Development of Electricity Markets – Options for Estonia

Anton Laur
Estonian Institute of Economics at Tallinn Technical University,
7 Estonia Ave., 10143 Tallinn, Estonia
fax: 372-6998851, e-mail: antonl@tami.ee

Sulev Soosaar
Estonian Energy Research Institute at Tallinn Technical University,
1 Paldiski Rd., 10137 Tallinn, Estonia
fax: 372-6613653, e-mail: sulev@eeri.ee

Koidu Tenno
Estonian Institute of Economics at Tallinn Technical University,
7 Estonia Ave., 10143 Tallinn, Estonia
fax: 372-6998851, e-mail: koidut@tami.ee

Abstract

This chapter discusses the situation of electricity markets both in the European Union countries and in transition economies. We analyse the possibility of reducing the monopoly of oil shale-based energy production and opening the market in electricity in Estonia. To evaluate the prospects of oil shale-based electricity production, we analyse the formation of the oil shale-based electricity production price today and in the future, focusing on the share and growth of the environmental component in the production price. The environmental costs of oil shale-based electricity production depend primarily on the resource tax and pollution charge rates. We predict considerable growth of these costs, especially in the tax rates of greenhouse gases (mainly CO_2) in connection with the tightening of the environmental requirements in the future.

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1. Introduction

By today, many countries across the world, including the European Union (EU) member states, have fully or partly liberalised their electricity market. By liberalisation of the electricity market, we mean in most general terms the opening of the market to competition. As at the present technical development stage, electricity transport (transmission and distribution) is considered a natural monopoly. The opening of the electricity market requires the establishment of new market structures that separate generation from the transmission and distribution business thus introducing competition across the electricity supply chain. In Europe, the process of electricity market liberalisation has progressed quite radically, being formalised with the EU Electricity Directive (96/92/EC) in February 1997.

Electricity market liberalisation may also involve negative aspects such as greater risks to investors, backlashes to environment saving technologies, to electricity systems' security of supply, etc. Therefore, energy firms have increasingly started to use mergers and purchases of other enterprises in order to benefit from increasing returns to scale. Such cost economising also creates better conditions for competition in a free electricity market and may even influence prices in this market.

The restructuring experience in many countries has indicated that the introduction of competition in network-related utilities is a complicated task. National practices for liberalisation have differed greatly in terms of the degree of concentration in generation, the stringency of unbundling requirements, the design of market mechanisms, and the extent of public ownership and regulatory institutions. The key issue has been to identify the proper balance between liberalisation and ensuring adequate generation and network capacity (Newbery, 2001). In small systems, like in Estonia, the unbundling may bring about some losses of economies of scale. Therefore, the vertical integration model of electricity sector presented by Kwoka (2002) should be considered when projecting the future for the electricity sector in Estonia.

The Estonian electricity sector is dominated by the role of local mineral resource – oil shale – in electricity generation. Two large power plants (*AS Narva Elektrijaamad*) and a number of small combined electricity and heat production plants are using oil shale. *AS Narva Elektrijaamad* was founded in 1999 based on the *Balti* and *Eesti* Power Plants, which were put into operation in 1959-1973. The total installed electrical capacity of *Narva Elektrijaamad* is 2700 MW today. The Estonian electricity sector is organised around a vertically integrated utility – *Eesti Energia AS* – a state-owned enterprise that controls the generation, transmission, distribution as well as retail sales throughout almost all of the country. Thus, today Estonia actually presents a monopolistic electricity market of *Eesti Energia AS*.

Estonia is a small country where electricity production, mining and processing of oil shale is a regional economic complex[1] with difficult social problems. Estonia is facing a complex situation in breaking up this monopoly and developing a free electricity market. Estonia has, therefore, applied for a transition period for solving oil shale-based energy sector development and opening of electricity market issues in the EU accession negotiations. According to the agreement achieved, Estonia will open 35% of its electricity market by the end of 2008 (Treaty, 2003). Estonia was granted a transition period until 31 December 2015 regarding the implementation of the EU Directive on reduction of emission into air from large combustion plants (2001/80/EC) for oil shale-fired power plants. The latter means that Estonia was granted a transition period also in respect to reduction of air pollution from oil shale-fired power plants. In spite of this provision, the first energy units in Narva Power Plants are being transferred to use new technology. The plant will be using circulating fluidised bed combustion, which is expected to considerably reduce air pollution, and it is likely that the share of oil shale in electricity generation will diminish in the future (Ots, 1999).

This chapter discusses the situation of electricity markets both in the European Union countries and in transition economies. We consider the possibilities of opening the electricity market and reducing the monopoly of oil shale-based energy production in Estonia. For evaluating the future of oil shale-based electricity production, we study the formation of the oil shale-based electricity production price today and in the future, focusing on the share and growth of the environmental component in the production price. The environmental costs of oil shale-based electricity production depend primarily on the resource tax and pollution charge rates. We predict considerable growth of these costs, especially in the tax rates of greenhouse gases (mainly CO_2) in connection with the tightening of the environmental requirements in the future.

The increase of the oil shale-based electricity production price primarily as a result of the high CO_2 tax rate may cause a contraction of oil shale-based electricity production, as well as a reduction of air pollution as a result of using new combustion technology. We analyse the possible scenarios to compensate for this production with imported energy resources. We also analyse sustainable development indicators for the Estonian energy sector and compare them with respective indicators of EU member states and neighbouring countries.

2. The Development of Electricity Markets: EU Experience and the Problems of the Transition Economies

Until recently, the electricity sector in most countries was characterised by vertically integrated monopolistic companies, many of which were state owned and operated in strictly regulated captive markets. This did not encourage profitability or energy efficiency and is being progressively abandoned by liberalisation processes in many countries.

2.1. Liberalisation

By liberalisation of the electricity market, we mean in most general terms to the opening of the market to competition. The liberalisation of energy markets involves three basic processes: **privatisation**, **unbundling** and **market deregulation**. These may or may not all be applied in one country, depending on the model of liberalisation adopted.

The privatisation of state-owned assets wholly or partially is usually the first step in liberalising markets. If this is done only partially, the state may retain a share or even a controlling “golden” share. Or the state may retain only a minority share for representation.
Unbundling is the separation of the monopolistic functions (transmission and distribution) from the competitive functions (production and supply). Some countries have done this by assigning the four functions into separate companies which all operate commercially, and dividing the competitive elements of production

and supply into many competing companies. Electricity can only go down one line, but different entities can produce it competitively and sell it. Other countries have conformed to the minimum requirement of retaining a vertically integrated utility but separating the accounting functions within one company.

Competition is introduced through independent electricity producers and energy sellers. There are many different permutations of this to suit national requirements. An industrialised country with a mature infrastructure and strong industrial off-take has different needs from a developing country, where the provision of cheap electricity is an overwhelming priority for social and political stability. Deregulation must provide customers with a choice of supplier and introduce price competition.

The first steps towards deregulation of the electricity market were taken in 1978 in the United States with the enactment of the Public Utility Regulatory Policies Act, opening wholesale electricity markets to non-utility producers of electricity. Chile began its reform in 1982 and New Zealand in 1987. In Europe, deregulation started in 1989 (England and Wales) and in 1991 in Norway. An increasing number of countries are now committed to opening up their electricity sectors to competition. In Europe, the process has progressed quite radically, being formalised with the EU Electricity Directive (96/92/EC) in February 1997. The Directive laid down the rules regarding the organisation and functioning of the electricity sector (e.g. separate accounts for generation, transmission and distribution activities; time schedule for the market opening), access to the electricity network (negotiated or regulated third party access, or single buyer), and criteria and procedures for granting authorisations for generation, transmission and distribution of electricity.

Compliance varies from country to country. Table 1 presents the basic legislative position of EU member states in regards to electricity market liberalisation, showing the proportion of the market open to competition and the relevant eligibility thresholds (Commission, 2002).

Table 1. Measures Adopted by EU Member States in Implementing Directive 96/92/EC (as in October 2002)

	Market opening	Eligibility threshold	100% opening in / by
Austria	100%	–	2001
Belgium	52%	1/10 GWh	2003/7
Denmark	35%	1 GWh	2003
Finland	100%	–	1997
France	30%	16 GWh	?*
Germany	100%	–	1999
Greece	34%	1 kV	?*
Ireland	40%	1 GWh	2005
Italy	45%	9 GWh	?*
Netherlands	63%	3*80 A	2003
Portugal	45%	1 kV	2003
Spain	55%	1 GWh	2003
Sweden	100%	–	1998
UK	100%	–	1998

** not yet decided*

The studies and reports analysing the implementation of the Directive on the internal market of electricity (Commission, 2001; Commission, 2002) demonstrate that the EU member states can be divided into two groups on the basis of the establishment rate of internal market requirements:

- countries with a liberalised electricity market;
- countries with slow liberalisation process.

The different rates of development are largely due to the previously developed structures of the electricity system in these countries – the scope of vertical integration, number of firms operating in the system, etc. In the first group of countries, the liberalisation process progressed faster than envisaged in the directive. This group includes, for example, United Kingdom, Sweden, Finland and Germany (markets completely liberalised) and Denmark, Austria, the Netherlands, Spain and Italy. The main reasons for the faster development are:

- pressure from industrial consumers with the purpose to achieve lower prices and better services;
- positive experiences of the countries which have completed liberalisation;
- attempts of national policy designers to prepare energy firms with competition in the home market for entrance to the common EU market.

In addition to the right of consumers to choose an electricity supplier, the opening of a market also requires a sufficient number of electricity producers. Also, independent electricity producers must have access to the market in addition to firms specialised in electricity production. This, however, is often complicated. Since the minimally necessary number of producers depends on many circumstances (e.g. size of market, quality of regulation, competition from abroad, etc.), it is not possible to have a model of liberalisation that is suitable for all countries.

Economic theory gives no clear indication of the minimum number of producers necessary for a market to arrive at a a competitive price-quantity equilibrium, which is defined as an approximate price equal to marginal cost. Since 1990s, both experimentalists and policy makers have generally believed that six to ten comparably sized suppliers define a workably competitive market (Green and Newbery, 1992; Andersson and Bergman, 1995). Lately, some experimental studies have indicated that a higher number of suppliers may be necessary to approximate competitive market solutions (Chapman *et al*., 2002). Some researchers even suggest that not less than 30 equal-sized market participants can bring equilibrium price to an acceptable level of 5% above marginal cost (Rudkevich *et al*., 1998).

Liberalisation may involve problems and negative implications also in terms of electricity system development (OXERA, 2001; Matthes and Timpe, 2000). For example, the liberalisation process involves greater risks to investors, which in turn compels them to raise the desired productivity level. Investors may then prefer projects with lower specific investments and high efficiency (e.g. combined cycle gas turbine plants). In the longer term, this may create the risk of deficit, since due to higher risks less investments are made into new production capacities than would be expedient for the system as a whole. For the same reasons, the liberalisation may backfire on the environment saving technologies, which are as a rule more capital intensive. For example, the application of hydro, wind and solar energy would be less attractive.

The liberalisation of electricity markets also has brought new aspects to the security of supply in electricity systems. Many events in the last couple of years have referred to seriousness of possible problems.[2] Though the installed production capacity in the electricity systems in EU countries on the whole considerably exceeds the cumulative peak load, we must take into consideration a kind of fragmentation of the EU electricity system and insufficient electricity trade between countries. In addition to the amount of installed production capacity, we must also consider the structure of capacities. For example, hydro-energy plants contribute 62% of total capacity in Estonia's close neighbours, the Nordic countries Norway, Sweden and Finland, and such dependence on the weather may cause great risks. Since the price level in the Nordic electricity market has been low for several years, in fact for a time it was even below the short-run marginal costs, the incentives to build new production capacities have been weak.

Despite some generally negative aspects of the electricity market liberalisation and some concrete problems in some countries, the process on the whole has been regarded as a significant step in raising the efficiency of the national electricity sectors (Commission, 2002). The opening of the national electricity market in turn enables a nation to co-operate internationally and creates more effective electricity trade through international electricity markets.

2.2. Consolidation

In recent years, electricity firms have attempted to improve efficiency by increasing production/activity scales. Since electricity consumption growth is relatively small, such increase in production/sales would be limited and an extremely long-term process. Therefore, firms have paid increasingly more attention to other expansion possibilities – the merging of enterprises and the purchasing of other enterprises partly or wholly.

The main positive factors arising in connection with the enlargement of enterprises are:

- lower capital costs ensuing from the returns to scale;
- more favourable fuel and equipment purchasing possibilities;
- possibility of dividing overhead and marketing costs between more consumers;
- possibility of more flexible administration of the structure of production capacities;
- reduced duplication of management and administration activity;
- simplified risk administration.

As mentioned by merging firms, the main reason for the active consolidation process is the effects of synergy from mergers, which enable a kind of cost economising, and at same time creating better conditions for competition in a free electricity market. However, the process has another facet, which the researchers of the electricity market development have recently noted – such consolidation often involves the possibility to influence and set prices in the market. Also, participation in several firms in some cases provides large corporations with the possibility to avoid competition and design strategic prices. Cross-subsidisation and discriminative treatment of the third party (e.g., distribution network company gives priority to its own market share) is also possible. To evaluate this tendency, it is important to consider that excessive concentration as a rule weakens the effect of market mechanisms.

In the EU, the question has been raised of what strategy to choose to control concentration and to preserve competition in the electricity sector in long-term perspective. Despite the internal electricity market rules established by the EU, there is no common model of electricity system enterprise taking shape so far. In it is important to note that these enterprises differ essentially by ownership type, size, structure and profitability. Table 2 provides an overview of the concentration rate of electricity enterprises in EU countries, reviewing the structure of the market for electricity generation and for retail supply. It should be noted that market share in supply tends to reflect the organisation of local distribution networks, i.e. existence of a high number of retail supply companies each with a small market share is not necessarily indicative of active competition since it may be a result of the existence of small local monopolies.

Eurostat has published some statistical data on the concentration of electricity markets in EU member states (Eurostat, 2002). Three indicators were taken to represent the market structure of the electricity generation and retail markets:

- the number of companies with a market share of at least 5% of the total;
- the aggregated market share of those companies;
- the market share of the largest company.

In 2000, the UK, the Netherlands and Austria contained the highest number of companies with a market share greater than or equal to 5% in the generation and supply markets. In the generation and supply industries in Greece, France and Ireland, only one company had a market share equal to or greater than 5%. This was also the case in Portugal with regard to supply. The highest concentration in generation and supply was recorded in Greece. In generation, the highest market share of the largest company was found in Greece and in Ireland (97%). In Belgium and France, the share earned by the largest company also exceeded 90%. The lowest market share was registered in Finland (23%), then Austria (33%), Germany (34%) and Denmark (36%). In supply, in those member states for which data was available, the market share of the largest company ranged from 100% in Greece and Portugal to 11% in Finland and 17% in Denmark.

Table 2. Concentration of Electricity Enterprises in EU Countries in 2000

	Installed capacity (GW)	Transmission utilities	Distribution utilities	Suppliers	
				total	incl. independent of distribution utilities
Austria	18.2	3	155	40	6
Belgium	15.7	1	33	16	16
Denmark	12.7	2	77	70	6
Finland	16.6	1	100	80	9
France	115.4	1	172	225	41
Germany	118.3	4	880	ca 1200	200
Greece	10.3	1	1	7	6
Ireland	4.8	1	3	19	18
Italy	78.1	1	219	170	135
Netherlands	20.6	1	18	33	15
Portugal	10.7	1	3	11	10
Spain	52.6	1	297	149	n.a.
Sweden	33.6	1	248	120	20
UK	78.9	4	15	59	59

Source: *OXERA, Netherlands Energy Research Foundation, Energy System Analysis and Planning Centre ATOM, Université Panthéon-Sorbonne, European Commission, DG TREN. (October) 2001. Electricity Liberalisation Indicators in Europe.*

These shares indicate that a significant degree of concentration exists in generation in many member states. The presence of generators with dominant market share is unlikely to be conducive to new entrants without tight control of wholesale and balancing markets. Therefore, in order to deliver more effective competition, many member states have instigated some release of generation capacity from the dominant suppliers, e.g. the UK and Italy. Other member states, e.g. France and Ireland, have made capacity from the incumbent generator available to the wholesale market through an auction procedure.

Without significant competition being generated internally, competition in the retail supply business has to come from cross border transactions but these transactions may also be limited if the arrangements for cross border transactions are discriminatory or if congestion exists. Market share in supply therefore tends to reflect the generation market to some extent although the historical development of regional distribution/supply companies has some impact. Many member states have seen considerable consolidation of the retail supply market.

In several models of market power in the electricity sector, the price-cost margin (known also as the Lerner index) is used. The **Lerner index (**L) measures how much the market price exceeds the marginal costs of the last dispatched unit: L = (P – MC)/P, where P is the price and MC is the marginal cost. Unfortunately, there is a significant practical obstacle to broader application of the Lerner index – determining the utility's marginal cost of production at any given point in time. Without a measurement or reasonable estimate of marginal cost, the ratio is incalculable.

The most common measure of market power is the **Herfindahl-Hirschman index** (HHI). HHI is the sum of the squares of all firms' market shares. The HHI is a statistical index that is often used to measure the degree of ownership concentration among suppliers in a relevant market. It takes into account the relative size and distribution of the firms in a market: in a pure monopoly where one firm has 100% share, the HHI is 10,000; and when a market consists of a large number of firms of relatively equal size, the HHI approaches zero. The HHI increases both as the number of firms in the market decreases and as the disparity in size between those firms increases.

Traditionally, the markets in which the HHI is between 1000 and 1800 are considered to be moderately concentrated, and those in which the HHI is in excess of 1800 points are considered to be concentrated.

The HHI values for electricity supply sectors in EU Member states ranged in September 2000 from 1209 in UK (England and Wales) to 9800 in Greece (International, 2000). The HHI for the Nordic electricity markets (based on energy shares) are low, ranging from 836 in Finland to 1745 in Sweden, still reaching 3123 in East Denmark. (NORDEL, 2002a). Our calculations for Estonia give the HHI value of approximately 9600 (on the basis of production).

2.3. Situation in Estonian Electricity Sector: Problems of Small Market

At present, most of the transition economies in Central and Eastern Europe are also reforming and restructuring their electricity sector. A central element of these reforms has been the introduction of competition.

The design of a reformed electricity market should make use of international experience but transposing the same structures and rules without taking into account the specific circumstances of country may give rather negative results. Recently, economists have actively participated in design efforts of many complex market institutions notably within the public utilities deregulation context (Wilson, 2001; Roth, 2002). When considering the electricity markets' performance, the market power issues are in the centre of the analysis. Because of the technical and economic properties of an electricity system and characteristics of electricity as a commodity, special tools are needed to identify, diagnose and measure the market power [3].

The restructuring experience in many countries has indicated that the process of ensuring effective and efficient competition in network utilities in the presence of essential facilities is not straightforward. The logical solution to ensure open, transparent and non-discriminatory access to the essential facility or network is to unbundle the industry and insist on ownership separation ? that is, the party that owns or controls the essential facility should have no ownership stake in or ability to control the potentially competitive services. The key issue is to identify the proper balance between liberalisation and ensuring adequate generation and network capacity. Whether and under what circumstances the ownership unbundling is cost-effective is an empirical question, the answer to which may change as a result of technical progress (Newbery, 2001).

The practice in several small countries indicates that the introduction of effective competition in small markets may be difficult. It is often argued that economies of scale, low levels of demand, fixed costs of restructuring, etc. are against the introduction of competition into small markets.

The evidence from Europe and the United States suggest that there are a number of conditions for successfully liberalising electricity markets (Newbery, 2001). The first condition is that for the wholesale market to be competitive, potential suppliers must have access to the transmission system enabling them to reach customers. This is best achieved by the ownership separation of transmission from generation. The second condition is that there is adequate and secure supply. For electricity, there are three conditions that need to be satisfied for supply security: the network infrastructure must be adequate and reliable; there is adequate generation capacity; and there is security of supply of the primary fuels. The third condition is that there is appropriate regulation of the markets of these liberalised utilities. This condition is less obvious, and has been largely ignored by the Commission and many EU countries, but without it, there are serious risks that the benefits of liberalisation may be lost.

The Estonian electricity sector has traditionally been organised around a vertically integrated utility – *Eesti Energia AS* – a state-owned enterprise that controls generation, transmission, distribution as well as retail sales almost throughout the country. To date, only 2% of installed generation capacity is owned by independent power producers (IPP).

The electricity industry has been run by the state as an administrative entity rather than a fully commercial business. Electricity tariffs covered mainly operational costs, therefore the need for investments in generation and in particular in network systems had to be ignored. In the beginning of the 1990's, the process of restructuring was initiated but it has been difficult to select a proper development strategy for such a small system. The unbundling was started with the splitting off the non-core activities and the separation of generation, transmission and distribution at accounting level. In the next phase, separate business entities were established for these main activity fields, keeping all of them still within the state-owned power utility *Eesti Energia AS*. Regarding privatisation, the sale of 49% of shares of two largest power plants to a foreign investor was cancelled in 2002[4]. Two relatively small distribution utilities were privatised, and then the process was stopped as well, as a result of political debates on ownership issues in energy sector. At the end of 1998, the Estonian Government approved the new reconstruction and privatisation plan of *Eesti Energia AS* and *AS Eesti Põlevkivi*, which is fundamentally different from the privatisation logic of large energy firms as stipulated in the current Fuel and Energy Sector Development Plan (Long-Term, 1998). A policy was enacted that created a joint energy firm which would comprise power plants and networks as well as the fuel base in the form of oil shale mines. This plan follows closely the vertical integration model in the electricity sector, the methods and implementations of which have been described by Kwoka (2002).

At present, the electricity sector is still almost completely state-owned. This, along with its small size, has made the introduction of competition very difficult. The autonomous and transparent regulatory framework is an important prerequisite for a well functioning electricity system where competition is to be encouraged. In Estonia, the regulation of the sector is carried out by a regulating body working in the domain of ministry governing the whole energy sector, while the state has retained ownership in utilities being regulated. This does not assist in a clear separation of 'policy' from 'regulation' and, as a rule, complicates the introduction of new independent power producers into Estonian market.

Industrial plants (autogeneration) as well as small-scale electricity providers should become important entities in small-scale electricity markets. This would comply with the principles of the distributed energy concept - an essential element of the security of supply policy. Also, it should enable to deploy electricity generation based on renewable sources. In principle, Estonia as a small country can benefit from interconnection with neighbouring countries to increase the size of market and thereby facilitate the introduction of competition in the market.

For Estonia, the closest EU electricity market is the Nordic one. According to market openness indicators, [5] all of the Nordic countries are well connected in terms of transmission capacity to the other Nordic countries. The openness of the Nordic electricity markets is high, especially for Denmark, Sweden and Norway where the import capacity is well above 20 percent of the internal generating capacity, but more limited for Finland with about 10 percent. Still, at present, the trade openness of these markets to *outside* the Nordic area is quite low, reaching only for Denmark up to 16 percent (NORDEL, 2002b).

The idea of constructing a transmission system interconnection between the Baltic and Nordic electricity systems has been under discussion for several years already (Ministry, 2002). At present, Estonian, Finnish and Latvian power companies are planning to lay a power cable between Estonia and Finland to link the electrical power systems of the Baltic countries and Scandinavia. The installation of the proposed 315 MW underwater power cable between Estonia and Finland, which is expected to cost about 100 million euros, should be completed by 2005. Proposals to construct a transmission interconnection between Lithuania and Poland have also been discussed.

During accession negotiations with the EU, Estonia has applied for several transition periods related to energy sector development. The continuation of energy production from oil shale for at least 10 years is considered as one of the pillars of the electricity market in Estonia. According to the present legislation, the Estonian electricity market is open to eligible consumers with capacity at least 8 MW and annual consumption at least 40 GWh, which means an open market share of ca 10 percent. At present, full liberalisation of the electricity market in Estonia is considered undesirable as it may mean end of oil shale based energy production, which would not survive the competitive pressure. This would be unacceptable to Estonia, as the restructuring of the oil shale energy sector rests on basically three principles – security of supply of energy, balancing of foreign trade of

Estonia and providing of employment in Ida-Viru County. Therefore, Estonia has constructed a plan, which requires a transitional period until the end of 2012.

Another important element of Estonia's request is granting EU financing to oil shale research. The government places significant priority on the support to the development of Estonian scientific potential in the field of oil shale research. For Estonia, research in the entire oil shale production chain is important, from the production of oil shale energy to shale oil and chemical products. Therefore, Estonia considers it necessary for the research projects to encompass the entire oil shale production chain. The EU has noted the unique character of Estonia's oil shale and took into consideration its social and economic aspects.

In reference to the opening of the electricity market, it was provided in the Treaty of Accession (Treaty, 2003) that Estonia would gradually open the electricity market according to the following transition protocol:

- Estonia will open up 35% of its electricity market by 31 December 2008;
- Estonia will open its electricity market by 31 December 2012 in line with the Decisions of the Barcelona European Council. (According to the decision of the Barcelona European Council, the member states must provide energy safeguards to all non-household electricity consumers by the year 2004, which would see the liberalisation of the market to at least a 60% level).

With this agreement, the EU has taken into account the social, economic, regional, environmental and security aspects of Estonia's request, as well as the exceptional issues related to the restructuring of the oil shale sector.

As to oil shale research, the EU agreed to Estonia's request that oil shale research be eligible for special purpose funding from the ECSC Research Fund for Coal and Steel (which as of 24 July 2002 came under the European Commission's administration). The term "oil shale" was added to the list of research that fits in with the above-mentioned fund's objectives.

In Estonia, the problem is to find ways to introduce competition without compromising other nationally important goals, particularly those related to the problems of the oil shale-based energy complex.

3. Reduction of the Dominating Role of Oil Shale-Based Energy Production

3.1. The Structure of Energy Resources in Electricity Production

Although the share of oil shale has considerably diminished in energy consumption in the recent decade, compared with the period before 1990, it is still high. Oil shale accounts for nearly 60% of all primary energy consumption, and even 90% of electricity production. At the same time, the renewable energy sources contribute 11% of the energy balance, and only 0.2% of electricity production (data of 2000). Hydro and wind energy comprised less than 0.1% (Table 3). In 2002, the latter reached 0.3%.

Table 3. Consumption of Energy Resources for Electricity Production

Indicator	1997	1998	1999	2000	2001
Electricity gross production, GWh	9218	8521	8268	8513	8483
Share of oil shale-based electricity, %	**95.7**	**93.9**	**93.1**	**91.1**	**90.5**
incl. from oil shale	95.3	93.5	92.3	90.7	90.0
from shale oil	0.4	0.4	0.8	0.4	0.5
Natural gas consumption, mill. m^3	21	26	34	89	91
Increase, %		+24	+31	+162	+2.2
Share of natural gas in electricity production, %	1.3	2.0	2.6	6.6	6.7
Consumption of other fuels, TJ	2431	3041	3079	2324	2698
Increase, %		+25	+1.2	-25	+16
Share of other fuels in electricity production, %	3.4	4.5	5.1	2.7	3.2
Electricity production from hydro- and wind energy, GWh	3	5	5	6	8
incl. hydroenergy, GWh	2.95	4.70	4.68	5.67	7.72
wind energy, GWh	0.05	0.30	0.32	0.33	0.28
Share of hydro- and wind energy, %					0.1

Source: *Statistical Office of Estonia. 1998…2002. Energy Balance 1997…2001. Tallinn.*

Oil shale-based energy production creates a remarkable negative impact on the environment. Oil shale mining, production and chemistry contaminate soil, create large amounts of waste, pollute air and water. The impact of the oil-shale energy complex reveals itself especially strongly in air pollution with solid waste, sulphur and nitrogen compounds and greenhouse gases (mainly CO_2). Emission of the latter from oil shale is even greater than from the combustion of other fossil fuels. Therefore, CO_2 emission per capita is relatively high in Estonia (see Section 4.2).

In addition to involving high environmental risks, oil shale-based electricity production has low energy efficiency. Own use of oil shale-fired power plants has in recent years amounted to 10.5-11%, own use together with losses in the system, however, account for up to one-third of the electricity gross production. This is a reason why energy consumption per unit of GDP (i.e. energy intensity) is in Estonia several times higher than in the developed European countries (see Section 4.2).

Considering all those factors and the generally acknowledged principles of sustainable development, the accent in planning further development of the Estonian energy sector is on the diversification of electricity production to mitigate its environmental impact by finding a reasonable alternative to oil shale-based energy production and by territorial decentralisation of electricity production.

The reduction of the share of oil shale and the necessity to develop energy production based on renewable and other (incl. imported) resources is also envisaged in the current Fuel and Energy Sector Development Plan (Long-Term, 1998). However, these principles have not been essentially realised so far. The new development plan up to the year 2015 (with a vision until 2030), which is currently under elaboration, also envisages reduction of oil shale-based energy production and proposes possible (allowed) outputs of oil shale-based electricity in the future (Ministry, 2002).

The main technological measure to serve the environmental targets in the 1998 Development Plan was the introduction of the circulating fluidised bed combustion (CFBC) technology in oil shale-based power plants. This would lead to a considerable reduction of SO_2 emission and other hazardous wastes and would also considerably slim down the generation of greenhouse gases (CO_2), improve the efficiency factor of boilers, etc (Ots, 1999). Unfortunately, the negative impact of energy production on the environment cannot be sufficiently reduced without changing the structure of the energy resources used, thus without introducing renewable energy resources and fuels that create less pollution and do not cause the greenhouse gas effect. To achieve this objective, the Development Plan suggested levying relevant taxes and establishing limits for concentration of pollutants in the flue gas dependant on the fuel.

3.2. Reduction of Oil Shale-Based Electricity Production

In recent years, a number of studies and analyses have been conducted in Estonia to evaluate the alternatives to electricity production and find out its future prospects (Liik and Esop, 1999; Laur and Tenno, 1999; Vares, 2001; *et al*.). The results of these studies are similar and confirm that oil shale-based energy production, primarily the duration and scales of continuing oil shale-based electricity production, is and will be the main issue for the Estonian energy sector during the next 10-15 years. The results of the studies indicate that the prime competitor to oil shale in electricity production will be natural gas – by 2010 gas-based electricity production may be cheaper even without combined heat production. A considerable competitor to oil shale in the combined production of electricity and heat may be also coal. An attractive possibility, primarily from the point of view of reducing environmental impacts, is a scenario concerning electricity import.

A key issue of oil shale-based energy sector development is the consideration of environmental impacts. It should be emphasised that the estimates of the competitiveness of oil shale-based electricity so far have been based on the assumption that the present, relatively conservative environmental and energy policy will continue. This actually indicates insufficient consideration of the environmental impacts. An example of the implementation of a more radical environmental policy in this paper is the prognosticated maximum version of the oil shale-based electricity production price in the year 2010 (see Table 4).

We have prognosticated the oil shale-based electricity production cost in 2005 and 2010 taking into account the requirements of the Estonian Environment Strategy and the Directive of the European Parliament and of the Council on the limitation of emissions of certain air pollutants from large combustion plants (2001/80/EC). The latter set limitations to the net production of Narva Power Plants – up to 6600 GWh after 2005 and 5340 GWh after 2008 (Ministry, 2002).

Prognostications of pollution charges for 2005 are based on the rates established in the Pollution Charge Act Amendment Act (Pollution, 2001). For 2010, there are two versions of prognosis. In the first version (low), the pollution charge and resource tax growth rates have been proposed based on the Estonian environment policy so far. For example, the CO_2 tax rate will be 30 kroons/t (according to the Pollution Charge Act Amendment Act it will be 11.3 kroons/t in 2005). We have also considered the rise in efficiency and the potential

Table 4. The Oil Shale-Based Electricity Production Cost and Forecasts

Cost items	2001, actual		Forecasts					
			2005		2010			
					Low environmental costs		High environmental co	
	sent/ kWh	%	sent/ kWh	%	sent/ kWh	%	sent/ kWh	%
Materials, consumables and supplies	25.8	68.1	29.2	63.1	33.5	54.1	33.5	4
incl. resource payments	1.3	3.5	1.5	3.2	2.4	3.9	2.4	
Operating expenses	6.8	18.0	8.9	19.2	14.9	24.0	29.6	3
incl. environmental costs	4.2	11.2	6.0	13.0	11.0	17.7	25.7	3
Personnel expenses	11.8	31.2	14.8	32.0	20.8	33.6	20.8	2
Other expenses	0.2	0.4	0.2	0.4	0.2	0.3	0.2	
Depreciation	6.6	17.4	7.6	16.4	10.5	17.0	10.5	1
Total costs	**51.2**	**135.0**	**60.7**	**131.1**	**79.9**	**129.1**	**94.6**	**12**
Sales of by-products	-13.2	-35.0	-14.4	-31.1	-18.0	-29.1	-18.0	-2
Total oil shale-based electricity production costs	**38.0**	**100.0**	**46.3**	**100.0**	**61.9**	**100.0**	**76.6**	**10**
Net production, GWh	6596		6430		5300		5300	
Production cost, sent/kWh	**38**	**100.0**	**46**	**100.0**	**62**	**100.0**	**77**	**10**
EUR/100 kWh	**2.4**		**3**		**4**		**4.9**	
incl. environmental costs, sent/kWh	**6**	**15.8**	**8**	**17.4**	**13**	**21.0**	**28**	**3**
EUR/100 kWh	**0.4**		**0.5**		**0.8**		**1.8**	

Sources: *Eesti Energia AS. 2002. Annual Report 2001/2002, Tallinn; Eesti Energia AS. 2002. Environmental Report 2001. Tallin Pollution Charge Act Amendment Act. 2001. Riigi Teataja (State Gazette). I 2001, 102, 667.*

reduction of pollution emissions as a result of technological reconstruction of the Narva Power Plants.

In the second version (high), for the year 2010, we have experimentally based our prognosis on the CO_2 tax rates proposed by the European Union in the mid-1990s - 10 USD per oil barrel equivalent (European, 1995), which with the present exchange rate of the US dollar equals approximately 300 kroons per tonne of CO_2. However, our prognosis still takes into account only half of this rate – 150 kroons/t. This is a very high rate for Estonia, though many EU countries (for instance, Nordic countries Denmark and Sweden) already today have much higher CO_2 tax rates (Database, 2001).

Our results (presented in Table 4) indicate that the oil shale-based electricity production cost in Narva Power Plants was 38 Estonian sents/kWh or 2.4 EUR/100 kWh according to the 2001/2002 financial year report (Annual, 2002). Of this, 15.8% were environmental costs [6]. The environmental costs and their share will increase in the future. The oil shale-based electricity production cost in the year 2005 will be 46 sents/kWh or 3 EUR/100 kWh, where the environmental costs will account for 17.4%. In 2010, in the lower version of environmental costs, the oil shale-based electricity production cost may rise to 62 sents/kWh or 4 EUR/100 kWh, and in the higher version of environmental costs to 77 sents/kWh (4.9 EUR/100 kWh). The share of environmental costs in 2010 will grow as high as 21% and 36.4%, respectively.

While the depletion of the economic advantages of oil shale-based electricity production is not a very precisely defined process, depending on various factors (electricity demand, prices of energy resources, etc.), the environmental restrictions laid down within the European Union, those established with other international agreements or those resulting from Estonia’s own normative documents, set quite concrete limits to oil shale-based electricity production. So, the SO_2 marginal rates fixed in the Estonian Environment Strategy allow to produce after 2005 on the basis of oil shale ca 6.6 TWh of electricity [7] per year – on the assumption that the ongoing renovation of two energy units in the Narva power plants will yield the expected results. But, if they continue with the old technology, it would be possible to produce not more than 4 TWh of electricity per year after 2005 (Ministry, 2002).

New model calculations using the planning system MARKAL (Goldstein, 1994) have been conducted for the possible development scenarios in the Development Plan for Estonian electricity sector

(Department, 2002) that has been formulated within the preparation of a new long-term development plan for the fuel and energy sector (Ministry 2002). The results of these calculations also indicate that the first priority, aside from oil shale, is natural gas-fired combined production plants (within the existing heat load), followed by natural gas-fired condensation plants. Wind and other renewable energy capacities will be used as possible given potential resources. After new oil-shale energy blocks are put into operation after 2010, the use of natural gas will diminish, but the capacity of natural gas-fired plants is needed to compensate for wind generator fluctuations. Unfortunately, investments in scenarios involving new oil-shale blocks are much larger than in other scenarios.

However, the results of the model calculations we described previously do not give a definitive answer for the future of oil shale-based energy production in a longer perspective. This is because we do not know the results of the first renovation stage in Narva Power Plants currently in progress. These results will tell what could be the role of oil shale-based energy production in providing sufficient electricity supply for Estonia. The following developments are possible in the period 2005–2015:

1. Annual net production of oil shale-based electricity will be possible at the level of 6.6 TWh after 2005.
2. Annual net production of oil shale-based electricity will fall below 6.6 TWh during the period 2005–2015.

   Possible reasons: renovation will not yield expected results, restrictions on emissions or environment taxes will become even stricter, oil-shale and/or oil shale-based electricity production capacities will exhaust themselves earlier than expected.
3. Net production of oil shale-based electricity in excess of 6.6 TWh after 2005.

   Such development can be realised if the renovation of the first blocks in Narva Power Plants yields better results than expected, oil shale-based electricity production technology will develop further and renovation will continue. At the same time, the above-mentioned environmental restrictions could be moderated or their implementation postponed.

Based on the analyses so far, the first and second development scenarios or their combination are more likely.

3.3. Possible Scenarios for Covering Electricity Demand

Based on the environmental restrictions and electricity demand forecasts, we have drafted possible scenarios for covering electricity demand. The variation of the scenarios is caused by covering of the unsatisfied part of electricity demand by using various combinations of imported energy resources.

The calculation results indicate that (depending on the prognosis of electricity demand) it will be necessary to produce additionally on the basis of imported resources or to import approximately 1500-2400 GWh of electricity in 2010 and 1700-3200 GWh in 2015. There will probably be no such need in 2005 yet. However, it will not be possible any more to export electricity then. We discuss three possible scenarios to cover such electricity demand. **In the first (I) scenario** all the electricity supply deficit will be covered with additional production of natural gas-based electricity. **The second (II) scenario** envisages covering of the deficit by 60% with gas-based electricity and by 40% with imported electricity. In the **third (III) scenario** gas-based electricity contributes 50%, imported electricity 25% and the remaining 25% will be covered by electricity produced from coal. The need for additional imported energy resources to cover electricity demand in the period studied according to the above-described scenarios is depicted in Table 5.

The first (I) scenario (natural gas) must be regarded as having the best future outlook from both the environmental impact, foreign trade and other aspects (Department, 2002). According to this, the potential for the combined production of electricity and heat is the first thing to be supplied from new, natural gas-based electricity production capacities. In the next stage (around 2015), there may arise a need also for new condensation power plants (especially if the development of electricity consumption will be in the direction of maximum prognosis). In the second scenario where 60% of the electricity deficit will be covered with additional production of gas-based electricity and 40% with imported electricity, the need for new electricity production capacities is smaller. In the third scenario (gas-based electricity 50%, imported electricity 25%, coal-based electricity 25%), it would be necessary to import more coal for electricity production. However, the expediency of the latter is still disputable, because compared with oil shale-based electricity production, there will be no considerable alleviation in environment pollution and the risks involved in unpredictability of environmental taxes will remain. A positive point in using coal is the expanding choice of resources, which is important from the security of supply aspect.

Table 5. Need for Additional Imported Energy Resources to Cover Electricity Demand

	2010		2015	
	Electricity consumption		Electricity consumption	
	min	max	min	max
Need for electricity supply to network to be covered by imports, GWh	1500	2400	1700	3200
I Scenario: Natural gas 100% Needed amount of natural gas, mill. m^3	430	690	430	820
II Scenario: Natural gas 60% Imported electricity 40% Needed amount of natural gas, mill. m^3 Needed amount of imported electricity, GWh	260 600	410 960	260 680	490 1280
III Scenario: Natural gas 50% Imported electricity 25% Coal 25% Needed amount of natural gas, mill. m^3 Needed amount of imported electricity, GWh Needed amount of coal, thous. t	220 375 170	350 600 270	220 430 170	410 800 320

The analysis results allow us to state that investment decisions involving the development of the Estonian energy sector must be made very soon – whether to continue renovation of oil shale-based power plants or stake (in which scales) on imported fuels-based electricity production as well as import electricity. In order to reduce risks involved in these decisions, it is necessary to carry out additional investigations, for example, to evaluate the negative aspects involved in increasing the import of energy resources. Estonia must also specify the possibilities of electricity production based on renewable energy resources and conduct a detailed analysis of the investment needs regarding all competitive possibilities to cover electricity demand. These decisions largely depend also on the first stage renovation results of Narva Power Plants.

4. Sustainability Indices of the Estonian Energy Sector

Energy consumption intensity indicators in relation to gross domestic product (GDP) are discussed as a part of the main sustainable development indicators of the energy sector (United, 2001). In our previous research, we have analysed energy consumption intensity in Estonia and various other energy consumption indicators, and compared them with respective indicators of the European Union member states and candidate countries until the year 1999 (Laur, Soosaar and Tenno, 2001; 2002). In this paper, we analyse the long-term dynamics of final energy consumption intensity in Estonia as it is prepared by the Statistical Office (Statistical, 2002), and primary energy, electricity and carbon dioxide (CO_2) emission intensity indicators for 2000, which have been calculated using the International Energy Agency database (International, 2002). The indicators have been harmonised through the use of national purchasing power parities (PPP).

4.1. Dynamics of Energy Consumption Intensity in Estonia

Here we discuss the dynamics of final energy consumption intensity indicators in Estonia in the period 1994-2000. The Statistical Office of Estonia has calculated the energy consumption intensities in this period in the national economy (ratio of final energy consumption to GDP), in transport (ratio of energy consumption by transport to value added), in manufacturing (ratio of energy consumption by manufacturing to value added) and in households (energy consumption by households per capita) (Statistical, 2002). They have also produced ratios of these indicators to 1994 (1994=100%). The latter are presented in Table 6 and in Figure 1.

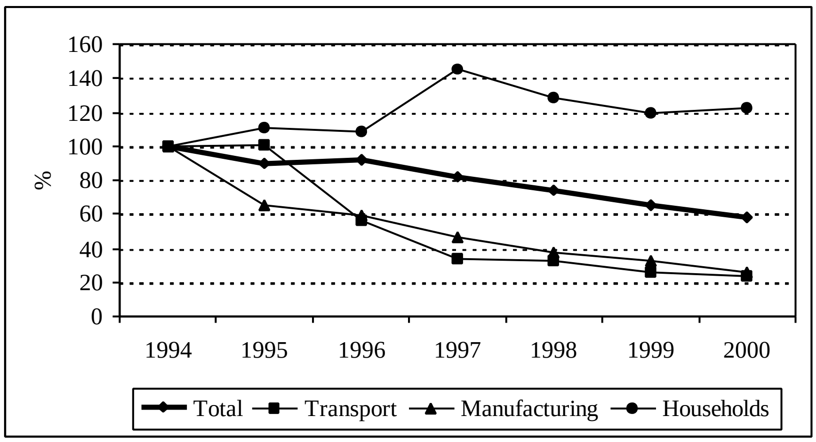
Table 6. Energy Consumption Intensity, 1994-2000 (1994=100)

	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Total	**100**	**90**	**92**	**82**	**74**	**65**	**58**
Transport	100	101	56	34	33	26	24
Manufacturing	100	65	59	46	38	33	26
Households	100	111	109	145	128	120	122

Source: *Statistical Office of Estonia. 2002. Indicators of Sustainable Development. Tallinn.*

As you can see from the Figure 1, the final energy consumption intensity has been decreasing in the national economy, in transport and in manufacturing throughout the period, but has considerably increased in households where it peaked in 1997. This can be explained by the decline in energy consumption throughout the last decade as a result of the contraction of production and the structural changes in the economy. The increasing energy consumption intensity in households, however, tells about a rise in the income of households. In conclusion, it means a rise in the energy consumption efficiency, which is certainly a positive tendency in the development of the Estonian energy sector.

Figure 1. Energy Consumption Intensity (1994=100)



4.2. Comparison of Sustainability Indices of the Estonian Energy Sector with Other Countries

Table 7 contains sustainability data for comparison of the Estonian energy sector with EU member states and candidate countries in 2000. For comparison with Estonia, we have taken the average of all 15 EU member states (EU-15) and Nordic countries – Finland, Sweden, Denmark and Norway (non-EU member country), as well as great powers – France, Germany and United Kingdom. Regarding the candidate countries, we take the average of the ten first countries (CC-10) invited to join the EU (2004) and separately Lithuania, Latvia, Poland and Czech Republic (countries with more similar climate conditions).

Table 7. Comparative Data of the Main Energy-Related Indicators, 2000

	Per capita				Per GDP(PPP), USD'95		
	GDP(PPP), USD'95	TPES, t oe	Electricity consumption, kWh	CO_2 emission [*], t	TPES, kg oe	Electricity consumption, kWh	CO_2 emiss kg
EU-15 average	**21875**	**3.86**	**6547**	**8.35**	**0.18**	**0.30**	**0.38**
France	22596	4.26	7302	6.18	0.19	0.32	0.27
Germany	23246	4.13	6684	10.14	0.18	0.29	0.44
United Kingdom	21141	3.89	5995	8.89	0.18	0.28	0.42
Finland	23807	6.40	15274	10.58	0.27	0.64	0.44
Sweden	22976	5.35	15661	5.86	0.23	0.68	0.26
Denmark	25687	3.64	6481	9.38	0.14	0.25	0.37
Norway	26301	5.71	25187	7.48	0.22	0.96	0.28
CC-10 average	**10088**	**2.64**	**3725**	**7.47**	**0.26**	**0.37**	**0.74**
Estonia	***8745***	***3.30***	***4628***	***10.21***	***0.38***	***0.53***	***1.17***
Lithuania	6554	1.92	2381	3.03	0.29	0.32	0.46
Latvia	6608	1.54	2080	2.76	0.23	0.31	0.42
Poland	9013	2.33	3223	7.58	0.26	0.36	0.84
Czech Republic	13042	3.93	5695	11.57	0.30	0.44	0.89

[*] *From fuel combustion*

Source: http://www.iea.org/statist/keyworld2002/key2002/keystats.htm

The first discussed indicator, **GDP per capita**, is presented in 1995 US dollars (USD'95) considering the national purchasing power parities. Naturally, both the EU average GDP per capita and that of all EU member states are much higher than those of the candidate countries. Estonia's GDP per capita is 2.5 times smaller than the EU-15 average, 2.9 times smaller than in Denmark and 3 times smaller than in Norway. Estonia's GDP per capita is also 1.2 times smaller than the CC-10 average and 1.5 times smaller than the Czech Republic's GDP. CC-10 average GDP per capita is 2.2 times smaller than the EU-15 average.

Finland, of all the countries discussed, has the highest **total primary energy supply (TPES)** in tonnes of oil equivalent (oe) **per capita**, followed by Norway, Sweden, France and Germany. The Finnish level exceeds the Estonian level by nearly three times, and the CC-10 average even more. EU-15 average exceeds the CC-10 average by 1.5 times.

The situation is analogous in **electricity consumption per capita**. Electricity consumption is the highest in Norway (over 25 thousand kWh), exceeding even the other Nordic countries Sweden and Finland over 1.6 times, EU-15 average nearly 4 times. Electricity consumption in Estonia lags behind the Finnish level by 3.3 times and EU-15 average 1.4 times. Such big differences in electricity consumption per capita can be partly explained by the cold climate in the case of Nordic countries, but large electricity consumption is above all characterising better economic development and higher standard of living as well.

CO_2 emission from fuel combustion per capita (in tonnes) is the biggest in Czech Republic, followed by Finland, Estonia and Germany with almost equal amounts. EU-15 average is 20% smaller than in Estonia. CO_2 emission is, as you know, primarily connected with the combustion of fossil fuels. Particularly large CO_2 emissions result from the combustion of solid fuels – coal and oil shale. The small population of Estonia against the background of relatively large energy consumption causes the very high value of this indicator. The reduction of this value is possible only by diminishing the share of oil-shale in Estonian energy sector.

The ratio of **primary energy consumption intensity to GDP** is the highest just in Estonia (0.38 kg oe/USD'95). The Estonian indicator exceeds the respective indicators of both Nordic countries and other Baltic States. The closest to Estonia by this indicator is the Czech Republic (0.3 kg oe/USD'95), and Finland (0.27 kg oe/USD'95) from among EU members.

A high value of primary energy consumption intensity indicates low level of energy consumption efficiency. Of course, the great difference of this indicator across countries is largely due to the different energy needs between northern and southern countries. However, the difference between Estonia and Finland lies primarily in our small GDP, as energy consumption in Finland is nearly two times bigger than in Estonia, but GDP 2.7 times bigger (per capita).

High **electricity consumption intensity** cannot be evaluated simply as an indicator of low efficiency. Though higher intensity indicates here higher GDP electricity intensity, it should be considered that higher electricity consumption characterises, as mentioned above, also rise of income. Norway is the first by this indicator among the countries examined by us (0.96 kWh/USD'95), followed by Sweden and Finland. Estonia's indicator also is relatively high (0.53 kWh/USD'95). Unfortunately this is not due to high electricity consumption, but rather a low GDP level.

CO_2 emission intensity indicates negative impact of energy consumption on the environment. Estonia is firmly on the first place with this indicator among the countries studied by us. Estonia's indicator (1.17 kg/USD'95) exceeds the EU-15 average three times, other Baltic countries and Finland 2.5-2.8 times. The reasons are, of course, both the large CO_2 emission of oil-shale energy and the low GDP level in Estonia.

Our analysis indicates that in order to ensure the sustainable development of the Estonian energy sector, we need to raise the energy consumption efficiency and reduce pollution (especially CO_2 emissions). Both indicators are negatively influenced by oil shale utilisation that dominates electricity production in Estonia, which has low efficiency and high CO_2 emission. Thus, the key of sustainable development of the Estonian energy sector lies in the mitigation of the environmental impact by increasing efficiency of the oil shale-based electricity production and/or reducing the share of oil shale in the Estonian energy balance.

5. Concluding Remarks

The opening of electricity markets in Europe started in the late 1980s. This process has been very rapid in several countries of the European Union – Finland, Sweden, United Kingdom, Germany and Austria have opened their electricity market 100% by today. However, there are some factors limiting rapid opening of the markets and in some countries this process is proceeding slowly (France). Opposition to liberalisation is caused primarily by the high risks involved in investment in new capacities, especially in more expensive, environment saving technologies. This in turn may create a deficit in energy supply when there is an unexpected increase in consumption, for example. To lessen the risks and increase the security of supply concentration of electricity, enterprises have started to spread by way of mergers and buying of other enterprises, and this process may extend also across national borders. In the Nordic countries, the three largest firms (*Vattenfall* in Sweden, *Statkraft* in Norway and *Fortum* in Finland) contributed 40% of the total production of the Nordic countries as a result of concentration.

The Estonian electricity market has, on the one hand, features of a typical monopolistic market where one vertically integrated energy enterprise (*Eesti Energia AS*) dominates. Its prices are under state regulation, but it is dictating conditions and connection fees to small producers for access to its network. On the other hand, an original feature of Estonia is also a monopoly in the supply of energy resources, as 90% of electricity is produced from oil shale. The latter fact is also a reason for the low efficiency of Estonian energy system and the high pollution load on the environment.

Due to the dominating role of *Eesti Energia AS*, the value of the most common measure of market power – the Herfindahl-Hirschman index (HHI) for Estonia is remarkably high – approximately 9600 (on the basis of production). Traditionally, the markets in which the HHI is between 1000 and 1800 are considered to be moderately concentrated, and those in which the HHI is in excess of 1800 points are considered to be concentrated (in a pure monopoly where one firm has 100% share, the HHI is 10,000).

But, as oil shale-based energy complex has a specific significance in Estonian economy, Estonia was granted a transition period in the accession negotiations with the EU both for opening its electricity market and for reducing air pollution from oil shale-based energy enterprises.

Considering these factors and following the widely accepted principles of sustainable development, the main emphasis in planning further development of the Estonian energy sector is placed on mitigating the environmental impacts of electricity production. The possibilities of achieving this are envisaged to be both the implementation of new, less environment-damaging technologies (CFBC) in oil shale-based energy production and the reduction of the share of oil shale and the introduction of reasonable alternatives to oil shale in electricity production. However, oil shale has been economically competitive with other energy resources so far. Therefore, we have thoroughly analysed in this paper the growing role of environmental costs in oil shale-based electricity production and their impact on the oil shale-based electricity production cost under tightening environmental requirements in the short term (taking into account the Directive on the limitation of emissions of certain air pollutants from large combustion plants 2001/80/EC and the pollution charge and resource tax growth rates). This analysis indicates that while currently the environmental component accounts for nearly 16% of the oil shale-based electricity production cost, by 2010 the production cost may rise twofold and the contribution of the environmental component even to 36%. Consequently, it is likely that economic advantages of oil shale-based electricity production over other fuels will diminish.

Model calculations carried out both by other researchers and by the authors of this chapter have demonstrated that when oil shale-based electricity production diminishes, the first competitors will be natural gas-based combined electricity and heat production plants. However, in this case, the heat load of the region will set limits to electricity production. The next competitor is a gas-based condensation plant. Wind and other renewable energy capacities are used within the available resources, but their share in the electricity balance does not exceed 0.3% currently. It is not possible to make any ultimate long-term decisions about oil shale-based electricity production until the first stage results of the currently ongoing renovation of *Narva Elektrijaamad* are not clear. When the renovation results are positive and emission of pollutants will fall to the expected level, then oil shale-based electricity production may continue in the period 2005-2010 in the amount of 6.6 TWh/y, after 2010 in the amount of 5.3 TWh/y. As a result of growing demand for electricity, the unsatisfied demand for electricity may in that case amount to the maximum of 2.4 TWh in 2010 and 3.2 TWh in 2015. It is possible to use mainly imported energy resources (natural gas, coal, imported electricity) to cover this demand. If renovation results are worse than expected, the Estonian energy strategy needs to be fundamentally revalued and other alternatives must be found to oil shale-based energy production to ensure the sustainable development of the energy sector.

By examining more important development indicators of the Estonian energy sector so far and comparing them with respective indicators of EU member states and our neighbouring countries, we can detect quite positive tendencies. The positivity is expressed primarily in that the GDP energy intensity as the main indicator of the sustainability of the energy sector has been diminishing in Estonia throughout 1994-2000, while the energy consumption by households has increased at the same time. This indicates a rise primarily in energy use efficiency, but, in a way, also in personal income.

Although energy consumption per capita is lower in Estonia compared with the EU average and the Nordic countries, GDP energy intensity is much higher here. This is primarily due to the low GDP level in Estonia. The most negative indicator for Estonia is the high CO_2 emission both per capita and in ratio to GDP, notwithstanding the continuous reduction of the total amount of CO_2 in recent years.

In conclusion, we can state that in addition to restructuring the electricity sector and organising opening of the electricity market, Estonia needs to make investment decisions – whether to continue renovation of oil shale-based power plants or stake on imported energy resources. Participation in the renovation of *Ignalina* (Lithuania) nuclear power plant has also arisen to the agenda lately, where the so far working units should be closed in 2005-2009 according to plans. This would give Estonia an opportunity to participate as a partner also in the Baltic and Nordic electricity markets and to control (or influence) electricity prices in the market.

Notes

1. Estonian oil shale-based energy complex is mainly situated in Ida-Viru County.
2. For example deficit of electricity s ystems peak capacity in the Nordic countries in winter 2002, partly also the crisis in the Californian electricity sector, etc.
3. New tools have been developed to enable to deal with complication of these new markets by providing guidance on details of market design, as well as helping to predict how procedural aspects influence participants' strategies and affect overall performance (Staropoli and Jullien, 2002; Wilson, 1998). These tools have contributed to the emergence of a new discipline, the so-called "design economics" in which economists play a role similar to engineers or architects (Wilson, 2001).
4. Negotiations with the potential foreign investor NRGenerating International B. V. (NRGen) failed as the parties could not agree on mutual obligations.

5. Export (import) openness is calculated as the permissible export (import) capacity of electricity divided by the total generation capacity.
6. 1 EUR = 15.64664 EEK (exchange rate is fixed)
7. We mean here electricity net production or electricity sup plied to network.

References

Andersson, B. and Bergman, L. 1995. Market Structure and the Price of Electricity: An Ex Ante Analysis of the Deregulated Swedish Electricity Market. – *The Energy Journal*, 16, 2, 97-109.

Chapman, D., Vossler, C. A., Mount, T. D., Barboni, V., Thomas, R. J., and Zimmerman, R. D. 2002. *Market Efficiency, Competition, and Communication in Electric Power Markets: Experimental Results.* Department of Applied Economics and Management at Cornell University. Working Paper WP 2002-29, Ithaca, New York.

Commission of the European Communities. 2001. *First Report on the Implementation of the Internal Electricity and Gas Market. Commission Staff Working Paper SEC 1957.* Brussels, 03.12.2001.

Commission of the European Communities. 2002. *Second Benchmarking Report on the Implementation of the Internal Electricity and Gas Market. Commission Staff Working Paper SEC 1038.* Brussels, 01.10.2002.

Database on Environmental Taxes. 2001. <http://europa.eu.int/comm/environment/enveco/ >

Department of Electrical Power Engineering at TTU. 2002. *Development Plan of the Estonian Electricity Sector until 2030.* Research Report. Tallinn (in Estonian).

Directive of the European Parliament and of the Council on the Limitation of Emissions of Certain Pollutants into the Air from Large Combustion Plants. 23.10.2001. (2001/80/EC).

Eesti Energia AS. 2001. *Annual Report 2000/2001.* Tallinn.

Eesti Energia AS. 2002. *Annual Report 2001/2002.* Tallinn.

Eesti Energia AS. 2001. *Environmental Report 2000.* Tallinn.

Eesti Energia AS. 2002. *Environmental Report 2001*. Tallinn.

European Commission Directorate General XII. 1995. *ExternE, Externalities of Energy.* Vol. 1: Summary by ETSU, UK, EUR 16520 EN. Brussels-Luxembourg.

Eurostat. 2002. *Competition Indicators in the Electricity Market* News Release 115/2002.

Goldstein, G. A. 1994. *MARCAL-MACRO: An Advanced Policy Assessment Tool.* Informal Report. Brookhaven National Laboratory. Upton, New York.

Green, R. and Newbery, D. 1992. Competition in the British Electricity Spot Market. – *Journal of Political Economy,* 100, 5, 929-953.

International Federation of Industrial Energy Consumers – Europe. 2000. <http://www.ifiec-europe.be/Elec6.htm>

International Energy Agency. 2002. Key World Energy Statistics from the IEA. 2002 Edition. Paris. <http://www.iea.org/statist/keyworld2002/key2002/keystats.htm>

Kwoka, J. E. 2002. Vertical Economies in Electric Power: Evidence on Integration and Its Alternatives. – *International Journal of Industrial Organization*, 20, 653-671.

Laur, A. and Tenno, K. 1999. Sustainable Development of the Estonian Energy Sector: a Modelling Approach. In: Ülo Ennuste and Lisa Wilder (eds.). *Harmonisation with the Western Economics: Estonian Economic Developments and Related Conceptual and Methodological Frameworks*. Estonian Institute of Economics at TTU. Tallinn, 283-302.

Laur, A., Soosaar, S. and Tenno, K. 2001. Utilisation of Estonian Energy Resources: Towards Sustainability. In: Ülo Ennuste and Lisa Wilder (eds.). *Factors of Convergence: A Collection for the Analysis of Estonian Socio-Economic and Institutional Evolution.* Estonian Institute of Economics at TTU. Tallinn, 193–226.

Laur, A., Soosaar, S. and Tenno, K. 2002.Sustainable Development Out looks of the Estonian Energy Sector for Convergence with the European Union. In: Valdur Tiit (ed.). *Investigation and Usage of Renewable Energy Sources*. Third Conference Proceedings. Tartu.

Liik, O. and Esop, M.-R. 1999. Modelling of Estonian Energy Sector and Emissions. In: Tiit Kallaste, Olev Liik, Arvo Ots (eds.). *Possible Energy Sector Trends in Estonia. Context of Climate Change.* SEI-Tallinn Centre, TTU. Tallinn, 128-163.

Long-Term National Development Plan for the Fuel and Energy Sector. 1998. *Riigi Teataja* (State Gazette) I 1998, 19, 295.

Matthes, F. C. and Timpe, C. 2000. *Sustainability and the Future of European Electricity Policy.* Heinrich Boell Foundation, Berlin.

Ministry of Economic Affairs and Communication, Department of Electrical Power Engineering at TTU. 2002. *Long-Term National Development Plan for the Fuel and Energy Sector until 2015 (with Vision until 2030).* Tallinn (in Estonian). <http://www.mkm.ee-/index.html?id=952>

Newbery, D. M. 2001. Economic Reform in Europe: Integrating and Liberalizing the Market for Services. – *Utilities Policy,* 10, 85-97.

NORDEL, Cambridge Energy Research Associates Inc. 2002a. *Market Power in Power Markets: Restructuring in Nordic and Northern Europe and Use of Concentration Measures.*

NORDEL, Copenhagen Economics. 2002b. *Relevant Markets in the Nordic Area. Main Report - Market power on the Nordic power market – Subproject 1*, 21 October 2002

Ots, A. 1999. Oil Shale Combustion Technology and Carbon Dioxide Emission. In: Tiit Kallaste, Olev Liik, Arvo Ots (eds.). *Possible Energy Sector Trends in Estonia. Context of Climate Change.* SEI-Tallinn Centre, TTU. Tallinn, 61-86.

OXERA, Netherlands Energy Research Foundation, Energy System Analysis and Planning Centre ATOM, Université Panthéon-Sorbonne, European Commission, DG TREN. (October) 2001. *Electricity Liberalisation Indicators in Europe.*

Pollution Charge Act Amendment Act. 2001. *Riigi Teataja* (State Gazette) I 2001, 102, 667.

Roth, A. E. 2002. The Economist as Engineer: Game Theory, Experimentation and Computation as Tools for Design Economics. – *Econometrica*, 70, 4, 1341-1378.

Rudkevich, A., Duckworth, M. and Rosen, R. 1998. Modeling Electricity in a Deregulated Generation Industry: Potential for Oligopoly Pricing in a Poolco. – *The Energy Journal*, 19, 3, 19-48.

Staropoli, C. and Jullien, C. 2002. *Designing Efficient Market Institutions, What Can We Learn from Laboratory Experiments? The Case of Wholesale Markets.* International Society for New Institutional Economics, 6th Annual Meeting. September 27-29, 2002, Cambridge. <http://www.isnie.org/ISNIE02/Papers02/staropolijullien.pdf>

Statistical Office of Estonia. 1998…2002. *Energy Balance 1997…2001.* Tallinn.

Statistical Office of Estonia. 2002. *Indicators of Sustainable Development.* Tallinn.

Treaty of Accession. 2003. Negotiations on Accession by the Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia and Slovakia to the European Union. *Legislative Acts and Other Instruments.* AA 2003 Final. Brussels, 3 April 2003.

United Nations. 2001. Indicators of Sustainable Development. Guidelines and Methodologies. Economic and Social Affairs. Second edition. New York.

Vares, V. (ed.). 2001. *Development Scenarios of the Estonian Energy Sector*. Contract No. 44 Report. Estonian Energy Research Institute. Tallinn (in Estonian).

Wilson, R. B. 1998. Design Principles. In: Hung-Po Chao and Hillard G. Huntington (eds.). *Designing Competitive Electricity Markets,* Kluwer Academic Publisher, 159-184.

Wilson, R. B. 2001. *Architecture of Power Markets.* Graduate School of Business Stanford University. Research Paper No 1708.