A vision for Romania based on INFORSE's Vision2050, -Background note.

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This background note gives an overview of the potentials for renewable energy and energy efficiency that is used in the sustainable energy vision developed by International Network for Sustainable Energy (INFORSE) – Europe and Prietenii Pamantului. The vision includes growth in most sectors.
All comments are welcome.

Renewable Energy Potentials

For renewable energy is in general used estimates by ICIMENERG made in 2007 for the Romanian government. Give the comment from ICIMENERG that not all the given potentials necessarily are technical and economical viable, not all potentials are expected to be used fully. On the other hand, an additional potential for energy for straw is included and in the long run, use of energy plantations for solid biomass (wood materials).

Windpower:
The windpower potential of from ICIMENERG is estimated to 23 TWh, equal to 9200 MW with 2500 annual full-load hours or 2/3 of current Romanian power consumption of 32 TWh.

In the current version of the vision is only used 37% of the above-mentioned potential, equal to 3400 MW. Most of the development (21% of the potential equal to 1900 MW) is expected for the period 2010 - 2020.

The first installations are already taking place; but a large-scale development of windpower has not started yet in Romania.

Solar Energy
Romania has a large potential for solar energy. In this vision is expected that solar heating will be starting shortly after 2010 with large increases in the period 2020 - 2030.

The area used for solar energy is divided between:

- Solar collectors for hot water (directly used domestically for service sector, industrial heat demand or eventually district heating) with an annual yield of 400 kWh/year (about 40% efficiency) and
- Solar electric cells (PV-cells) with an annual yield of 100 kWh/year (about 10% efficiency).

The solar heating installations can be used for low to medium temperature heat demand (below 150'C) and district heating. Normal flat-plate solar collectors will be limited to supply heat below 90’C, while higher temperatures can be achieved with use of vacuum tube solar collectors.

The use of solar energy is limited to:
- 1/3 of buildings heat demand (limited because of seasonal variation) for domestic and service sector heating

- 2/3 of low-temperature process heat (assuming equal demand throughout the year)
-15% of medium-temperature heat

To cover 1/3 of buildings demand for space heating and hot water will require energy storages of about 1-2 months. This is also necessary to cover 2/3 of low-temperature process heat. Because of the costs of such storages, they are not included in this vision.

There is a small market for solar energy installations in Romania for the moment. This is not expected to change until 2010; but the development of solar heating is then expected to start and then follow a path like:
-2010 – 2020: 23,000 m2/year (total 230,000 m^2 installed in 2020 equal to 0.1 m2/capita)
-2020 – 2030: 200,000 m2/year (total 2,300,000 m^2 installed in 2030, equal to 1 m2/capita)
-after 2030: 350,000 m2/year

The installed area for solar electric generation (PV) is expected to start after 2020 with 200,000 m2/year until 2030 and then 230,000 m2/year.

With this development, 90 mill m2 will be used for solar heating and the 67 mill. m2 will be used for solar electric generation in 2050. This is equal to almost 7 m2/person for solar energy use in 2050 in total. Most of this is expected to be on roofs. This area is of course not a maximum and it leaves room for additional solar installations after 2050.

Biomass
The potential for solid biomass consists of wood and straw available for energy purposes. In addition there are potentials for bio-fuel for transportation, biogas and energy plantations; they are all treated separately below.
Wood is already used to a large extent today, mainly for domestic heating. Use of wood was 155 PJ in 2000 according to IEA statistics. The potential is 318 PJ according to ICIMENERG. 2/3 of this potential is included in this vision for 2020, gradually increasing to 100% for 2040.

There is a potential for straw for energy use in Romania, which is partly included in the estimation from ICIMENERG.
Straw is hardly used today for energy today in Romania, and no additional potential is included. In the practical implementation of a sustainable energy strategy, probably straw for energy will play a role.

Liquid Bio-fuel
Liquid biofuel is not included in this vision, in spite of some development in Romania. The use of biofuel is not expected to contribute in a larger way to the realisation of the transition to sustainable energy.

Biogas
There is a potential for biogas (from waste water, agriculture etc.), which is partly included in the ICIMENERG potential for biomass. No separate evaluation is included in this vision.

Energy Crops
The potential for energy crops is dependant of the excess land of agriculture. It is estimated that at least 4000 km2 of land in Romania can be used for energy crops such as energy forest in the later part of the period.
With a yield on the land of 7 tons dry matter/ha and an energy content of 4.9 MWh/ton[1] of dry matter, the corresponding energy potential is 64 PJ. This is an average of figures obtained for willow-plantations in Southern Scandinavia and Latvia. Similar yields can be achieved with other fast-growing trees such as poplar. Higher yields are possible with intensive plantation with fertilisation and eventually irrigation. Wastewater can be used to fertilise and irrigate such intensive plantations.

We expect the development of energy plantation to take off in 2040 and reach its maximum yield in 2050. As it is based on well know technologies (e.g. no GMO species needed), it can be applied any time during the period.

Geothermal energy
There is a potential of geothermal energy for heating, estimated to 7 PJ by ICIMENERG. We do not know about the technical and economical feasibility of this potential, so we have only included 1 PJ by 2020 and 2 PJ by 2030. It is expected to be used for heating including district heating.

Hydropower
The hydropower production was 53 PJ (14.8 TWh) in 2000 (IEA statistics). There is in principle a large potential for additional hydropower on smaller rivers and on the Danube, to reach 130 PJ (ICIMENERG estimation); but there are environmental problems with it. We have only included plans from Hydrolectrica, the operator of Romanian hydropower plans. They expect to rehabilitate existing sites which is equivalent to add 67 MW by 2012, to finish a number of unfinished hydropower plants and to build new capacity. These plans are expected to be finished by 2030 by which the hydropower production is expected to be 86 PJ in annual average.

Efficiency Potentials
For the vision is used the finding that the efficiency can be increased a factor 4-10 with known technologies. This has been shown to be possible for Western European energy consuming sectors, see e.g. "Factor 10 Club" (www.factor10.de). Even though the increase of efficiency is cost effective, it will not happen by itself, as the decision-makers, e.g. the designers and manufacturers of equipment are not dedicated to supply and install energy-efficient products for a number of reasons. The increase in efficiency can be measured as decrease in the specific amount of energy used to provide a certain energy service (heated floor space, transported persons or amount of goods, amount of industrial production, use of electric appliances etc.)

For transport, electric appliances, and industrial production, energy consuming vehicles and equipment will be changed several times during the 45 years that the vision covers. Thus, there are not technical limitations to raise the efficiency a factor of 4 or more. The following increase in

[1] Biomass includes humidity and the calorific value depends on this. As an example coniferous wood with 40% humidity has a lower calorific value of 2.9 MWh/ton, but relative to the dry matter content (60%) the lower calorific value is 4.8 MWh/ton. For beech wood with 20% humidity the lower calorific value is 4.1 MWh/ton and relative to the dry matter the lower calorific value is 5.1 MWh/ton. For straw with 15% humidity the lower calorific value is 4.0-4.2 for different types of straw and relative to its dry matter content the lower calorific value is 4.7 – 4.9 MWh/ton. As an average the (lower) calorific value is set to 4.9 MWh (17.6 GJ) / tons of dry matter.

efficiency is included in the vision for electricity use in industry, service, domestic, and other sectors, construction sector heat demands, private car use, and road freight a factor 4 efficiency increase 2000 - 2050:

- 2000 – 2010 5% in total (10% for road freight, domestic and service electricity use)
- 2010-2020: 2%/year (less for road freight, domestic and service electricity use)
- 2020-2030: 3%/year
- 2030-2040: 4%/year
- 2040-2050: 4.6%/year

For manufacturing heat and fuel demands is "only" included a 60% efficiency increase and only 40% for blast furnaces. For agriculture is only expected a 30% efficiency increase as much of the agriculture presently has very low heat demands.

In the transport sector the realisation of the efficiency will require a technological shift from present internal combustion engines with 15-20% efficiency to hydrogen fuel cells with >60% efficiency and electric vehicles with about 80% efficiency, including battery charging cycle losses. In addition is expected implementation of technologies to regain brake-energy from vehicles.

For rail and water transport the following efficiency increases are included until 2050: 60% for rail transport (partly achieved with electrification), and 25% for navigation.

For all sectors the start is expected to be slow: 5% increase 2000 – 2010

Efficiency of heating

For this vision we assume the following development of specific heat demand, compared with 2000:

	Specific heat demand relavitve to 2000	
2000	100%	
2010	95%	0.5%/year
2020	74%	2%/year
2030	61%	2%/year
2040	50%	2%/year
2050	41%	2%/year

Efficiency in Energy Supply

For energy supply we expect an increase in the conversion efficiency in the electricity and heat sector, leading to a decrease in the average loss in power and CHP plants.

from IEA Statistics can be estimated the efficiencies of Romanian power plants divided 2000:

Powerplant efficiencies	Electric efficiency	Heat efficiency	Total efficiency
Power only	25%		25%
CHP	21%	31%	52%

Efficiencies including own consumption

With the gradual closure of nuclear power, the power sector will be able to run with higher efficiencies.

We use the following efficiencies for power plants in the vision:

Power plant efficiencies	2010	2020	2030 and later	
Electric	21%/25%*	31%/25%*	41%/45%	
Heat	31%	31%	36%	
Total	52%	62%	77%	

* Figures for power-only plants.

The electric efficiencies are based on power plant efficiency data used for Danish energy planning for new plants (Danish Energy Authority, "Technology Data for Electricity and Heat Generating Plants" from www.ens.dk), with reductions due to only partial replacement of power plants. The Danish energy efficiencies data are:

Power plant efficiencies, new plants*		2010	2020 and later
Gas-fired combine-cycle, 100 – 400 MW	Electric (at 100% load)	58-62% (no heat prod.) 53-58% (full heat) 6% lower at 50% load	59-64% (no heat prod.) 54-60% (full heat) 6% lower at 50% load
	Total (at full heat)	90%	91%
Gas-fired combine-cycle, 10 – 100 MW	Electric (at full heat)	47-55% (100% load)	48-56% (100% load)
	Total (at full heat)	90%	91%
Gas engine 1-5 MW	Electric	41-44% (100% load)	as 2010
	Total	88-96%	as 2010
Large biomass-fired steam turbine plant, 400 MW	Electric	46.5% (100% load) 2.5% lower at 50% load	48.5% (100% load) 2.5% lower at 50% load
	Total	90%	as 2010
Straw-fired steam turbine, 5-15 MW**	Electric	29-30%(>75%load)	as 2010
	Total	90%	as 2010
Wood gasification, 1-20 MW	Electric	35-40% 5% lower at 50% load	37-45% 0-5% lower at 50% load
	Total	103%***	103%***

*Net efficiencies, adjusted for own consumption
** Larger installations have larger electric efficiencies
*** With flue gas condensation

The expected efficient of the plants are conservative compared with the Danish data, also for 2030 and later.

Also the efficiency of the electricity network is expected to increase; given the large electric grid losses (20% of consumption) to 8% of consumption until 2030.

The losses in heat grid was 16% of consumption in 2000. We expect these losses to remain stable as the expansion of the network will increse loses similar to the networ improvements.

A phase-out of nuclear power in 2025 is included in the vision.

Demand for energy services
In this model is not included an automatic link of economic development (GDP growth) and energy consumption. Instead is included expected growth of energy consuming factors, such as heated floor area, transport, production in volume, not in value. These drivers are referred to as energy service demands.

The demand for energy services (heated floorspace, transport etc.) is expected to increase as follows:

Heating (district heating + fuels):
With the increase in construction, the dwelling area is now growing. This is expected to speed up after 2010, resulting in the following developing of dwelling areas compared with 2000:
2000: 100%
2010: 110%
2020: 130%
2030: 150%
2040: 170%
2050: 180% (slower growth 2040 – 2050)

Construction of service buildings is increasing faster than dwellings and is expected to remain in the future, leading to the following development of heated service sector areas:
2000: 100%
2010: 130%
2020: 160%
2030: 180%
2040: 200%
2050: 210%

Industry heating service demand is expected to decline to 80% of the 2000 level until 2010, based on current statistical trends (IEA 2000 and 2004 statistics) and then increase to the 2000-level in 2050; but because of efficiency the actual heating demands will be lower. Activities of steel smelters (blast furnaces etc) are expected to remain stable during the period.

Agriculture heating service demand is expected to go up 30% until 2020 because of its low current level and then remain stable.

Construction is expected to increase 50% 2000 - 2010 and then remain stable.

Electricity service demands:
Household Sector: we expect household use of electric appliances to increase 40% 2000 – 2010 because of EU approximation, 10% above increase in floor-space 2010-2020 and than increase similar to the in floor space. This will lead to an energy service level in 2050 of 220% of the 2000 level.
Service sector: We expect use of electric appliances to grow 50% 2000 – 2010 and then follow growth in floors-pace, leading to a level in 2050 of 230% of the 2000 level.
Industry and farming: We assume increase of 2%/year until 2020 (because of increased mechanisation), and the lower growth to 180% of the 2000 level in 2040 and later.

Construction: We an increase of 70% 2000-2010 because of increased activity and more mechanisation, then stable on the new higher level

Transport:
Passenger car use has increased in Romania substantially since 2000.

The increase of passenger cars is expected to continue until 2020, when we expect a doubling compared with 2000, and then slower growth to reach 250% of the 2000-level by 2040. Then the increase is expected to stop.
The use of trains is expected to grow slower with 1%/year increase during the period to reach 155% of the 2000-level by 2050.
Other public transport (buses) is expected to increase 20% from 2000 until 2010 and the level off to reach 150% of the 2000-level by 2030 and the remain stable.
This gives the following development of personal transport relative to 2000:

	Cars	Train	Buses etc.
2000	100%	100%	100%
2010	150%	110%	120%
2020	200%	121%	140%
2030	240%	133%	150%
2040	250%	144%	150%
2050	250%	155%	150%

Aviation is expected to double from 2000 to 2020 and then remain stable.

For this vision we expect a growth of road freight of 150% 2000 – 2010, followed by a gradually slower increase 2010-2030 to reach 250% of the 2000-level and then remain stable.Rail freight is expected to increase slower to reach 150% of the 2000-level by 2050.
This gives the following freight transport relative to 2000:

	Road	Rail
2000:	100%	100%
2010:	150%	110%
2020:	200%	120%
2030:	240%	130%
2040:	250%	140%
2050:	250%	150%

Fuel shift
Fuel shift is in general limited to max 3%/year increase or decrease for a specific energy source in a specific sector, but the total can be more as more fuel shifts can happen simultaneously. In a few instances are foreseen more rapid fuel shift, but only after 2030. The fuel for blast furnaces for steel production is expected to change from coal to wood in 2040.

Fuel shift in transport is starting with increae of electricity in transport, starting with railways and after 2020 also in road transport. After 2030 also hydrogen is expected to play a role in road transport and navigation. In 2050 all expected that all rail transport and 75% of the road transport will be driven by electricity while the remaining 25% of road transport will be driven by hydrogen.

Fossil fuels and nuclear, imports and exports

The oil production is expected to decrease gradually, assuming an reserve/production (R/P) ratio of 11.7 at the end of 2006 (according to BP), and end before 2030. The decrease 2000 - 2010 is expected to be 16% according to Romanian estimates (Source)

The oil production is expected to decrease 20% 2000 - 2010 following Romanian estimates (source), remain stable until 2020 and the gradually decrease till 35% in 2050.

Coal production is expected to continue on current level until 2040 and then be phased out. In Romania coal is mainly used in blast furnaces for steel production.

Lignite production is expected to remain on the 2000-levle until 2010 and then decrease a power production is taken over by other fuels 2ith a 90% decrease until 2040 and full phase-out before 2050.

Gas production is expected to decline to 35% of today's level by 2050.

We expect that the remaining fossil fuel use is covered by imports, while the excess gas production can lead to a temporary, smaller gas export from 2040.

Nuclear power is assumed to be phased out by 2025.

Electricity export of 1 TWh/year is expected to continue during the period.

Energy storages and flexible energy use

Reliance on intermittent renewable energy – wind and solar- can require energy storages and flexible energy use. The total fraction of intermittent electricity production in 2020 is 12% raising to 19% in 2030 and further to % in 2050. After 2030 this requires special electricity storages; but use hydro pump-storage should be sufficient together with some electricity exchange with neighbouring countries. The closure of nuclear power will free the regulation capacity in the electricity grid.

In the electricity sector is also introduced some flexible consumptions:

- hydrogen production for transport.
- electric cars with batteries that can be charged at different times at night
- heat pumps coupled with CHP plants, a combination that will increase regulation capacity drastically and will use excess windpower production for heating in an efficient way. In 2030 such system-integrated heat pumps are introduced consuming 5 PJ of power to produce 20 PJ of heat.

For the CHP plants and combined CHP+heat pump systems are recommended daily/weekly heat storages (water tanks) to de-couple electricity and heat deliveries on short-medium terms.

For solar heating there will be some need for some seasonal storages after 2030 when solar thermal is expected to cover more than 10% of heat demand for space and water heating.

Non-energy use of fossil fuels is assumed to be phased out from 2030. Non-energy use of fossil fuels is mainly oil (52 PJ in 2000) an natural gas (34 PJ in 2000), in total about 6% of primary energy supply. This use must be replaced with renewable resources, such as agricultural products and biogas. The replacement of 20% with biomass resources are included in this study in 2050.

About this note

This note was developed by Gunnar Boye Olesen, INFORSE-Europe and with Ion Zamfir, Prietenii Pamantului for the Vision2050 for Romania. Read more about the vision and vision for other countries at www.inforse.org/europe. Please send comments to ove@inforse.org.

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