901	131 745	437 010
	after 12 years	246	0	0	690	20 318	0	0	0	0	427 774

What should be done in the future ?

- Get more quantitative figures about “environmental awareness” into the model
- Include risk & safety assessments (including financial and political risks)
- Assess the different options in view of energy- and resource dependency, CO2-emission certificate trade etc.
- Make the model acessible via the www

Conclusion

- The system dynamic approach presented in this study by modelling the behaviour of Slovak market on the basis of system dynamic model (Forrester model), enables real energy mix in the extent of 12 years and helps understanding of the market limits. In addition this tool can be used for sensitivity calculations depending on many parameters to develop possible trends in the economic development of the Slovak Republic.

Outcome 1:
Bohunice 1,2 On &Mochovce 3,4 On

If both nuclear power options are maintained then it becomes obvious that electric excess energy is produced and could be exported. This export option remains for the situation that a strong growth of the gross national product is assumed without any increase in energy efficiency.

Outcome 2:
Bohunice 1,2 off & Mochovce 3,4 On

- Between these extremes is the scenario that Bohunice 1,2 off is balanced by Mochovce 3,4 on and increasig demand this will lead to more moderate but still not negligible potential of CO2 increase..

Outcome 3:
Pesimistic scenario
Bohunice 1,2 off & Mochovce 3,4 off

Switching off Bohunice 1, 2 and not switching on Mochovce 3, 4 leads to energy need which must be counterbalanced either by investments in other power plants or by import of energy. As far as domestic production is concerned even assuming 50 % CHP production leads to partly remarkable additional CO2-production which might infringe on a long term basis with the Kyoto goals. Assuming additional CO2-emissions from increasing traffic real problems can be expected in such a case.

To Maintain National Nuclear Capabilities in Slovakia is very important for today and for future of Nuclear energy option in enlarged EU

Thank you