

BELARUS: ADDRESSING CHALLENGES FACING THE ENERGY SECTOR

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**Infrastructure Department
Europe and Central Asia Region**

Acronyms and Abbreviations

AAU	Assigned Amount Unit
BCM	Billion Cubic Meters
BOO	Build-Operate-Own Contract
BOT	Build-Operate-Transfer Contract
CHP	Combined-Heat-and-Power
CIS	Commonwealth of Independent States
EBRD	European Bank for Reconstruction and Development
EE	Energy Efficiency
ESCO	Energy Service Company
EU	European Union
FSU	Former Soviet Union
GDP	Gross Domestic Product
HOB	Heat-Only Boiler
IET	International Emission Trading
IFI	International Financial Institution
JI	Joint Implementation
KP	Kyoto Protocol
RE	Renewable Energy
ROO	Rehabilitate-Operate-Own Contract
ROT	Rehabilitate-Operate-Transfer Contract
VAT	Value Added Tax
WART	Weighted Average Retail Tariff

Weights and Measures

bcm	Billion Cubic Meters
GW	Gigawatt (10^9 watts)
GWh	Gigawatt-hour (10^9 watt-hours)
kVA	Kilovolt ampere (10^3 volt amperes)
MCM	Million Cubic Meters
TWh	Terawatt-hour (10^{12} watt-hours)

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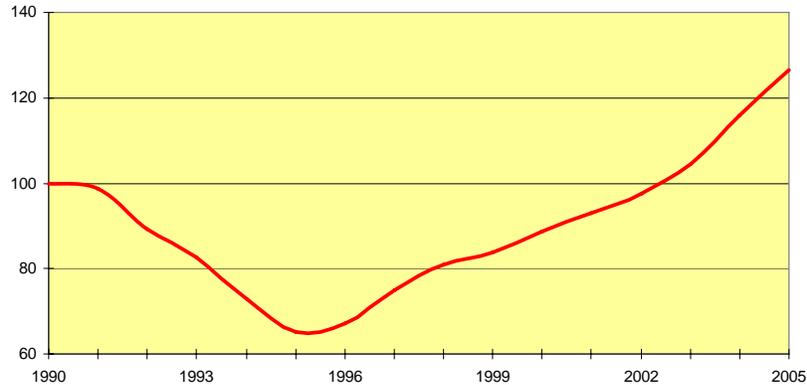
This report was prepared by Yuriy Myroshnychenko, Energy Operations Officer, Infrastructure Department, Europe and Central Asia Region, World Bank. The report is based on information from line ministries in Belarus and analytical papers prepared by a team of consultants and Bank staff including Ray Tomkins, Director, Economic Consulting Associates; Wolfgang Mostert, Renewable Energy Specialist/Consultant; Tuomo Utriainen, Fuel Wood Industry Specialist, Electrowatt-Ekono Oy; Elena Rakova, Macroeconomist/Consultant; Jane Ebinger, Energy Specialist, Infrastructure Department, Europe and Central Asia Region, World Bank; Elena Klochan, Operations Officer, Europe and Central Asia Region, World Bank.

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Preface

Belarus' economy has been growing consistently since 1996 by an average of 7 percent per year. Officially reported 2005 GDP was 126 percent of the 1990 level, as shown in figure I.1. While all the former Soviet Union (FSU) countries enjoyed an economic upturn in the second half of the 1990s, only a few of them surpassed their respective 1990 output levels by 2005.¹

Figure I.1. Belarus Index of Real GDP (1990=100)
2005 GDP US\$29,575 million
2005 GDP per Capita US\$3,025



Source: Ministry of Statistics and Analysis.

A combination of the following factors contributed to the economic growth in Belarus: (i) significantly improved external environment for Belarus exports both to Russia and the EU (especially since 2001) and strengthened domestic demand; (ii) improvements in labor productivity, energy efficiency, and capacity utilization; and (iii) government investments in housing construction and preferential financing of state-supported sectors and enterprises.² Moreover, Belarus' recovery was backed by Russian subsidies in form of (i) preferential energy prices charged to Belarus for gas, crude oil, and electricity imported from Russia; and (ii) barter exchange of overpriced Belarusian industrial products against underpriced Russian energy commodities in the second half of the 1990s.³

The energy sector has played a key role in supporting Belarus' recovery by providing affordable, reliable, and sufficient energy to the national economy over the past decade. However, Russia's recent actions to introduce market-based prices for its energy exports to the CIS countries are likely to result in phasing out Russian energy subsidies to Belarus⁴. This creates the risk of depriving the sector of hefty margins that allowed it to finance its investments directly from cash flows and compensate for weaknesses and limits associated with state ownership and the vertical monopoly structure of the energy companies. This situation underscores the need for reforms that would allow the sector to raise financing and improve efficiency. Furthermore, Belarus should

¹ For instance, Russian GDP reached 90.7 percent and Ukrainian GDP 62.6 percent of their respective GDPs in 1990.

² For further details on the drivers of the Belarus economic recovery see World Bank, 2005, "Belarus Country Economic Memorandum," Washington, DC.

³ According to expert estimates, the Russian annual subsidies to Belarus stemming from barter arrangements and underpriced energy exports may have reached 11–14 percent of Belarusian GDP in the second half of the 1990s.

⁴ Gazprom officials have made a number of public statements in the past months about the increase in gas price for Belarus from the current level of US\$ 46.68/mcm to US\$ 200. The increase is set to begin on January 1, 2007.

carry out measures to reduce its historically excessive dependence on energy imports from Russia and thus strengthen energy security.

The need for action in these areas has been recognized by the government and has been reflected in a number of strategic programs that outline the government strategy and develop concrete action plans to modernize the energy sector, improve energy efficiency, and increase the use of domestic energy resources.⁵

This report contributes to government efforts by reviewing current standings of the electricity and gas sectors and developing policy recommendations in order to mitigate the impact of gas price increases on the energy sector. Furthermore, the report discusses options for Belarus to strengthen its energy security and maximize benefits from its strategic energy transit location. The report is organized into four sections:

- assuring sustainable functioning of the electricity and gas sectors
- achieving further progress in energy efficiency
- diversifying energy supply
- maximizing gas transit benefits

In addition, three appendixes are included. The first appendix describes the Belarus' status under the Kyoto Protocol and lists the actions to be completed by the end of 2006. The second appendix provides an indicative list of secondary legislation to complement the legal framework to be established by the Law of the Republic of Belarus on Non-Traditional and Renewable Energy Resources; the appendix also reviews various types of renewable energy subsidies. The third appendix develops recommendations on how to increase the production of fuel wood in a sustainable and rational manner.

⁵ The main energy sector strategic documents developed by the government in the past years are as follows:

- State Integrated Program for Modernization of Basic Production Assets of Belarus Energy System, Energy Saving and Enhanced Use of Local Fuel and Energy Resources for 2006–2010.
- National Energy Saving Program for 2006–2010.
- Main Areas of Belarus Energy Policy for the Period up to 2020.
- Target Program of Ensuring Generation of at least 25 percent of Electricity and Heat from Local Fuels and Alternative Energy Sources in Belarus for the Period up to 2012.

Executive Summary

1. At the time of independence in 1991, Belarus inherited extensively developed electricity, gas, and district heating sectors, and significant oil transit and refining capacity. The country, however, is endowed with only limited indigenous energy resources and is, therefore, heavily dependent on imports of primary energy fuels, essentially all from Russia. In 2005, net imports accounted for 86 percent of Belarus' total primary energy consumption.

2. The country, however, also enjoys a strategic location between Russia and the European Union. This allows Belarus to play a key role as a transit route for energy exports from Russia to European markets. This role takes the form of both the outright transit of oil and gas and that of converting crude oil supplied from Russia into refined product exports.

3. To obtain an understanding of the key issues that Belarus faces with regard to its energy sector, it is instructive to look at an analysis of the sector's strengths, weaknesses, opportunities, and threats (SWOT) (Table ES1).

Table ES1. Belarus Energy Sector SWOT Analysis

Strengths	Weaknesses
<ul style="list-style-type: none"> • Location as a transit country • Geographical proximity to its primary energy supplier • Extensive wood resources • Established electricity network • Established gas transmission network • Export refining capacity 	<ul style="list-style-type: none"> • Limited indigenous energy resources • High dependence on imported energy • Very heavy dependence on Russia as a supplier of primary energy • Aging physical infrastructure • Limited oil and gas storage • A weak legislative and regulatory framework • Limited commercial focus
Opportunities	Threats
<ul style="list-style-type: none"> • Increased production of domestic resources (primarily wood) • Diversification of energy supply sources • Expanded transit activities and increased transit revenues • Increased security of domestic supply as a result of expanded storage facilities • Private sector participation 	<ul style="list-style-type: none"> • Disruption in energy supplies from Russia (particularly gas) • Higher energy import costs • Deterioration in service quality • Further deterioration of the domestic infrastructure • Pressures on fiscal revenue streams as a result of explicit and implicit subsidies

4. To date, the sector has successfully built on its strengths and somewhat minimized its weaknesses and threats, and as a result has been able to provide reliable and affordable energy to the economy. The transit of crude oil and natural gas and export of petroleum products grew consistently in the past years and contributed to the economic growth of Belarus. A preferential tax regime between Russia and Belarus helped Belarusian oil refineries compete with other refineries in the region (for example, in Ukraine). This tax regime, together with depressed prices

for imported crude oil,⁶ allowed Belarus to boost petroleum product exports, which has generated exceptional revenues in the past few years.

5. Furthermore, discounted energy import prices together with relatively high retail tariffs and good collections allowed the sector to meet to some extent its rehabilitation needs and also support other government priorities such as the expansion of the gas distribution network and energy efficiency investments. However, Russia's recent actions to introduce market-based prices for its energy exports to the CIS countries are likely to result in phasing out Russian energy subsidies to Belarus. This in turn will deprive the sector of significant margins that have allowed it to finance its investments from cash flows and compensate for limits and weaknesses associated with state ownership and the vertical monopoly structure of the energy companies.

6. The risk of energy import price shocks underscores the vulnerability of the Belarus energy sector and the need for policy measures to improve the sector's ability to attract finance, improve efficiency, and strengthen overall energy security. The following four challenges need to be addressed by the government:

- assuring sustainable functioning of the electricity and gas sectors
- achieving further progress in energy efficiency
- diversifying energy supply
- maximizing gas transit benefits

Assuring Sustainable Functioning of the Electricity and Gas Sectors

7. The current structural and institutional arrangements for the energy sector⁷ provided stability during the period of economic change following Belarusian independence in 1991. Recent performance in the sector has generally been satisfactory; the sector's short-term financial viability has improved in recent years through maintaining tariff levels at cost recovery and improving cash collections. However, the present arrangements in the energy sector are not well suited for withstanding a significant shock to the sector through a gas price adjustment toward market-based levels.

8. The energy sector structure and institutional arrangements show a number of limits and weaknesses that affect its ability to raise commercial financing and improve efficiency. In particular, there is incomplete separation between the Ministry of Energy and the management of the energy companies, weak commercial focus in the companies, and lack of transparency and accountability. Furthermore, the regulatory role is vested with the Ministry of Economy, which lacks the skills and autonomy to properly perform the regulatory functions. As a consequence, there is limited access by the energy companies to external finance and lack of economic incentives to improve efficiency.

9. Preserving the status quo in the energy sector in the face of the transition to market-based energy import prices would undermine its performance and competitiveness. Therefore, the World Bank recommends the gradual introduction of structural and institutional reforms in the sector in order to address these above mentioned challenges. Three scenarios for the institutional and structural reforms are outlined below.

Scenario 1: Vertically integrated/state-owned utilities

⁶ Average crude oil import prices were about US\$30 per barrel in 2005.

⁷ The Belorussian electricity and gas sectors are dominated by three vertically integrated monopoly companies managed by the Ministry of Energy and overseen by the Ministry of Economy.

10. Under Scenario 1, ownership in the sector would remain with the government but the utilities would be operated as commercial businesses. The main thrust would be to improve governance in state-owned utilities by (i) establishing independent supervisory boards, (ii) introducing performance contracting with the management, and (iii) adopting best practices of international accounting. There would be a clear separation of policy making (the Ministry of Energy) from the business of energy supply; it is proposed that the Ministry of Finance should represent government as the owner of the utilities and should help promote policies and governance arrangements that assure the financial viability of the companies and minimal use of state resources. The capacity and autonomy of the Ministry of Economy to regulate tariffs and quality of supply should be substantially strengthened, or an independent energy regulator should be introduced.

11. The regulatory and institutional changes would raise confidence among lenders and may allow some investments to be financed from external sources. The shift to a more commercialized focus would allow the introduction of management efficiency incentives, possibly including performance-based salaries for senior management. Simple forms of private sector participation would be introduced, including the outsourcing of some functions to the private sector, while noncore activities would be divested.

Scenario 2: Unbundling/continued state ownership

12. Scenario 2 includes all of the reforms identified in scenario 1 but additionally there would be some unbundling of the utilities. Initially, unbundling would separate accounting and management, with ownership retained by the government through a holding company/subsidiary company structure.

13. Unbundling allows management to focus on their core activities and, combined with appropriate incentives, encourages them to introduce operating efficiencies in their businesses. Unbundling would also allow financial transparency in the subsidiary businesses and build capacity within the companies in preparation for further liberalization and the introduction of competition, should that option be elected.

14. The trade functions, including the rights to energy imports and exports, should be left within the holding company, which will include production and distribution/supply subsidiaries. The transmission company will need to be fully unbundled and will provide only transmission services. A degree of competition could be introduced through build-own-operate (BOO) arrangements, particularly in distributed power generation (for example, small hydropower generation plants or cogeneration units at heat-only boilers [HOBs]).

Scenario 3: Ownership change, liberalization

15. Scenario 3 includes a degree of wholesale competition and third-party access. Large “eligible” consumers would contract for gas or electricity supply from suppliers (gas importers or electricity generators). Complex balancing markets would need to be established to match demand and supply for electricity (perhaps at half-hourly intervals) and gas (perhaps at daily intervals). Eventually, retail competition might be introduced to allow all users, whatever their size, their choice of supplier. This type of market is being introduced in many countries in the region.

16. A number of reforms should be implemented in Belarus, particularly those outlined in Scenarios 1 and 2, before a Scenario 3 framework is introduced. Therefore, it would be prudent to focus the mid-term reform agenda on the measures recommended under the first two scenarios.

These reform measures will be very valuable in themselves in improving operating efficiency and in attracting financing to the sector, but they are also preconditions for an energy market model outlined by Scenario 3. While this may appear to be an unambitious target when countries such as Ukraine and Kazakhstan have moved rapidly to a Scenario 3 framework, it is important to initiate reforms by creating a viable framework and avoiding the disorder that could arise if an advanced market model is introduced too quickly.

Achieving Further Progress in Energy Efficiency

17. Improving energy efficiency is a win-win option for addressing concerns about energy security. Belarus nearly halved its energy intensity⁸ in the past decade by applying a combination of administrative and market measures. However, to secure US\$3.81 billion in order reduce energy intensity by 30 percent through 2010, as stipulated in the National Energy Saving Program for 2006–10, Belarus will need to develop a sustainable lending market for energy efficiency investments. The options are as follows:

- *Promote the energy service company (ESCO) concept and private sector participation in energy efficiency investments.* The following measures would support this option: (i) an effective legal framework for third-party financing, (ii) incentive regulation such as a price cap or an energy conservation surcharge in tariffs, (iii) an escrow account for monetized energy savings, and (iv) energy efficiency funds.
- *Develop energy efficiency lending through local financial institutions.* Several countries in the region have supported such lending through (i) partial risk and partial credit guaranty instruments and (ii) capacity building at financial institutions.
- *Scale up the energy efficiency revolving fund established by the Committee of Energy Efficiency.* Success factors for transforming the fund into a sustainable, wide-scale revolving lending instrument include the following: (i) strong business practices, (ii) simple and transparent procedures, (iii) risk mitigation through many small projects, and (iv) prioritization of low-risk and simple investments.

18. Furthermore, investments in energy efficiency could be supported by exploiting carbon trading opportunities under the Kyoto Protocol. In order to take advantage of this exceptional opportunity, Belarus should undertake the following actions: (i) continue with current programs to meet eligibility criteria for Joint Implementation (JI) and International Emission Trading (IET) by January 1, 2007, (ii) establish a pipeline of projects under the JI track 2 mechanism to demonstrate that the appropriate regulatory frameworks are in place and conditions in Belarus are conducive to investment in JI projects, and (iii) review and examine conditions for trading in Assigned Amount Units and develop a proposal for engaging with potential buyers (for example, through a green investment study).

19. Besides the above measures aimed at securing financing for energy efficiency investments, wide-scale reforms in the demand and supply sides of the heating market are warranted since they will yield substantial energy, and in particular gas, saving benefits.

⁸ Energy intensity is measured as the total energy consumption divided by GDP.

Diversifying Energy Supply

20. Existing infrastructure and Belarus' geographical proximity to Russia ensure that Russia will be Belarus' primary source of energy supply for the foreseeable future. However, Belarus should seek to mitigate the overall risk associated with this excessive dependence by sustaining its oil production, expanding its oil and gas storage capacities, and increasing energy trade and related investments with neighboring countries. Furthermore, Belarus should exploit available energy diversification options, including the following:

- Enlarge the use of domestic energy resources.
- Develop alternative electricity supply options.

Enlarge the use of domestic energy resources

21. Belarus is poorly endowed with hydrocarbon resources, which met only about 7 percent of the country's primary energy consumption in the past years. The production of these resources can hardly be increased because of geological conditions. However, Belarus enjoys significant wood stock and peat deposits and has a hydropower potential suitable for small hydropower generation plants and should better exploit these resources. Furthermore, efforts need to be undertaken for sustaining the domestic oil production.

22. In order to increase the production of wood and peat in an environmentally sustainable and rational manner, there is a need to embrace best international practices, for instance those of Finland.⁹ Furthermore, in order to meet investment challenges, the government should focus on policy, oversight, and research and development, while transferring production activities to the private sector. The expansion of small-scale biomass and hydropower distributed generation calls for enacting policies that facilitate investments in these types of renewable energy (RE). The policies would comprise (i) RE subsidies, (ii) quantity forcing policies, (iii) a legal and regulatory framework for independent power producers, and (iv) RE legislation.

Develop alternative electricity supply options

23. The electricity needs of Belarus are satisfied by domestic generation that is essentially run on gas imported from Russia, electricity imported from Russia.¹⁰ Belarus has the following options to diversify away from Russia for electricity supply:

- *Expand electricity import from Ukraine.* The sensitivity of Belarusian electricity system to gas prices, together with an excess of base load nuclear generation capacity in Ukraine, suggests that opportunities to import electricity from Ukraine should be developed further. One option would be to build a high-voltage line from the Rivne nuclear station in Ukraine to Belarus, which could allow for a tripling in the present level of trade.¹¹
- *Build coal-fired generation plants.* Another diversification option is to build coal-fired plants while retiring depreciated and obsolete gas fired plants. The liquid international market and multiple suppliers of coal, including neighboring countries such as Poland, Ukraine, and Russia, would give increased security of supply.

⁹ Wood and peat account for about 20 percent in the total energy consumption of Finland.

¹⁰ Net electricity import accounted for 10 percent to 22 percent of gross consumption in the past three years.

¹¹ Belarus started to import electricity from Ukraine in 2006. It is expected that 2.5 TWh of electricity will be imported in 2006 at the price of US\$0.02.1 per kilowatt-hour.

- *Produce electricity at heat-only boilers (HOBs).* Extensive district heating systems including thousands of HOBs provide the opportunity to increase fuel efficiency by installing electricity cogeneration units at HOBs.

Maximizing Gas Transit Benefits

24. Belarus' oil and gas transit network is one of the most important strategic assets in the country. The network generates a steady revenue stream from the transit of Russian crude oil and natural gas to Europe and strengthens Belarus' bargaining position with Russia on prices of imported fuels, in particular natural gas. In developing its gas transit strategy toward Russia, the challenge for Belarus is to maximize the economic rent from transit, meet its investment needs, and retain the control over transit. It must do this within the confines of the competitive threat from alternative transit routes.

25. Belarus' strategy for capturing the benefits of its transit position should include the following steps:

- *Position itself as the transit route of choice.* Belarus' reputation as a reliable and dependable supplier of transit services should be viewed as one of its key international trade assets. It should develop and strengthen its reputation with Russia and also work to enhance confidence and build partnerships in receiving countries. One of the key focuses for reforms should be to raise Beltransgas' standards of operation by applying best international practices of corporate governance.
- *Capitalize on its competitive advantages as a transit country.* Given a relatively low long-run cost of gas transit through Belarus, it is in Gazprom's interests to transit gas through Belarus up to the maximum capacity in preference to using alternative transit routes. However, if Belarus is to maintain its competitive advantage, the level of transit fees should remain attractive for Russia. This limits the leverage of transit fee in offsetting increases in the price of gas purchases.
- *Maintain control of transit, but invite partnerships with foreign investment and expertise.* Belarus would benefit from establishing a joint venture with or granting concession to Russia or receiving countries for developing and operating Beltransgas' transit pipelines. This will bring expertise and foreign capital and overall strengthen Belarus' position against competing transit routes.

1. Assuring Sustainable Functioning of the Electricity and Gas Sectors

1.1. The Belarusian energy sector has made good progress in the recent years in improving cash collections while keeping tariffs at cost recovery levels. These two factors have improved the gas and electricity sector's short-term financial viability and reduced the incidence and scope of quasi-fiscal activities¹². However, there remain energy debts accumulated at the time of nonpayment, and economic inefficiencies in the pricing structure due to misbalanced tariffs between customer groups. Furthermore, commercial losses in the electricity sector need to be recognized and eliminated, while technical losses should be further reduced, though the losses are among the lowest among the Commonwealth of Independent States (CIS) countries.

1.2. While the above mentioned financial and operational improvements are necessary, they will not be sufficient for addressing the challenges associated with an increase in energy import prices. Because this increase is likely to significantly reduce the sector's ability to keep financing its investments from cash flows, there would be a need to improve efficiency of sector operations and enable the sector to borrow from commercial financial institutions. A gradual introduction of structural and institutional changes would help the sector achieve these objectives.

1.3. The following two sections review the recent performance of the energy sector and discuss issues and options associated with structural and institutional reforms.

Recent Performance of the Energy Sector

Collections

1.4. The collection of electricity and gas bills, especially in cash, has significantly improved since 2001. These improvements were largely driven by the need to pay cash for the energy imports. The remaining problems with cash collections are concentrated in the agricultural sector and among financially weak industrial enterprises. The energy companies should make efforts to sustain and further improve the collections.

Figure 1.1. Belenergo's Collections (Electricity and Heat)

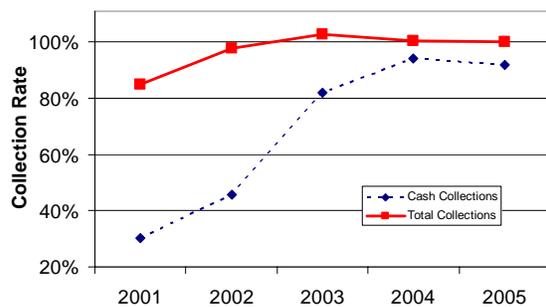
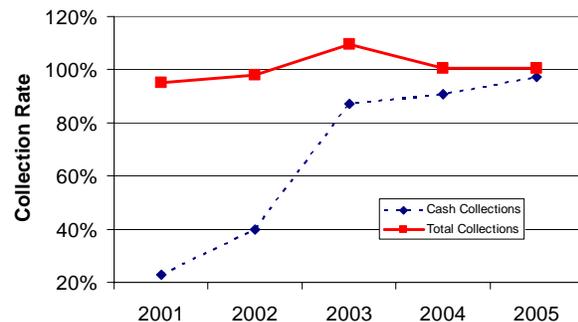


Figure 1.2. Beltopgas' Collections (Gas)



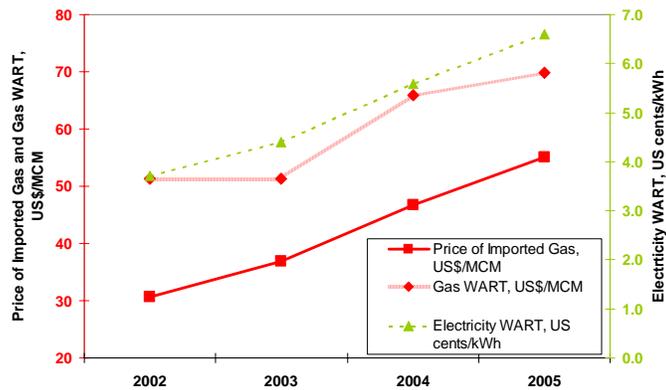
Source: Ministry of Energy.

¹² Electricity and gas sector implicit subsidies in Belarus were collectively below 0.5% of GDP in the past years.

Tariffs

1.5. The electricity and gas weighted average retail tariffs (WARTs) have been sufficient to recover recurrent costs and some investment costs in the past years. The retail tariffs followed increases in the price of imported gas, as indicated in figure 1.3, and provided for hefty margins. This allowed the electricity and gas companies to operate profitably and finance their investments nearly exclusively from cash flows. Profits together with depreciation charges and an innovation fund (investment surcharges to tariffs) were sufficient to meet rehabilitation and modernization needs, as well as to support some other priorities of the government such as expansion of the gas distribution network and energy efficiency investments in other sectors.

Figure 1.3. Comparison of Electricity and Gas WART Dynamics against Changes in Price of Imported Gas (with VAT)



Source: Ministry of Energy, World Bank analysis.

Note: The price of imported gas in 2005 remained at the 2004 level, that is, US\$46.68/MCM. However, there was an internal gas price increase of 18 percent in 2005 due to the change in the VAT regime between Belarus and Russia.

1.6. Although average tariffs for electricity and gas have been at cost recovery levels in the past years, tariffs between customer categories remain misbalanced. Particularly, the ratio of household to industrial tariffs for both electricity and gas remains below 1.0 despite the higher cost of serving households. There has been improvement in tariff rebalancing in the early 2000s, as indicated in the table below, but there has been more misbalance since 2004 because of the rising cost of gas imports.

Table 1.1. Ratio of Household Tariff to Industrial Tariff for Electricity and Gas

Sector	2002	2003	2004	2005
Gas	0.51	1.03	0.79	0.80
Electricity	0.34	0.76	0.61	0.58

Source: Ministry of Energy, World Bank analysis.

1.7. While the need for further tariff reform is acknowledged in energy sector strategic documents that were prepared by the government in the past years, the documents do not indicate the timeframe for conducting reform. This report recommends that the government begin tariff rebalancing soon. However, rebalancing should be done gradually and preceded by improvements in the social safety net (such as better targeting, eventually elimination of some nonpoverty related privileges) in order to mitigate the impact of higher tariffs on the poor.

1.8. Moreover, there are tariff imbalances between industrial customers. Several industrial consumers benefit from preferential electricity and gas tariffs granted by Ministry of Economy resolutions on an ad hoc basis. The cost of these subsidies is largely offset by a tariff increase for other industrial customers.¹³ International experience shows that consumption subsidies do not create incentives for recipients to improve their efficiency unless the subsidies are provided for a well-defined, limited period. Implicit subsidies for electricity and gas for industrial enterprises in Belarus should be phased out by establishing deadlines and restructuring the recipient enterprises.

Sector indebtedness

1.9. The improvements in cash collections within the Belarusian electricity and gas sectors allowed the country to make the full payment to its energy suppliers in 2004 and 2005. Belarus has also made good progress in reducing the debt owed to Russia due to previous internal undercollection. At the end of 2005, the arrears for electricity purchases from Russia had been reduced to US\$2.7 million and the arrears for gas had been reduced to US\$88.3 million.¹⁴ Strong cash flows also allowed the energy companies to largely honor other payment obligations such as taxes, salaries, and credit repayments.

1.10. The accumulated domestic energy debts are the most pressing issue affecting financial viability of the energy companies. While tariffs have been raised to cost recovery and collections have been brought to nearly 100 percent, the accounts receivable still hamper financial viability of the energy companies (the scope of the sector debts is shown in figure 1.4). The companies, supported by the government as necessary, should carry out debt restructuring including the following steps:

- Make an inventory of the receivables and payables.
- Determine a portion of payables and receivables that could be mutually offset.
- Determine the portion of payables and receivables that needs to be written off.
- Restructure the remaining debts along the debt chains (end consumers Belenergo-Beltopgas, end consumers Beltopgas-Beltransgas).
- Estimate the debt overhang¹⁵ and determine sources of its repayment.

Losses

1.11. Belarus has historically had relatively low losses in its electricity networks compared with neighbors. The total level of losses continues to be better than in the other CIS countries, though there is still room for further improvement.¹⁶ Moreover, officially stated losses, which are reflected in retail tariffs, seem to include just technical losses and ignore commercial losses—hence the need to strengthen commercial focus of Belenergo.

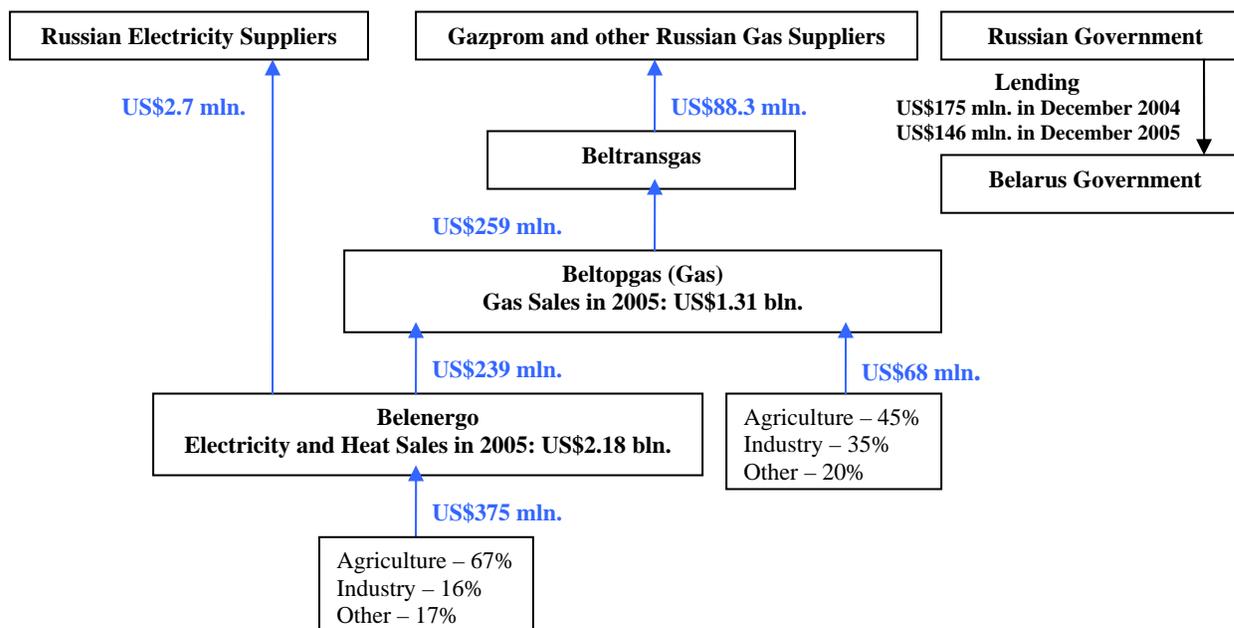
¹³ The electricity tariff for protected industrial enterprises ranged between US\$0.02.62 per kilowatt-hour and US\$0.05.68 per kilowatt-hour, while the tariff for the nonsubsidized industrial customers was US\$0.06.42 per kilowatt-hour in 2004. The cost of the subsidies amounted to US\$54 million in 2004.

¹⁴ Belarus electricity and gas debts to Russia were US\$31 million and US\$170 million, respectively, as of January 1, 2004.

¹⁵ While Belenergo's and Beltopgas' receivables exceed their respective payables, the bulk of the former is bad debts (particularly the agriculture debts) that are unlikely to be collected. Therefore, in fact the companies have debt overhang, that is, their receivables are not sufficient to pay for their payables.

¹⁶ The electricity transmission and distribution losses totalled about 11.1 percent in the past years. The commercial losses are not officially reported, but based on electricity balance figures, they are estimated at about 1.6 percent.

Figure 1.4. Belarus Domestic and Foreign Energy Debts as of January 1, 2006



Source: Ministry of Energy.

Note: Figure does not include oil and petroleum debts.

Investments

1.12. Improved cash collections and cost recovery tariffs generated cash flows sufficient to meet in part rehabilitation, modernization, and expansion needs of the sectors in the past years. Cumulative investments in Belenergo, Beltopgas, and Beltransgas' assets attained 1.8–1.9 percent of GDP in the past two years as indicated in the table below. Belenergo's investments in 2005 reached a record level of about 16 percent of the company's revenues. The investments were mainly financed from cash flows, whereas borrowing was barely utilized.¹⁷

Table 1.3. Actual Energy Sector Investments in 2004 and 2005

	2004	2005
Beltransgas, US\$ mln.	64	83
Beltopgas, US\$ mln.	94	93
Belenergo, US\$ mln.	272	346
Total, US\$ mln.	431	522
Total energy investments/GDP, %	1.9	1.8

Source: Ministry of Energy.

Issues and Options Associated with Structural and Institutional Reforms

1.13. The current structural and institutional arrangements for the energy sector provided stability during the period of economic change following Belarusian independence in 1991. Recent performance in the sector has generally been satisfactory; the sector's short-term financial viability has improved in recent years through maintaining tariff levels at cost recovery and

¹⁷ Belenergo's investments in the past three years were financed from the following sources: depreciation and profit—58 percent; innovation fund (investment surcharge to tariff)—35 percent; and other, including credits—7 percent.

improving cash collections. However, the prospect of market-based pricing for gas imports from Russia jeopardizes the sustainability of the energy sector and therefore stresses the need for reform measures.

1.14. Belarus has been enjoying energy import prices from Russia below those charged to other CIS countries and significantly below prices charged to Europe. Russia significantly increased the price of gas for several CIS countries in early 2006, while the gas price for Belarus remained at US\$46.68/mcm.¹⁸ A similar increase in the price to Belarus would have significant impacts throughout the economy and in particular on the energy sector.

1.15. The immediate impacts on the energy sector would include the following: (i) retail gas and electricity tariffs would likely become loss-making; (ii) increased retail tariffs would likely cause nonpayments; (iii) the sector's energy debts to Russia suppliers would significantly increase; (iv) the margin on retail tariffs would be eroded, removing a source of investments; and (v) energy sector implicit subsidies to favored noncompetitive industries would be difficult to sustain, threatening the viability of these enterprises.

1.16. Restructuring of several segments of the economy, including the energy sector, would be required in order to mitigate the impact of rises in energy prices. In the energy sector, priority reforms should be aimed at enabling the energy companies to raise commercial financing and improve operational, managerial, and financial efficiency. The following section outlines three scenarios for institutional and structural transformations of the electricity and gas sectors. The scenario discussion includes review of relevant international cases and specific recommendations for Belarus. It is preceded by a review of key issues that are common to each scenario.

Common Issues

Unbundling

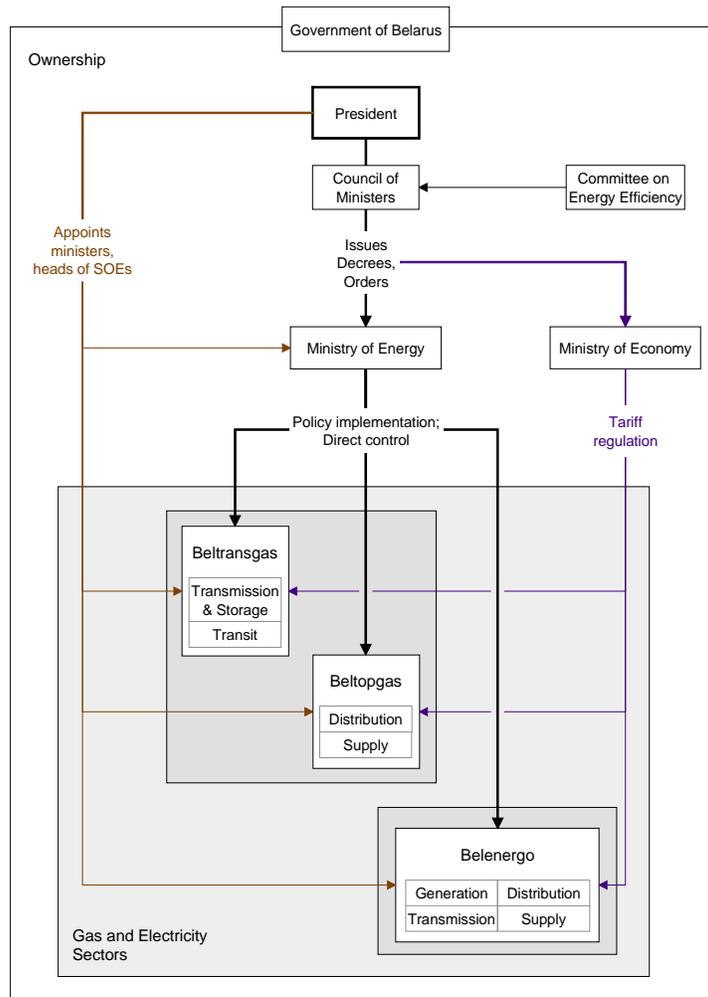
1.17. Each of the three energy companies in Belarus is currently a large conglomeration of integrated activities that span the energy supply chain, as demonstrated in figure 1.5. Most countries that have sought to benefit from reform of their energy sectors have unbundled these activities into more closely related and focused business units. The government has indicated in energy sector strategic documents an intention to "demonopolize" the sector but has also expressed its intention to retain natural monopolies in state ownership.

1.18. Unbundling can be generalized into accounting and managerial, subsidiary companies, and ownership separation:

- *Accounting and managerial unbundling.* This model involves separate accounting and managerial systems for each business but the business units are not created as legal entities/companies. With accounting unbundling, the business units would generally be operated as profit centers with internal transfer pricing between the business units.
- *Legally established subsidiaries.* In this model, the business units are established as legal entities but are 100 percent owned by the parent. Such arrangements typically require formal contracts between the subsidiary companies but the parent, often a holding company, can intervene to settle disputes.
- *Ownership unbundling.* This involves complete separation of the business units including ownership separation.

¹⁸ For instance, the price of Russian gas nearly doubled for Ukraine (from US\$50/mcm to US\$95/mcm) and Armenia (from US\$56/mcm to US\$110/mcm) in early 2006.

Figure 1.5. Structure of the Belarus Energy Sector



Corporate governance

1.19. *Separating commercial operation from government policy.* An important step in building private sector confidence in the Belarusian energy sector will be to separate commercial operation of the energy enterprises from the government’s conflicting position as owner, policy setter, and regulator. This separation will likely improve commercial operation, efficiency, and attracting finance.

1.20. *Reporting standards and transparency.* Reporting standards serve two related functions: to improve financial management of the firm, and to reassure and attract financiers. Investors or financiers will require assurances of the financial health of any enterprise to which they provide finance. Reassurance is best provided by financial reporting that follows internationally accepted high standards, such as International Financial Reporting Standards (IFRS) adopted by the European Union.

1.21. The *Guidelines on Corporate Governance of State-Owned Enterprises*, which were approved by OECD in 2005, give concrete advice to countries on how to manage their companies

more effectively.¹⁹ A number of the Guidelines' recommendations may not be immediately relevant for the Belarus energy sector, which is still dominated by noncorporatized entities (such as Belenergo and Beltopgas). However, the application of general principles developed in the *Guidelines*, namely in the chapters "Disclosure and Transparency" and "State Acting as an Owner," would help the government manage the energy companies more professionally and effectively.

Financial control

1.22. Currently, Belarus has tariffs set to recover costs, healthy bill collections, and a systematic plan to repay external debt in place. However, continued financial strength will depend on good financial discipline and cost control and the ability to raise finance for investment purposes. The financial management of the energy sector utilities should meet international standards. This requires diligent budgetary and financial planning processes and transparent financial auditing. The establishment of transparent financial processes to international standards is an important step in attracting borrowing from commercial financing institutions.

Regulation

1.23. Government programs for the energy sector recognize the need to reform the regulatory framework and indicate an intention to establish a regulatory agency to oversee tariff setting and licensing. Although the programs discuss broad plans for regulatory and market reform and privatization, they neither provide a timeframe nor details of what these changes would actually be.

1.24. International practice typically requires that:

- Ministries should develop policy and laws.
- The ownership function should generally be exercised by the Ministry of Finance or state property agency.
- Regulation should be undertaken by a regulatory agency that is independent of the policy makers and owners.

This separation:

- allows transparency—policy must be introduced in writing through laws or decrees
- allows greater regulatory certainty
- avoids conflicts of interest between short-term policies and long-term sector viability
- encourages private investors

1.25. The regulator should be independent of policy makers but "independence" is hard to define. It requires legal separation of policy-making functions from regulation but also requires a number of other practices to remove political influence from the regulators. Most countries provide regulators with a distinct legal mandate separated from ministerial control. The majority prescribe professional criteria for appointment of the chairman and chief officers, fixed terms, and protection from arbitrary dismissal. These are perhaps the most important safeguards.

¹⁹ The *Guidelines* can be found on the OECD website:
http://www.oecd.org/document/33/0,2340,en_2649_37439_34046561_1_1_1_37439,00.html

Institutional and Structural Reform Options

Scenario 1: Vertically-integrated/state-owned

1.26. Scenario 1 is the framework in countries where the gas and electricity utilities are vertically integrated and state owned but they operate as commercial businesses. The companies are distanced from the state and there is a clear separation of the policy-making role (which is the responsibility of the appropriate ministry) and energy supply (by the company). The tariffs continue to be regulated by the state and large investments need to be approved by the state, but management is given the independence to run the business from month-to-month and is responsible for successful commercial operation.

International examples

1.27. International examples of Scenario 1 include France and Ireland before the recent reforms, Vietnam, and Japan. Even after the reforms in Europe the structure of Electricité de France (EdF), Gas de France (GdF), Electricity Supply Board (ESB) and Bord Gáis in Ireland continue to conform to Scenario 1. Following the reforms these companies have unbundled in accounting terms but not in legal or ownership terms.

1.28. Electricity Vietnam (EVN) is a good example of a Scenario 1 structure that has introduced a range of reforms. The structure of the Japanese utilities, though privately owned, is very similar in all respects to the French, Irish, and Vietnamese utilities.

1.29. Scenario 1 covers a range of suboptions. All of the international examples mentioned above have introduced some reforms including some degree of accounting unbundling and internal trading systems, but these reforms are recent. Even before the reforms, the companies were fully commercialized. They may have had public service obligations such as obligations to supply rural communities at prices no higher than urban consumers (France, Ireland, Japan, and Vietnam all have such obligations). Vertical integration allows such obligations to be maintained without the need for explicit transfer mechanisms between companies.

1.30. In Scenario 1 the production/import, transmission, and distribution divisions are generally run as cost centers rather than as profit centers; but in some instances they may be run as profit centers. Vietnam, for example, created its distribution businesses as profit centers in the 1990s and in 2001 it went further and introduced an internal transfer pricing arrangement between the generation businesses and the transmission business (though, unusually, the generation businesses remained as cost centers). In France and Ireland, the companies are now required by EU legislation to have accounting separation and transfer pricing between the unbundled businesses.

Scenario 1 in Belarus

1.31. Within the constraints of Scenario 1, a number of improvements could be made to commercialize the energy sector, create incentives for efficiency improvement, and enable external financing to help meet investment requirements.

1.32. *Clear separation of roles.* There should be a clear separation of ownership, policy making, regulation, and management. The companies should be owned by the Ministry of Finance (or by a special government asset ownership agency) and not by the Ministry of Energy as at present. The Ministry of Energy should exercise its policy-making role through formal channels by issuing decrees within a mandate granted to it in the primary law. The Ministry of Finance should exercise the role of owner by reviewing the performance of the management and

ensuring that the businesses are profitable and financially viable, and that they do not require cash injections from the national budget. The energy companies will need to be monitored by a variety of regulatory bodies such as the environment regulator, the health and safety regulator, and so forth. Energy tariffs and quality/reliability of supply will need to be regulated. Initially, the energy regulation functions could be left with the Pricing Department of the Ministry of Economy but its capacity should be substantially strengthened. However, in anticipation of future reforms, the tariffs and quality/reliability standards should ideally be regulated by a stand-alone agency.

1.33. With the introduction of the above reforms, the energy companies should gain independence from political intervention. Additionally, management of the companies should be given a clear obligation to operate on commercial terms (cost minimization or profit maximization). The above reforms will all require some changes to the legal framework.

1.34. Within this institutional framework, one of the Ministry of Energy's key roles in Belarus will be to introduce policies on security and diversification of supply. It would introduce such policies through formal channels by, for example, requiring that the companies maintain a certain fuel mix or that a certain proportion of their energy is sourced from indigenous energy.

1.35. *Enabling external finance.* The changes to the institutional, regulatory, and corporate governance framework described above will make it more attractive for banks, whether local or international, to lend to the energy companies. A strengthened regulatory body with a clear mandate to allow tariffs to rise according to prescribed procedures (such as fuel pass-through, maintaining an agreed rate of return, and so forth) would also help attract investment. Financing would also be enabled by greater financial transparency, which would be provided by the accounting reform in line with international accounting standards.

1.36. *Incentivizing efficiency.* Management incentives to reduce costs and improve energy efficiency should also be introduced. Rewards to management could be linked to profitability or defined organizational performance measures. The introduction of an incentive-based tariff regime (such as a price cap) would provide an opportunity for profit-making that could translate into managerial bonuses.²⁰

1.37. *Private sector participation.* The simplest forms of private sector participation should be introduced while maintaining state ownership of core energy sector assets. The companies should undertake a major review of their business and identify noncore businesses that could be spun off as separate companies and sold. The companies should also review the activities that could be outsourced rather than undertaken in-house.

1.38. With some variants of Scenario 1 there could be private participation in some activities. In the case of electricity, the private sector could be invited to develop distributed generation (small hydropower and biomass-fired generation plants) through BOO-type schemes and sell the power to the utility under a long-term power purchase agreement. In the gas sector, the private sector could be involved in the development or rehabilitation of gas distribution networks on a concession basis.

²⁰ For instance, Vietnam has successfully introduced such a scheme.

Scenario 2: Unbundling/continued state ownership

1.39. In general countries that fit the Scenario 2 framework have legal separation of parts of the supply chain, though ownership remains in state hands. Internationally, these structures were often introduced for historical reasons. In some cases, the distribution businesses may have had developed independently (for example, they may have been developed historically by municipalities). In other cases, the structure may have been introduced because distribution business are considered to be very different from the production business.

International examples

1.40. Two international examples of Scenario 2 in the electricity sector are the United Kingdom (before the reforms in the late 1980s) and Thailand. Before the reforms in the late 1980s, the United Kingdom had 12 distribution companies and one national generation/transmission company (the Central Electricity Generating Board). Thailand currently has a similar structure, with one national generation and transmission company (EGAT) and two distribution companies (the Metropolitan Electricity Authority and the Provincial Electricity Authority). In the case of Thailand, reforms introduced in the 1990s have led to a number of privately developed power plants selling power to EGAT under long-term contracts.

1.41. Scenario 2 may also be considered to be an interim step toward Scenario 3. Before launching more comprehensive reforms and exposing the companies to a more open market, it would be useful to unbundle the companies and give them experience of operating as independent entities in a controlled environment.

1.42. The importance of establishing the necessary supporting conditions and allowing sufficient time for preparation before moving to the next stage of reform is illustrated by the experience of Ukraine. It introduced a Scenario 3 framework in the second half of 1990s at a time when there were serious problems of nonpayment, barter trade was rife, and the sector legal framework and regulatory institution was just beginning to emerge. The gross-pool that was introduced at the time was generally ineffective and Ukraine subsequently to some extent reverted to a Scenario 2 framework (with a single buyer model).

Scenario 2 in Belarus

1.43. The institutional and structural framework in Scenario 2 in Belarus assumes that the reforms discussed in Scenario 1 are implemented. The reforms described in Scenario 1 might be considered as an “enabling environment” that would allow Scenario 2 to be introduced. It would be valuable to unbundle vertically integrated companies even if there is no intention to introduce competition at a later date.

1.44. *Structure.* Initially, unbundling would need to take the form of accounting and managerial separation with ownership retained by the government through a holding company/subsidiary company structure. The natural lines of separation for the companies are as follows:

- Belenergo: organized into one generation company, one transmission company responsible for transmission and system operation, and several physical distribution/supply (sales) companies. The distribution/supply functions could be divided along regional lines, probably based on the existing Republican Unitary Enterprises. At a

later date, the generation business could be split into a number of generating companies if the competition in generation could be effectively introduced and generate economic benefits exceeding those provided by the economies of scale.

- Beltransgas: organized into four companies: transmission, transit operations, storage and construction, and maintenance.
- Beltopgas: organized into two companies: distribution/supply and construction and maintenance.

1.45. In this arrangement, Belenergo, Beltransgas, and Beltopgas would become holding companies that own their respective subsidiary companies. Common activities, such as network maintenance (for the Belenergo and Beltopgas distribution/supply companies), could be reorganized into a single business unit that contracts its services to the other business units and is paid for them. Initially, payment for services provided within the group may be based on a system of transfer pricing and this could be graduated to normal contractual and payment terms later.

1.46. One of the advantages of a holding company/subsidiary structure is that there can be a gradual reallocation of responsibilities from the parent to the subsidiary over time.

1.47. However, a number of issues will arise relating to the roles of the holding company versus the roles of the subsidiary company. For example, the division of roles on the following items will need to be agreed upon: (i) procuring major equipment, (ii) borrowing from banks, (iii) deciding salary and wage rates, and (iv) liaising with the regulator.

1.48. *Trading arrangements.* With the unbundling of the companies there will be a need to introduce trading arrangements between them. There are two main options, namely keeping trading functions within a holding company, or introducing the single buyer model. The latter option has been proved as a suboptimal solution and as a result has been retired in a number of markets where it was initially established. Therefore, it is recommended to elect the first (holding company) option. In this case, the transmission company will need to be fully unbundled and will provide only transmission services. The trading functions, including the rights to energy imports/exports, will be left within the holding company that will include production and distribution/supply subsidiaries. One of the main advantages of this option over the model with the transmission company as a single buyer/seller is that it protects the market participants against a possible misuse of strong power of the transmission business.

1.49. *Policy making/diversification.* As in the Scenario 1 framework, in Scenario 2 the Ministry of Energy will be able to influence security of supply and fuel diversity through formal policy channels (decrees) such as requirements for a certain mix of energy sources or a minimum share of indigenous energy.

1.50. *Private sector participation.* As in Scenario 1, private sector participation could be introduced in Scenario 2 by outsourcing of services whenever feasible. A degree of competition should be introduced through BOO arrangements for new power generation or for rehabilitation of older power plants (rehabilitate, own, operate or ROO). The power purchase contracts for power supplied by BOO plants should be awarded by the holding company but it is important that the selection should be based on competitive tenders rather than negotiation. International experience (for example in Indonesia) suggests that the price of power sold through negotiated contracts is considerably higher than the price of power through tendering.

1.51. *Benefits.* One of the benefits of unbundling in Scenario 2 is that it allows management to focus on their core activities and to introduce operating efficiencies in their businesses. It also

facilitates the task of the regulator and allows it to introduce benchmarking regulation that compares indicators of distribution subsidiary companies among themselves and against the best international practice.

1.52. Another benefit of this structure is that it allows financial transparency for the subsidiary businesses. Transparency is important for both the owner—the Ministry of Finance—and regulator, and it also gives lenders confidence that the business to which they are lending is independently viable.

Scenario 3: Ownership change, liberalization

International examples

1.53. The general trend in the region is best illustrated by countries that are applicants to the European Union, such as Bulgaria, Romania, and Turkey. The Scenario 3 framework has also been introduced for electricity in Kazakhstan and to some extent in Ukraine. In general, countries that fit the Scenario 3 framework have introduced a degree of wholesale competition and third-party access. A necessary precondition for wholesale competition and third-party access is that there should be unbundling of generation (electricity), transmission/system operation, and distribution. There also needs to be several generation companies in electricity to allow competition to take place (this implies that further unbundling of electricity would be necessary in Scenario 3 compared with the Scenario 2 proposed above for Belarus).

1.54. Competition in electricity and gas is now mandated by the EU and the accession countries of eastern Europe are reforming their electricity and gas sectors to move toward compliance with EU regulations. The EU regulations now also require retail competition (all consumers, including households, have the right to choose suppliers) but it has been accepted by the EU that the accession countries will not immediately introduce retail competition.

1.55. The introduction of wholesale competition requires the creation of a complex framework for handling unavoidable imbalances between gas or electricity entering the network and gas or electricity consumed by customers. Some countries introduce a gross-pool (or mandatory pool) in which all gas or power is traded through the pool and the pool automatically takes care of imbalances. Other countries introduce a net-pool arrangement in which only the imbalances are traded.

Scenario 3 in Belarus

1.56. A number of reforms should be implemented in Belarus, particularly those outlined in Scenarios 1 and 2, before a Scenario 3 framework is introduced. Therefore, it would be prudent to focus the mid-term reform agenda on the measures recommended under the first two scenarios. These reform measures will be very valuable in themselves in improving operating efficiency and in attracting financing to the sector, but they are also preconditions for a more advanced energy market model. While this may appear to be an unambitious target when countries such as Ukraine and Kazakhstan have moved rapidly to a Scenario 3 framework, it is important to initiate reforms by creating a viable framework and avoiding the disorder that could arise if an advanced market model is introduced too quickly.

2. Achieving Further Progress in Energy Efficiency

2.1. Improving energy efficiency is a win-win option for addressing concerns about energy security:

- Energy efficiency and demand-side measures are often the most cost-effective, low-risk and versatile approach to reduce the need for energy and associated infrastructure.
- Energy production efficiency improvements increase effective energy supply and reduce costs.
- Efficiency savings realize environmental benefits through reduced emissions of greenhouse gases and local air pollutants.

2.2. Belarus has made good progress in reducing energy intensity in the past decade. Energy efficiency has been a top priority for the Belarus government since the mid-1990s. This has brought tangible results, with the energy intensity factor reduced from 0.76 to 0.45 in 2004 and the downward trend continued in 2005 as shown in figures 2.1 and 2.2.

Figure 2.1. Energy Intensity Dynamics in Belarus, Ukraine, Poland, and Germany in 1995–2004

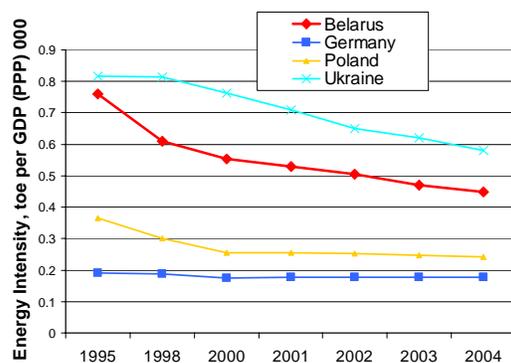
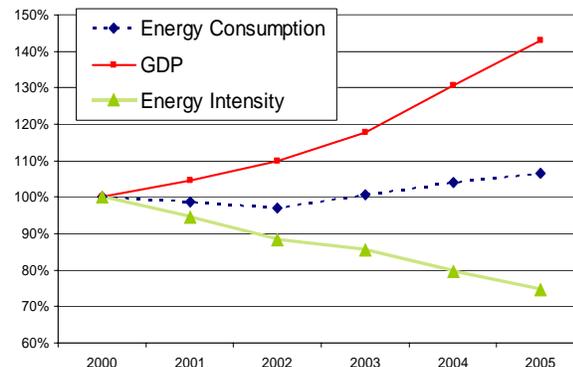


Figure 2.2. Belarus Progress in Reducing Energy Intensity in 2000–5



Source: World Bank, Belarus Energy Saving Program 2010.

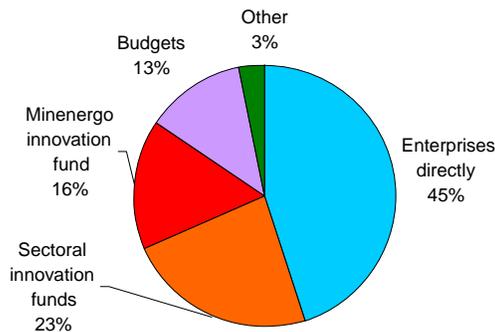
2.3. The combination of the following administrative and market measures allowed Belarus to reduce energy intensity:

- passage and enforcement of energy efficiency legislation
- establishment of Committee on Energy Efficiency and empowering it with an effective mandate to promote energy efficiency and monitor compliance with energy efficiency targets by sectors and regions
- increase of energy tariffs and cash collections
- availability of budget funds to catalyze energy efficiency investments
- establishment of energy efficiency targets for sectors and regions and administrative and financial sanctions against economic agents and leadership that fail to meet the targets
- fiscal and staff incentives for enterprises implementing energy efficiency projects
- public awareness campaign

2.4. Securing financing is the main challenge facing the Belarus energy efficiency agenda in the years ahead. The government adopted in February 2006 the National Energy Saving Program for 2006–10 that sets a target of reducing energy intensity by about 30 percent and calls for investing about US\$3.81 billion in energy efficiency projects. While the energy efficiency projects have been identified and the implementation capacity is in place, there a risk of not achieving the planned reduction of energy intensity because there is no lending market for energy efficiency projects.

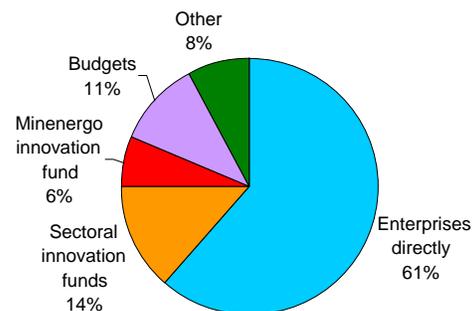
2.5. Belarus has succeeded in reducing energy intensity by 25 percent in the past five years by investing about US\$1.17 billion. The breakdown of the financing sources is shown in figure 2.3. Because the energy efficiency organizational measures and least-cost projects were largely exhausted in the past five years, the investment needs to achieve similar results in 2006-2010, as estimated by the Program, are significantly higher. Moreover, the share of financing that should be secured by by enterprises is also supposed to substantially grow as indicated in figure 2.4. While it should be technically feasible to implement the investment projects identified by the Program, the reliance on cash flows as a major financing source²¹ will not allow the enterprises to secure the needed funds. Instead, financial mechanisms need to be developed to provide for mid-term project financing.

Figure 2.3. Belarus Actual Investments in Energy Efficiency in 2001–5



Note: Total investment is US\$1.171 billion.

Figure 2.4. Belarus Projected Investments in Energy Efficiency in 2006–10



Note: Total investment is US\$4.659 billion, including US\$3.81 billion for energy efficiency projects and US\$849 million for boosting the use of domestic energy resources.

Source: National Energy Saving Program 2006–10.

2.6. In order to meet the energy efficiency investment challenge the government should develop a sustainable lending market for energy efficiency investments. At the same time the government should maintain energy tariffs and collections at levels that provide incentives to consumers to invest in the energy efficiency project. The options for lending instruments are as follows:

2.7. *Promote ESCO concept and private sector participation in energy efficiency investments.* The energy service company (ESCO) concept or energy performance contracting can offer three-

²¹ Most of the investments in 2001–5 were financed directly from cash flows, without borrowing.

fold services: an energy efficiency audit, investment financing, and project implementation. The following options could be considered by the government for promoting ESCOs: (i) establish an effective legal framework for third party financing, (ii) replace the cost-plus tariff methodology with an incentive regulation or allow utilities to include in the tariff an energy conservation surcharge, (iii) introduce accounting rules that permit the accumulation of monetized energy savings in an escrow account and ensure prerogative access to the account by a financier, and (iv) promote the supply side of the market by establishing energy efficiency funds.

2.8. *Develop energy efficiency lending through local financial institutions.* Participation of local banks in financing energy efficiency investments has proved to be a successful strategy in establishing sustainable energy efficiency lending markets in many countries. The following measures are usually employed to break down the barriers preventing commercial institutions from entering the energy efficiency market: (i) establish partial risk and partial credit guarantees to share risks, extend loan maturities, and lower interest rates; and (ii) build capacity at financial institutions, including raising awareness and developing specialized energy efficiency financial products and partnerships with project developers such as ESCOs. The World Bank and the European Bank for Reconstruction and Development (EBRD) have been providing lending and technical assistance in support of the above measures to several countries in the region, and Belarus would also benefit from expertise and experience of these international financial institutions (IFIs).

2.9. *Scale up the energy efficiency revolving fund established by the Committee of Energy Efficiency.* A common approach to expanding project financing for energy efficiency investments is to use existing or develop new special purpose funds and associated institutions. Belarus could build on the energy efficiency fund that has been established by the Committee of Energy Efficiency under a United Nations Development Program project, and has been funded from the Ministry of Energy innovation fund. The financing sources could be expanded by including energy taxes and potentially IFIs loans. Success factors for transforming the existing fund into a sustainable, wide-scale lending instrument include the following: (i) strong business practices, (ii) simple and transparent procedures, (iii) risk mitigation through many small projects, and (iv) prioritization of low-risk and simple investments with energy efficiency improvements that are easy to quantify. Moreover, the borrower must contribute to project financing.

2.10. Furthermore, investments in energy efficiency could be supported by exploiting carbon trading opportunities under the Kyoto Protocol (KP). Belarus has ratified the KP and is an Annex 1 party to the UN Framework Convention on Climate Change (UNFCCC). However, unlike other transition economies under Annex 1, Belarus is unable to engage in international emissions trading (IET) or project-based activities through the Joint Implementation (JI) mechanism because it does not have yet an emissions allowance under Annex B of the KP. Furthermore, Belarus at this point does not have enough experience with the JI mechanism to be able to engage in JI or IET; hence the need to demonstrate to the market that the country is a credible partner. In order to benefit from JI and IET Belarus should implement the following actions in 2006:²²

- Continue, as a priority, with current programs to meet eligibility criteria for JI and IET by January 1, 2007.
- Establish a pipeline of projects under the JI track 2 mechanism to demonstrate that the appropriate regulatory frameworks are in place and conditions in Belarus are conducive to investment in JI projects.

²²Appendix 1 to this report provides further information on the actions to be taken by Belarus in order to be eligible to JI and IET. Appendix 3 also lists areas for potential assistance by the World Bank.

- Review and examine conditions for trading in Assigned Amount Units (AAUs) and develop a proposal for engaging with potential buyers through, for example, a green investment study.

2.11. A good track record in carrying out energy efficiency projects and relatively well-functioning government institutions place Belarus, once it is eligible for JI and IET, ahead of several other countries in the region while competing for funds under the Kyoto Protocol.

2.12. The energy efficiency reform agenda can be further supported by reforms in the heating market. The National Energy Efficiency Program for 2006–10 includes some investments in the district heating (DH) sector, but a standalone reform program for this sector would allow Belarus to better exploit the sector's energy efficiency potential. The DH sector consumes annually about 8 bcm of gas or 40 percent of the country's gas consumption. The gas consumption can be reduced by about 30 percent through wide-scale investments in energy efficiency, including retrofitting of buildings, replacement of group heat substations with individual heat substations, rehabilitation of the DH network, modernization of heat generation, and selective replacement of DH with decentralized heating options. However, in order to realize the energy efficiency potential stemming from these investments there is a need to secure financing. This in turn calls for reforms on both the demand and supply sides of the heating market.

2.13. Reform measures on the demand side should include the development of (i) effective forms of ownership and management of multi-apartment buildings (for instance, homeowner associations); (ii) professional companies to manage common property in multi-apartment buildings; and (iii) a lending market to finance energy efficiency retrofitting of buildings. Besides, cost-recovery tariffs for heat and full collection of heat bills are mandatory policy measures for providing incentives to the building owners to invest in energy efficiency.

2.14. Efforts on the supply side of the market need to be focused on commercializing the sector through raising heat tariffs to cost recovery levels and ensuring full collections of heat bills. Furthermore, best corporate governance practices should be introduced in management of heat utilities in order to raise their efficiency and effectiveness. Commercial borrowing is unlikely to be available to heat utilities until they are perceived by lenders as creditworthy clients. Therefore, there may be a need to support initial investments in the sector and build its creditworthiness through a state-funded revolving financing mechanism.

2.15. While the sector was largely decentralized to the municipal level, the central government should play a leading role in developing a nation-wide sector strategy and support the sector reform by specific actions. Key policy areas for government intervention are (i) developing legal and regulatory frameworks for both the demand and supply of the market, (ii) developing corporate governance tools, (iii) improving the efficiency of social safety net, and (iv) supporting municipalities in development of heat master plans.

3. Diversifying Energy Supply

3.1. A key issue for Belarusian energy security is its dependence on a single energy supplier. As indicated in table 3.1, Belarus consumes approximately 26 million tons of oil equivalent (mtoe) of primary energy resources annually but only produces a little over 3 mtoe. The balance is imported from Russia, with crude oil and natural gas topping energy imports. While the bulk of imported crude oil is processed at the Belarus refining complex and then petroleum products are exported, imported natural gas is fully consumed domestically. As a result, imported gas accounts for about 64 percent of the country's primary energy consumption.

Table 3.1. Belarus Primary Energy Supply and Consumption

	2000	2001	2002	2003	2004	2005
PRODUCTION						
crude oil (mt)	1.85	1.85	1.84	1.82	1.80	1.79
natural gas (bcm)	0.26	0.26	0.25	0.25	0.25	0.23
peat & wood (mt)	6.60	6.80	7.10	6.80	7.00	7.00
hydropower (TWh)	0.03	0.03	0.03	0.03	0.03	0.03
Total production (mtoe)	3.39	3.43	3.47	3.39	3.41	3.38
IMPORT						
crude oil (mt)	12.01	11.91	14.02	14.89	17.81	19.32
natural gas (bcm)	17.12	17.27	17.58	18.11	19.64	20.12
petroleum products (mt)	1.08	0.38	0.49	1.00	1.14	0.57
electricity (TWh)	7.22	8.32	6.79	7.40	4.05	4.94
coal (mt)	0.43	0.43	0.33	0.30	0.30	0.14
Total import (mtoe)	29.17	28.76	30.80	32.75	36.23	37.70
EXPORT						
crude oil (mt)	0.35	0.40	0.60	0.80	1.05	1.35
petroleum products (mt)	7.78	7.66	9.88	10.54	12.96	13.49
electricity (TWh)	0.00	0.00	0.23	0.75	0.80	0.90
Total export (mtoe)	8.17	8.09	10.58	11.57	14.27	15.12
PRIMARY ENERGY CONSUMPTION (mtoe)						
	24.39	24.10	23.69	24.57	25.37	25.96

Source: Ministry of Statistics and Analysis.

Note: A ton of oil equivalent is defined as 10 gigacalories. The applied conversion factors are: coal, 0.39; crude oil and petroleum products, 1.0; natural gas, 0.81; peat and wood, 0.18; electricity, 0.25.
bcm = billions of cubic meters; mt = millions of tons; TWh = terawatt hours.

3.2. Energy exports and imports have substantial macroeconomic implications for Belarus. As indicated in table 3.2, the cost of energy imports amounted to about 19 percent of country GDP in 2005. Revenues stemming from energy exports (largely dominated by petroleum products) reached 18 percent of GDP the same year. Though the revenues from energy exports largely offset the cost of energy imports, the latter, especially natural gas imports, do cause a significant strain on the Belarus trade balance.

Table 3.2. Cost of Energy Imports

	2000	2001	2002	2003	2004	2005
Natural Gas						
Volume, bcm	17.1	17.3	17.6	18.1	19.64	20.12
Price, US\$/1,000 m ³	30.7	31.1	30.6	36.9	47.68	47.2
<i>Natural gas subtotal cost, US\$ mln.</i>	525	538	538.6	667.9	936.6	949.5
Crude Oil						
Volume, mt	12.01	11.91	14.02	14.89	17.81	19.32
Price, US\$/ton	136.2	115.8	107.3	133.2	181.4	218.6*
<i>Crude oil subtotal cost, US\$ mln.</i>	1636	1379	1504	1983	3231	4222
Petroleum Products						
Volume, mt	1.08	0.38	0.49	1	1.14	0.57
Price, US\$/ton	195.4	242.5	198.3	161.7	155.4	267.57
<i>Petroleum products subtotal cost, US\$ mln.</i>	210.1	91.18	97.17	161.7	177.2	152.6
Electricity						
Volume, TWh	7.2	8.3	6.8	7.4	4.05	4.94
Price, US cents/kWh	1.79	1.78	2.1	1.94	1.94	2.02
<i>Electricity subtotal cost, US\$ mln.</i>	128.9	147.7	142.8	143.6	78.57	99.93
TOTAL, US\$ mln.	2,500	2,156	2,283	2,956	4,424	5,424
GDP, US\$ mln.	11,417	12,094	14,489	17,622	22,880	29,575
Fuel and Energy Import to GDP, %	19.6%	17.5%	15.6%	16.9%	19.3%	19.3%

Source: Ministry of Statistics and Analysis.

bcm = billions of cubic meters; mt = millions of tons; kWh = kilowatt hours; TWh = terawatt hours.

* Equivalent to about US\$30 per barrel.

3.3. Existing infrastructure and geographical proximity ensure that Russia will be Belarus' primary source of energy supply for the foreseeable future. However, Belarus should seek to mitigate the overall risk associated with this excessive dependence. Belarus can mitigate risk by sustaining domestic oil production, expanding oil and gas storage capacities, and increasing energy trade and related investments with neighboring countries. Furthermore, Belarus would benefit from exploiting energy supply diversification options, including the following:

- Enlarge the use of domestic energy resources.
- Develop alternative electricity supply options.

Enlarge the Use of Domestic Energy Resources

3.5. Belarus is poorly endowed with hydrocarbon resources, which met only about 7 percent of the country's primary energy consumption in the past years. These resources can hardly be increased because of geological conditions. However, Belarus enjoys significant wood and peat resources and has a hydropower potential suitable for small hydropower generation plants. The wide-scale use of other renewable options such as wind, solar, and geothermal seem to be less attractive from an economic standpoint because of Belarus' geographical and geological conditions. Therefore, priority should be given to expanding the use of wood, peat, and hydropower resources for small-scale energy generation, as well as to sustaining the oil production.

3.6. The access to cheap gas from Russia and lack of energy diversification policies prevented Belarus from developing the potential of wood and peat resources for energy generation.

However, in 2004 the government prepared a program²³ that sets a target of nearly doubling the power and heat production from domestic wood and peat by 2012. The available wood stock and peat deposits are sufficient to meet this target. However, there is a risk that the targeted increase in production of fuel wood may cause an extensive use of high-quality logs as fuel wood, which will have negative environmental implications and cause a suboptimal exploitation of the forest resources.

3.7. Embracing international best practices would allow Belarus to increase the production and use of fuel wood in a sustainable and rational manner. The following lists main measures that should be implemented to this end:²⁴

- Develop a Research and Development (R&D) program.
- Integrate the production of fuel wood into conventional forestry and procurement of industrial timber.
- Assure quality standards for forest chips.
- Increase production efficiency.

3.8. Furthermore, in order to meet investment challenges associated with the increased production and utilization of fuel wood and peat, the government should focus on developing policy, establishing a legal and regulatory framework, and conducting research and development programs, while transferring production activities to the private sector.

3.9. The development of small-scale biomass and hydropower power distributed generation calls for enacting policies to facilitate investments in these types of renewable energy (RE). Most critical barriers to distributed power generation in Belarus include the following: (i) depressed prices for competing fuels (namely natural gas), (ii) unfavorable power pricing rules, (iii) incomplete legal framework for independent power producers, and (iv) transmission access and interconnection requirements. Many of these issues are not unique to Belarus and are being faced by several countries that thought to promote RE.

3.10. An emerging body of international experience in developing RE offers a number of policy measures to address the above mentioned barriers. These measures include (i) subsidies that reflect RE location, environmental, energy security, and other associated values,²⁵ (ii) quantity-forcing policies that mandate the quantity of energy to be produced from RE, (iii) a legal and regulatory framework for independent power producers that creates transparent conditions and simple-to-follow rules enabling the participation of private sector,²⁶ and (iv) legislation to support the development of RE.²⁷ Belarus has made initial steps in some of the above areas, but further efforts are needed if RE potential is to be utilized.

²³ Target Program of Ensuring Generation of at least 25 percent of Electricity and Heat from Local Fuels and Alternative Energy Sources in Belarus for the Period up to 2012.

²⁴ Appendix 3 to this report presents further recommendations on this matter. Furthermore, materials on Finland's experience in production of fuel wood were handed over to the government in the context of this study.

²⁵ RE subsidy options and motivations they are driven by are provided in Appendix 2 to this report

²⁶ This topic is being reviewed in details under the study "Advisory Services on Strategy for Private Sector Participation in Decentralized Energy Generation," which is being conducted by Mercados & Ramboll and funded by the Public-Private Infrastructure Advisory Facility (PPIAF).

²⁷ The draft Law of Belarus on Renewable Energy has been developed but still needs to be passed. Appendix 2 to this report provides a tentative list of secondary legislation to complement the Law on Renewable Energy.

Alternative Electricity Supply Options

3.11. The installed electricity generation capacity in Belarus²⁸ is sufficient to fully meet the present and mid-term demand (assuming a continued reduction in energy intensity). However, nearly all domestic electricity generation plants are run on natural gas, which makes electricity supply and retail tariffs dependant on the gas supply and its price. In order to mitigate this dependence Belarus could boost electricity imports, develop fuel substitution options, and exploit cogeneration opportunities.

3.12. Aside from Russia, Belarus has electricity grid connections with Ukraine and Lithuania. Lithuania has exported electricity to Belarus in the past. However, the first of the two reactors at the Ignalina nuclear plant, which dominates the Lithuanian power system, was closed in 2005 and the second is due for closure in 2009. Once this closure is complete imports from Lithuania will not be an option.

Table 3.3. Belenergo Electricity Balance and End Consumption

	2003 GWh	2004 GWh	2005 GWh
Production gross	25,937	30,370	30,113
Production net	23,862	28,048	27,828
Net import	6,829	3,249	4,043
Consumption gross	30,691	31,297	31,871
Losses	3,945	3,991	4,033
<i>Consumption net</i>	<i>26,746</i>	<i>27,306</i>	<i>27,838</i>
Of which:			
Industry above 750kVA	14,209	14,732	14,913
Industry below 750kVA	1,978	2,060	2,099
Railways	410	412	424
Urban transport	325	326	326
Non-industrial	2,798	2,955	3,297
Agriculture	1,576	1,485	1,551
Households	5,450	5,336	5,228

Source: Belenergo Annual Reports.

GWh = gigawatt hours; kVa = kilovolt amps.

3.13. Ukraine has an excess of base-load nuclear generation capacity. Imports of electricity from Ukraine to Belarus began in 2006 and are expected to reach around 2.5 terawatts for the year. The import price is set at US cents 2.1 per kilowatt hour. This compares favorably with the average import price for Russian/Lithuanian electricity in 2005 of US cents 2.02 per kilowatt hour.²⁹ The electricity trade price in South Eastern Europe, where gas prices are closer to the Western European levels, is above US cents 4.0 per kilowatt hour. Given that the Belarusian electricity system, which is almost entirely gas-fired, is sensitive to an increase in the price of imported gas from Russia, the South Eastern European price suggests that opportunities to import from Ukraine should be developed further.

²⁸ The installed electricity generation capacity of Belenergo was 7,656 megawatts, whereas the total installed capacity in Belarus was 7,798 megawatts in 2005. Belenergo's installed generating capacity was 98 percent thermal, of which 55 percent was combined heat and power. The country peak load in 2005 was 5,900 megawatts, leaving a nameplate reserve margin of 32 percent (although much of this is economically or technically inoperable).

²⁹ While about two-thirds of imported electricity was supplied from Lithuania in physical terms, the electricity trade in commercial terms was only with Russia.

3.14. The existing electricity network connections between Belarus and Ukraine limit the volume of electricity trade. One option would be to build a high-voltage line from the Rivne nuclear station in Ukraine to Belarus, which could allow for a tripling in the present level of trade. However, if electricity import from Ukrainian nuclear plants is to significantly increase, it should be accompanied by the development of regulating generation capacity and introduction of real-time pricing in Belarus. The capacity could be enhanced by rehabilitating existing and constructing new small hydropower plants, and retiring steam/open-cycle gas turbine plants and replacing them with combined-cycle gas turbine plants.

3.15. Another diversification option is to build coal-fired plants while retiring depreciated and obsolete gas-fired plants. The liquid international market and multiple suppliers for coal, including neighboring countries such as Poland, Ukraine, and Russia, would give increased security of supply. Abundant wood resources in Belarus also offer some opportunities to fuel switching.

3.16. Extensive district heating systems, including thousands of heat-only boilers (HOBs), provide another diversification opportunity, namely to install electricity cogeneration units at HOBs. However, this option will lead to an increase in the base-load installed electricity capacity and therefore will need to be accompanied by investments expanding domestic regulating capacity.

3.17. The option of building a nuclear power plant in Belarus has been considered since the 1980s. The program was halted after the Chernobyl accident but was further explored in the late 1990s. The Commission tasked with reviewing the options concluded in 1999 that the country should not build a nuclear plant within 10 years. However, recent increases of energy prices revived the discussion of the nuclear option in Belarus.

3.18. While requiring investment in rehabilitation, the installed thermal generation capacity together with continued electricity imports are sufficient to fully meet the present and mid-term electricity demand. The cost of building a nuclear power plant and the related upgrading of the national electricity grid needs to be carefully considered against the cost of developing the network to allow electricity import diversification. In addition, the nuclear option should be compared with the costs of and benefits from further energy efficiency improvements in generation, transmission, and final use of energy.

3.19. Though Belarus has made good progress with energy efficiency in its economy, there remains significant room for improvement. In countries with high dependence on energy imports and significant energy efficiency potential, investments in energy efficiency have better economics and greater impact on energy security compared to investments in additional electricity generation capacity. Therefore, Belarus would benefit from further reducing energy intensity to the level demonstrated by developed countries before considering the greenfield construction of a nuclear power plant. For instance, investing in electricity connections to Ukrainian nuclear plants together with the rehabilitation of district heating (DH) systems, and energy efficiency retrofitting of buildings connected to DH, may result in even stronger energy supply diversification and gas savings.³⁰ Moreover, this would be accomplished at a lower cost and in a shorter time than the construction of a one gigawatt nuclear plant.

³⁰ Replacement of thermal generation plants with a one gigawatt nuclear plant could save about 2 billion cubic meters of gas per year. However, the same amount of savings can be achieved by optimizing the gas consumption of the

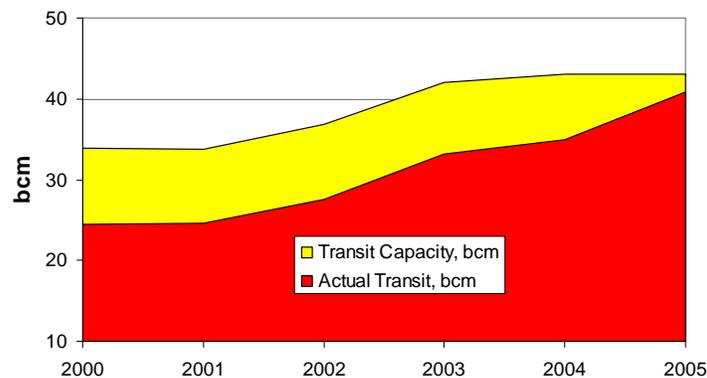
4. Maximizing Energy Transit Benefits

4.1. Belarus' oil and gas transit network is one of the most important strategic assets in the country. It generates a steady revenue stream from the transit of Russian crude oil and natural gas to Europe and strengthens Belarus' bargaining position with Russia on prices for imported fuels, in particular natural gas.

4.2. Belarus is also strategically located to benefit from electricity transit from Russia. The Belarusian electricity transmission network is part of a large high-voltage loop that connects the Baltic states with Russia. It is interconnected with Russia to the east, Lithuania to the north, and Ukraine to the south.³¹ To the west, Belarus is connected to Bialystok, Poland by a 220 kilovolt line but this is electrically islanded on the Polish side. However, there is currently no significant cross-border transit toward the West, and infrastructure is not allowed to transit.³² Therefore, the role of Belarus as an energy transit country is likely to focus in the medium term on Russian gas and oil exports to Europe.

4.3. Belarus lies on the gas transit route for Russian gas to Europe and is the second largest transit country for Russian gas by volume after Ukraine. Russian gas transit has been growing in the past years and reached 40.5 bcm in 2005 as indicated in the figure below.

Figure 4.1. Russian Gas Transit through Belarus' Territory



Source: Ministry of Energy.
bcm = billion cubic meters.

4.4. The actual total annual transit capacity in 2005 was around 43 bcm. The major gas transit pipelines existing and under development in Belarus are as follows:

district heating systems (which now consume about 8 billion cubic meters of gas per year) through rehabilitation and modernization investments in the demand and supply sides of the DH market.

³¹ This mainly consists mainly of a 330 kilovolt network with three interconnections with Russia, five with Lithuania (three of which are to the Ignalina nuclear power plant), and two with Ukraine (one at Chernobyl). Belarus also has a 750 kilovolt interconnection to the Smolensk nuclear power station in Russia.

³² Until the United Energy System (UES), including Russia, Belarus, Ukraine, and several other countries of the FSU, is synchronized with Union for the Co-ordination of Transmission of Electricity (UCTE), export to the EU will be limited to "island" and high-voltage direct current (HVDC) options.

- *Yamal – Europe pipeline (Yamal I)* – Began operation in 1995; its full capacity of 33 bcm/year is expected to be reached in 2006. While the pipeline is controlled and operated by Beltransgas, it is owned by Gazprom.
- *Beltransgas transmission network* – The total transmission capacity of the network is about 31 bcm/year. It is utilized for both gas transport to domestic customers (about 20 bcm/year) and transit of Russian gas.

4.5. A second European pipeline (Yamal II) to run parallel to the first is planned but construction has not yet started. It is expected to have a capacity 34 bcm/year.

4.6. Fees for transit are differentiated by pipeline, with fees on the Beltransgas network set to US\$0.75/mcm/100 km and on the Gazprom-owned Yamal pipeline US\$0.46/mcm/100 km. On the basis of two-thirds transit through the Yamal pipeline in 2005, Belarus earned approximately US\$135 million from gas transit. While the transit fees are much lower than the levels applicable for gas transit in neighboring countries, there is an apparent link between the level of the transit fees and prices for gas charged to Belarus by Russia. However, should both the gas price and transit fees be adjusted to EU market levels, the net loss for the Belarus economy would run into US\$ billions.

Opportunities and Threats for Gas Transit

Strategic location and increasing exports from Russia

4.7. Belarus benefits from its strategic location between the gas and oil fields of Russia and the energy markets of western and, increasingly, central and eastern Europe. Energy imports into the European Union will increase as demand rises and indigenous reserves are depleted and a significant proportion of this is expected to come from Russia.

4.8. Russia currently supplies approximately 40 percent of the natural gas consumed in Europe and exported 148 bcm by pipeline in 2004.³³ Projections of future Russian gas supply to Europe vary but by some estimates it is expected to rise to as much as 200 bcm by 2010 (estimates of the International Energy Agency).

4.9. As Gazprom seeks to increase its share in the European market it will require expanded transit capacity. This presents a continued and potentially increasing opportunity for Belarus to benefit from fees for energy transit across its territory.

Competition to transit Russian gas to Europe

4.10. Since the 1990s, Gazprom has been seeking to diversify its export routes to Europe. By diversifying its transit options Gazprom can exert competitive pressure on transit providers to lower their transit fees, improve reliability, and improve its negotiating position by reducing its exposure to any one transit provider.

4.11. The development of alternative routes to transport Russian gas to EU markets represents a competitive threat to Belarus' transit role. However, Gazprom's desire to diversify its transport options also presents Belarus with an opportunity to introduce a new transit pipeline through Belarus (Yamal II).

4.12. Currently, Russian gas transit routes to Europe are as follows:

³³ BP Statistical Review of World Energy, June 2005. This includes exports to Turkey and some non-EU states.

- Ukraine. With transit capacity of 175 bcm/year, it currently delivers approximately 112 bcm of Russian gas to Europe, making it by far the largest transit country. Approximately 75 percent of Russian gas to Europe is transited through Ukraine, although this has been declining since the late 1990s as Gazprom has sought to develop alternatives.
- Belarus. Most of the remaining 25 percent of Russian gas sold to Europe is currently exported via Belarus. Around two-thirds passes through the Yamal I pipeline.
- Turkey. The Blue Stream pipeline under the Black Sea began operation in 2003 with a planned capacity at full operation of 16 bcm.
- North Europe Gas Pipeline (NEGP). Not yet constructed, it is a joint venture between Russia's Gazprom and two German companies³⁴ with an initial capacity of 27.5 bcm planned for 2010, increasing to 55 bcm with the addition of a parallel pipeline in a second stage. NEGP will be a subsea pipeline across the Baltic that will link Russian territory directly to customers in Germany,³⁵ completely bypassing transit countries. A framework agreement was signed between the partners in September 2005.

4.13. A further transport option, known as the Amber project, would see Russian gas transported to Poland via the Baltic countries, bypassing Belarus. This project was suggested as an alternative to the NEGP,³⁶ but has not moved beyond the discussion phase.

4.14. To date diversification has focused particularly on reducing the transit monopoly inherited by Ukraine from the Soviet Union. The construction of the Yamal I pipeline through Belarus was a significant step in lowering Ukraine's proportion of transit, and the Yamal II expansion, should it take place, will continue this to the benefit of Belarus.

4.15. The initial phase of the subsea Baltic NEGP pipeline would be sufficient to displace 75 percent of current transit through Belarus. Based on estimated 2005 transit fees this represents potential lost revenue to Belarus of US\$101 million per year as well as strategic implications. The NEGP pipeline is expected to be in operation from 2010, although this may be an optimistic start date.

4.16. However, in 2003 the European Commission defined the North European/Baltic area as a priority pipeline axis.³⁷ Developing the NEGP and expanding the Yamal pipeline was recognized as gas transit infrastructure projects of "common interest" to the European Commission.

Gazprom interest in controlling Belarusian transit

4.17. Gazprom's interests will compel it to attempt to gain control over all transit routes to its markets. In Belarus, Gazprom already owns the Yamal I pipeline. Gazprom's involvement can be viewed as both an opportunity and a threat. It could provide a fiscal injection and access to much needed capital, and engage Russia with a greater stake in continued transit through Belarus. It

³⁴ Ownership in the NEGP joint-venture is shared 51 percent by Gazprom and 24.5 percent each by the German energy and chemical companies E.ON Ruhrgas and BASF.

³⁵ Germany, with consumption of 38 bcm in 2004, is the largest customer for Russian gas in the EU.

³⁶ The potential transit countries point to the benefits to their gas markets and the broader common EU gas market, as well as the transit fees they would receive. For the exporter, they note the lower construction costs for the overland pipeline of up to 30 percent.

³⁷ Proposal for a Decision of the European Parliament and the Council laying down guidelines for trans-European energy networks and repealing Decisions No 96/391/EC and No 1229/2003/EC. COM (2003) 742 of 10.12.2003.

could also diminish Belarusian control over its key strategic asset and thereby weaken its position in broader dealings with Russia.

Future options for Belarusian gas transit

4.18. In developing its gas transit strategy toward Russia, the challenge for Belarus is to maximize the economic rent (or other benefits) from transit, meet its investment needs, and retain control over transit. It must do this within the confines of the competitive threat from alternative transit routes. Belarus' strategy for capturing the benefits of its transit position should include the following steps:

- Position itself as the transit route of choice.
- Capitalize on its competitive advantages as a transit country.
- Maintain control of transit, but invite partnerships with foreign investment and expertise.

Transit route of choice

4.19. Belarus' reputation as a reliable and dependable supplier of transit services should be viewed as one of its key international trade assets. It should develop and strengthen its reputation with Russia and also work to enhance confidence and build partnerships in receiving countries. Belarus enjoys favored status with Russia and has an existing network, experience of transit, and contacts in place. Belarus also has existing plans to significantly increase its transit capacity.

4.20. As the controller and operator of the country's transit system, Beltransgas has the central role in ensuring reliability and maintaining the country's transit reputation. Therefore, a key focus of reform in the sector should be to raise Beltransgas' standards of operation by applying best international practices of corporate governance, including transparency and disclosure requirements, international accounting standards, and supervisory boards that are independent from management.

4.21. Furthermore, Beltransgas should actively seek to increase confidence in its network operation and management by monitoring its performance, particularly as regards reliability, according to clearly defined standards and by making the results available to transit customers. For example, the UK gas transmission operator (National Grid) monitors the operational performance of its network in terms of time between failures in its compressor fleet and compares annual results against a five year average. Gas Infrastructure Europe (www.gie.eu.com) is the industry body for gas transmission companies in Europe; it published a number of papers on standards and approaches in gas transport and storage (for instance, "Guidelines on Good Practice"). These would provide a good indication for Beltransgas of the direction being followed by European gas companies.

Belarusian competitive position as a transit country

4.22. Despite its efforts to diversify, Gazprom's transport options all currently require it to transit through intermediate countries. Belarus enjoys a number of competitive advantages as a transit country:

- Belarus is seen as a relatively stable and reliable gas transit provider.
- Ukraine remains dominant and Gazprom will continue to seek alternatives.
- The scale of Ukraine's share in transit coupled with the projected growth in Russian exports makes it difficult to reduce dependence on Ukraine transit using only non-Belarusian alternatives. The development of NGEP in the medium term combined with Blue Stream would meet only 20 percent of Russia's projected 2010 exports.

- The cost of transit through Belarus is among the lowest compared to other transit options. For instance, the long-run marginal cost of transport through Yamal I is estimated at US\$61.4/MCM while through Ukraine's Soyuz pipeline it is US\$75.4/MCM³⁸.
- The transit fees currently charged by Belarus are significantly lower than other European comparators.³⁹

4.23. Belarus' cost advantage over alternative routes is an important component of its competitiveness. Faced with limits on its own financial resources, Gazprom has sought foreign partnership to support its investment program in pipelines to Europe. Given Belarus' lower long-run cost of transit, it is in Gazprom's interests to transit gas through Belarus up to the maximum capacity in preference to alternative transit routes. However, in this context it is important to note that the ability of Belarus to increase its transit fees to offset increases in the price of gas is limited by the competitive environment for transit.

Network investment and control of transit

4.24. Belarus could cede partial or full control of existing or future transit pipelines to Gazprom, or another international investor. The options include:

- Sell the existing Beltransgas transit pipelines for cash or in exchange for debt write-down.
- Form a joint venture to develop and operate the pipelines.
- Grant concessions to develop and operate transit pipelines.

4.25. The benefits to Belarus of involving a foreign partner would be a one-off cash injection from a sale, access to finance, and access to foreign expertise.

4.26. Selling the transit routes would present Belarus with a short-term gain at a selling price set to capture expected future rent from the routes. However, Belarus' transit role is one of its key strategic assets and fully ceding control would remove the strategic value. Gazprom has to date established a significant presence in Belarusian transit with ownership of the Yamal I pipeline.

4.27. The value of transit control in the face of Russian pressure was illustrated in January 2006 when Gazprom interrupted gas supply to Ukraine. While Russia's motives appeared to regard Ukraine only, Ukraine was able to strengthen its position by leveraging its control of transit to Europe. Although the Belarusian transit position would not be as robust as Ukraine's it still strengthens its position in dealing with the political and economic misbalance between itself and Russia.

4.28. A joint venture has the advantage of enabling access to Gazprom's finance and technical and operational expertise while maintaining a degree of Belarusian control over decision making in the transit routes. By offering a stake to Gazprom, Belarus' position against competing routes would be strengthened. Another option would be a joint venture with receiving country(ies). This would enable Belarus to diversify away from Gazprom while still creating an interest in transit across its territory. Receiving countries are clearly interested in diversifying and strengthening import routes from Russia, as demonstrated by the NGEF project.

³⁸ Assessment of Internal and External Gas Supply Options for the EU, Observatoire Méditerranéen de L'énergie.

³⁹ The gas transit fee charged by Ukraine is US\$1.6/MCM per 100 km. The fees charged by Slovakia and Germany are about US\$2.4/MCM per 100 km. "Gas Transit Tariffs," Energy Charter, January 2006 (<http://www.encharter.org/>).

4.29. An alternative to a joint venture arrangement, in which a share in the network would be sold outright, would be a concession arrangement whereby the ownership of the asset would remain in the hands of the Belarusian government, but the right to operate the network and the obligation to maintain it would be transferred to a private operator for an extended period of time (typically between 15 and 30 years). A concession arrangement would have the advantage of alleviating some of the Belarusian concerns related to the sale of its strategic asset, while at the same time it would transfer the obligation to maintain and upgrade the system to a third party. In the event a concession approach was selected, care would have to be taken to ensure that the interests of Belarus and of the concession holder remain consistent throughout the life of the concession.

Background – Belarus’ Status under the Kyoto Protocol

Belarus has ratified the Kyoto Protocol (KP) and is an Annex 1 party to the UN Framework Convention on Climate Change (UNFCCC). However unlike other transition economies under Annex 1 Belarus is unable to engage in international emissions trading (IET) or project based activities through the Joint Implementation (JI) mechanism since it does not have an emissions allowance under Annex B of the Kyoto Protocol (KP). The reason being that Belarus was not party to the UNFCCC at the time the KP was adopted and was therefore left out of the distribution of commitments and allowances.

Belarus will be eligible for JI and IET only after it is included in Annex B of the Kyoto Protocol. This will require the KP to be amended to include a greenhouse gas (GHG) emission target for Belarus. Further to the decision at the Conference of Parties (CoP) meeting in Montreal in November 2005, Belarus has submitted to the UNFCCC a draft amendment to Annex B of the KP and has initiated negotiations with parties to the KP who would need to endorse this amendment. The amendment is proposed for adoption at the next CoP to be held in November 2006 in Nairobi, Kenya.

Meeting Eligibility Requirements for IET and JI

To be able to participate in International Emissions Trading, and JI track 1, transition economies must meet the following eligibility requirements by January 1, 2007:

- Calculate their assigned amount in tonnes of CO₂e emissions, as referenced in Articles 3.7 and 3.8 and Annex B of the KP.
- Put in place a national system for estimating emissions and removals of greenhouse gases within their territory.
- Put in place a national registry to record and track the creation and movement of ERUs, AAUs and RMUs¹ and annually report such information to the secretariat of the UNFCCC.
- Annually report information on emissions and removals to the secretariat.

Belarus is taking appropriate steps on the institutional and regulatory front to meet its obligations under the KP and to be able to engage in the Kyoto mechanisms. Specifically, Belarus has committed to establish the following in 2006:

- (i) A national system and center for calculation of the GHG inventory - the 2004 inventory and the second national communication have been prepared. A GHG emission reduction strategy for 2007-2012 is being drafted.
- (ii) A National Registry.
- (iii) A National Body to review and endorse JI projects.

¹ Removal Units – sequestration achieved domestically in Annex 1 countries.

Potential Opportunities for Belarus under the JI Mechanism

Two areas where there are potential opportunities for engaging under the JI mechanism are:

- (i) Energy efficiency investments - Belarus for some time has had a policy to reduce energy intensity. While energy efficiency reforms² have brought tangible results³ there remains a need to continue rigorous support for these measures to achieve European standards; Belarus' energy efficiency potential is still two times above the EU average⁴.
- (ii) Land use change and afforestation - Belarus could also benefit from LULUCF projects such as afforestation within the Chernobyl restricted zone and the preservation of wetlands. Here JI revenues could help to make the case for land use change and reform. While opportunities on the JI market for such projects may be limited these could be good candidates for greening under an AAU transaction (see below).

Potential Opportunities for Belarus under IET

Belarus' greenhouse gas emissions are around 50% of their (baseline) 1990 emission levels. While these numbers are indicative, since Belarus does not yet have an established emission reduction target, this raises the possibility for Belarus to trade part of its assigned amount unit (AAU) in the first commitment period.

The potential supply of AAUs from other economies in transition is estimated at over 6 billion tonnes; more than 3 times expected demand. However the sale of all available AAUs may not be possible for a couple of reasons⁵:

- (i) potential sovereign buyers have concerns that AAU transfers are not "additional" and have expressed interest in IET only if AAUs are 'greened', i.e. AAUs that are linked to investments and activities in projects and programs with environmental benefits; and
- (ii) Buyers have expressed a preference for credible, transparent and well structured proposals for greening that provide assurance the resources will actually flow to an agreed project pipeline and that environmental benefits are achieved.

To be eligible to trade, Belarus must first meet the eligibility criteria outlined in the section above, and must develop a proposal for greening and trading of its surplus assigned amount for discussion with potential buyers. Typically, in designing a proposal for IET, a country would need to:

- Determine the volume of AAUs for trading and to be held in reserve for future commitment periods
- Review and identify the decisions, rules, regulations, and institutions are needed to (i) be able to execute trades in AAUs; and (ii) manage the proceeds of sales of AAUs
- Identify ways of using the proceeds of AAU sales to promote greening and identify the different economic sectors with investment as well as the emission reduction potential

² Supported with economic incentives on the demand side, such as raised tariffs, improved payment discipline, and tax exemptions

³ The energy intensity factor has reduced from 0.76 toe per US\$1,000 of GDP (PPP) in 1995 to 0.45 toe per US\$1,000 of GDP (PPP) in 2004 (CEM, 2005)

⁴ WDI and UNFCCC statistics.

⁵ These requirements are expected to substantially reduce (by 50% or more) the amount of available AAUs that could be offered for trade.

- Outline a design option(s) for an AAU backed green investment scheme

Actions Going Forward

On the assumption that a positive decision will be made on the amendment of the KP to include an assigned amount for Belarus in December 2006; and that this will be endorsed by parties to the KP, it would be prudent for Belarus to prepare the necessary groundwork to engage in JI and IET. Since Belarus would at the end of 2006 be lagging in progress on both fronts when compared with other transition economies it will be important to be able to move quickly to establish credibility in the market.

As Belarus at this point does not have experience with the JI mechanism to be able to engage in JI or IET it would be important to demonstrate to the market that Belarus is a credible partner. The list of immediate actions includes the following:

- (i) Continue, as a priority, with current programs to meet eligibility criteria for JI and IET by January 1, 2007
- (ii) Establish a pipeline of projects under the JI track 2 mechanism to demonstrate that the appropriate regulatory frameworks are in place and conditions in Belarus are conducive to investment in JI projects.
- (iii) Review and examine conditions for trading in AAUs and develop a proposal for engaging with potential buyers through for example a green investment study.

It is recommended that while decisions are pending that priority is placed on (i) and (ii) and once the situation regarding Belarus' assigned amount is clearer that work commences on (iii).

The World Bank could potentially support (i) and (ii) through the following activities:

- Review of Belarus' KP compliance plan, with a view to providing support to improve the plan and/ or increase its effectiveness
- Review of Belarus' second national communication and in conjunction with sector specialists from the World Bank provide support to identify a potential pipeline of KP opportunities that would be worthwhile to pursue under track 2 JI
- Assistance to Belarus to help with JI Track 2 project development
- Capacity building assistance for JI/ IET institutions

In terms of support for (iii), the Bank has experience through activities with other transition economies (Bulgaria, Ukraine, Latvia and Russia) in the development of options for trading of assigned amount units. Similar support could be provided to Belarus if there were a positive response from COP/MOP 2.

An indicative list of secondary legislation to complement the Draft Law of the Republic of Belarus on Non-Traditional and Renewable Energy Resources

- “White Paper on Renewable Energy Policy” providing the precise objectives, quantitative targets, policy instruments and expected economic and environmental outcomes from the policy.
- Law introducing state financial support to investments in renewable energy (RE) – could include the creation of a the following measures: i) RE-Fund, ii) tax credits, iii) guaranteed topping-up tariffs, and iv) support to research, development, and demonstration (R&D&D).
- Law providing RE- independent power producers (IPPs) and surplus producers with right to be connected to the grid and to sell to the single buyer, and defining who pays for the costs of connection, metering, etc. as well as upgrading of the distribution grid (when required).
- Changes to the Electricity Law, empowering the Government to impose obligatory use of wood-fuels in specified (types of) plants for heat and power supply.
- New land use regulations favoring accelerated development of fast growing wood-fuel forests on degraded lands (including clarification of ownership or long-term user rights to the land).
- Laws and ordinances delegating the implementing powers for specific interventions to specific authorities.
- Regulations defining procedures for expedient and coordinated approval of RE-projects (construction, land use, etc.).
- Regulations introducing simplified procedures for environmental impact assessments for specified types of RE-generators.
- Regulation imposing reporting requirements on RE-generators.
- Circulars defining how the level of subsidy support is to be calculated.
- Circular defining the formula for how the price of surplus heat from RE-based heat production, which is sold to district heating systems is to be calculated.

Options and rationale for financial support to renewable energy technologies (RETs)

Overall, there are seven types of **RE-subsidies**, each driven by a specific motivation:

- 1) Subsidies given to RETs to *compensate for price distortions in the energy market*, which prevent economically viable RETs from competing on equal footing with conventional power supply. (e.g. subsidized natural gas prices in thermal power).
- 2) Subsidies to RETs to *compensate for the non-inclusion of external costs* in the financial cost of production of conventional power (environmental costs or macroeconomic costs of fuel price risks)
- 3) Subsidies to RETs to *compensate for weaknesses in the financial markets*, which prevent RETs from getting access to debt finance on competitive terms with conventional power plants. .
- 4) *“Market jump-starting” subsidies to RETs* with a mass market potential (household PV-systems), which create the minimum demand needed to motivate entrepreneurs to invest in an effective marketing and after-sales-service infrastructure for the RET.
- 5) *“Learning curve” subsidies to RETs* with a strong potential for technological progress (wind energy, PV-systems). They create the mass market demand which motivates manufacturers of RET to invest considerable amounts in R&D bringing down each year the cost of production of new generations of the RET. Subsidies, which increase consumer demand for new RETs, thus, expand the market directly in the short term and, by accelerating the rate of cost reductions in the subsidized RET also in the long term.
- 6) *“Sustainable development” subsidies to RE*. These subsidies allow RETs with an economic cost of production higher than conventional power production (according to conventional economic cost analysis) to gain market shares. Because conventional power production uses finite resources and contributes to global warming it is not considered to be sustainable.
- 7) *“Picking the winner” subsidies to R&D&D* in potentially promising RETs that are at the pilot stage of development.

Portfolio of Financial Supporting Instruments

The portfolio of financial support instruments used to increase the market share of RE-generated energy is summarized in the matrix below.

The rows identifies four **potential financing sources** for subsidies to RE:

- (i) subsidies financed by the public budget,
- (ii) subsidies raised through electricity invoices,
- (iii) subsidized export credits for RETs and soft loans from development banks,
- (iv) payments for greenhouse gas reductions from use of RE

The columns point out three **potential subsidy targets**:

- (i) subsidies to investments,
- (ii) subsidies to output
- (iii) subsidies to the cost of operation

All strategies for increasing the share of RE in national energy supply involve the use of subsidies to some degree, and all use a portfolio of subsidy instruments to promote the defined goal. Most subsidy instruments in the table are complementary to each other, and the few that are direct alternatives can be modified to co-exist. There is, thus an "infinite" range of subsidy combinations. The "ideal" subsidy package depends on its political expediency, the scope and scale of potential RE-supply in the country, and the power market philosophy of the Government.

Portfolio of Subsidy Instruments for RE			
Financing Mechanisms	Subsidy Targets		
	Cost of investment	Price of output	Operating Costs
Public Budget Finance Instruments	<ul style="list-style-type: none"> • direct capital subsidies • soft loans • VAT exemption • Import duty exemption • Accelerated depreciation • Tax holidays on income • Subsidies to exporters of RET-equipment • Subsidies to R&D&D 	<ul style="list-style-type: none"> • topping-up premiums to producers • production tax credit • topping-up premiums to consumers • VAT/excise duty exemptions • Public green electricity purchases 	<ul style="list-style-type: none"> • Subsidies to the marketing of green electricity
Electricity invoice financed instruments	<ul style="list-style-type: none"> • Grid reinforcement (deep connection costs) paid by utilities • Part of (shallow) connection costs paid by utilities • R&D&D of power utilities on interfaces between windfarms and regional/national power system 	<ul style="list-style-type: none"> • Premium feed-in-tariffs for RET-electricity • Renewable portfolio standards with or without RECs • Eco-taxes on alternative fuels • Voluntary green consumer premium tariffs 	<ul style="list-style-type: none"> • Wheeling tariff below the true opportunity cost of utility • Balancing costs charged to consumers not to generators • Use-of-system charges fixed below cost • Subsidized administration of green invoicing
Subsidized export credits to RETs	<ul style="list-style-type: none"> • Soft loans for RE-investments • Grants for project preparation 		
Greenhouse gas payments		<ul style="list-style-type: none"> • CO₂-certificate • CER-/JI revenue/kWh 	

Appendix 3

The appendix provides recommendations on how to increase the production of fuel wood in Belarus in a rational and environmentally sustainable manner. The recommendations were developed by Electrowatt-Ekono consultants based on a short mission to Belarus and the review of the government program that sets the target of producing 25% of electricity and heat from domestic energy and renewable resources. Moreover, the appendix shares Finland's experience in production of fuel wood.

The program sets the target to increase the production of fuel wood by 4,79 Ms-m³ and woodworking waste by 340 000 s-m³ from 2005 by the year 2012. While the wood stock is sufficient to meet this target, the present fuel wood production practices will not provide for an optimal use of the forest resources and may have an adverse impact on the nutrient balance. The application of the following measures will help address these concerns:

Develop a Research and Development (R&D) program

The proposed increase in the production of fuel wood requires the development of a R&D program. The ultimate objective of the R&D program is to secure that fuel wood production is done in a sustainable way integrating the fuel and raw material supply chains, optimizing rational use of national wood resources, and finally reducing forest fuel production costs. The R&D program should include the following components: (i) basic research projects, (ii) industrial /demonstration projects, (iii) development of cooperation between different organizations, (iv) development of entrepreneurship, and (v) development of suitable quality standards for wood based fuels. In addition to machine development, the focus should be on reducing the harvesting and transportation costs by improving logistics and applying modern information technology solutions within the supply chain.

The government should finance the R&D program, involve in its development both research organizations and practitioners, and facilitate its effective implementation in Belarus. While developing the program it is recommended to draw on the experience in fuel wood production and utilization of other countries, for instance Finland.

Integrate the production of fuel wood into conventional forestry and procurement of industrial timber

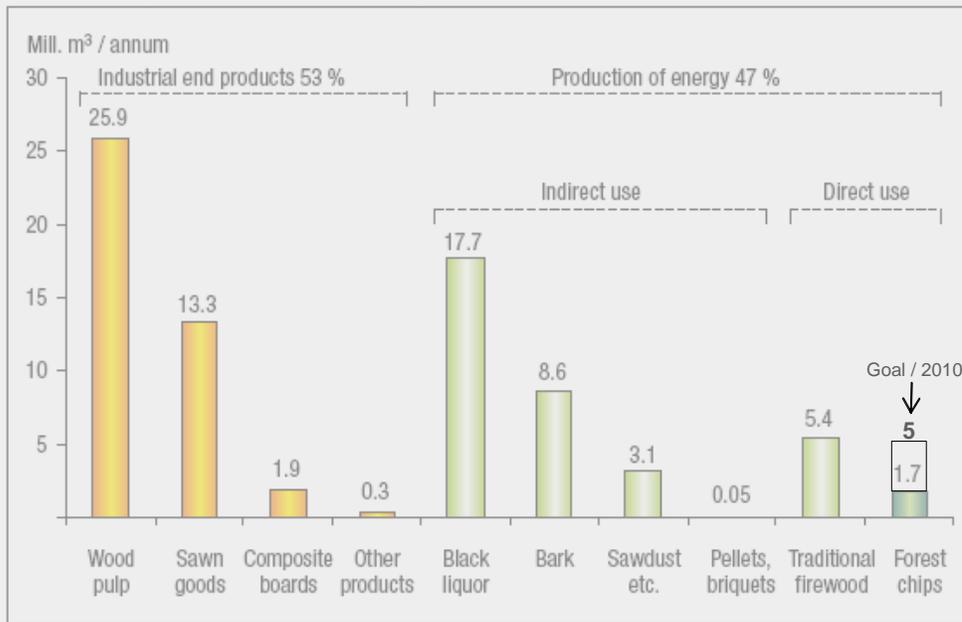
At present large quantities of harvesting residues are compiled into piles and left or burned in the forest. These residues are not utilized in energy production. However, huge volumes of not only low quality round wood logs, but also high quality logs (e.g. pulpwood) are sold as fuel wood to meet the local fuel wood demand. The use of high quality logs as fuel wood is the waste of valuable natural resources. Logs suitable for industrial further processing should be primarily processed to wood products giving much more value added than just burned as a fuel.

Since forest biomass is to be recovered as a by-product of industrial timber, the integration of operations should be a natural solution. Therefore, there is a need to invest in mechanical and chemical wood processing capacity. This in turn would increase the demand for high quality wood logs and effective forest management practices, leading to an increased supply of forest fuels. An exception is the early thinnings where fuel is the primary product and pulpwood only a side product, if it is recovered at all. In these young stands, machine contractors can operate independently of the forest industry timber procurement organizations and form networks for delivering forest chips to local heating and power plants.

Production of Fuel Wood in Finland in 2002 (recycled wood excluded)

The total consumption of wood in Finland is about 75 million m³ annually. Wood and the entire forest cluster have played a very significant role in the national economy. At present, over 90% of the wood harvest is used as raw material by the forest industries. Only 5 million m³ per annum is used directly for fuel, but much more energy is derived from forest industries' processing residues.

Process residues included, *almost a half of the wood used in Finland ends up as fuel*, either directly or indirectly. Consequently, 20% of the total consumption of primary energy, corresponding to 7.1 Mtoe in 2004, and 12% of the electricity, is derived from wood-based fuels.



Increase the use of woodworking waste

At present only about 40% of the available woodworking waste is utilized in energy production in Belarus. In other words, about 1.71 million m³ or 0.27 mtoe is wasted. Efforts should be undertaken to maximize the utilization of the available woodworking waste.

Assure quality standards for forest chips

The quality of forest chips is dependent upon the source of biomass and the techniques employed for comminution, handling, and storage. Different boilers demand different fuel properties. The larger the plant, the more tolerant it usually is to random variations in fuel properties. Even so, knowledge of fuel properties and careful control of quality are essential to the operational reliability and efficient combustion of all boiler systems, large CHP plants included. The role of quality becomes more pronounced as the production of forest chips increases. The quality of chips is affected by many properties such as moisture content, heating value, energy density, foliage content, ash content, specific emission of CO₂, and particle size. It is not only the averages that matter. Perhaps even more important is the random variation of properties. Variation occurs within a truck load, between truck loads, and also depends on a season. An important goal of quality control is to reduce such variations.

Increase production efficiency

There is room to increase the efficiency and reduce costs of fuel wood production since Belarus is at a very early stage of the learning curve of forest fuel production. The country would benefit from embracing best international practice and implementing the following measures:

- Developing regional forest thinning plans jointly with the bio-fuel utilization plans;
- Developing transport means for chips, uncomminuted loose residues, and composite residue logs;
- Developing technology for receiving, comminuting, handling and storage of wood fuels at energy generation plants;
- Encouraging the participation of forest machine and truck contractors in the wood fuel branch;
- Encouraging local machine and equipment manufacturers to develop suitable and more cost effective systems for wood fuel production and transportation;
- Establishing a wood fuel production association to develop the fuel production and marketing in general; and
- Supporting the development of fuel production and marketing entrepreneurship.

Finland's Experience in Production of Fuel Wood

TECHNOLOGY FOR LARGE-SCALE FOREST CHIPS PRODUCTION IN FINLAND

(Source: TEKES; Wood Energy Technology Programme 1999-2003; Developing technology for large-scale production of forest chips)

System development

A prevailing feature of the programme is a *systems approach*. A forest chip production system consists of a sequence of individual operations performed to process biomass into commercial fuel and transport it from source to plant. The main phases of chip procurement are purchase, cutting, off-road transport from stump to roadside, comminution, measurement and secondary transport from roadside to mill. The system offers the organization, logistics and tools to control the process.

The efficiency of a procurement system is highly dependent on both the environment and the infrastructure in which it is operating. Economic, social, ecological, industrial and educational factors, as well as local traditions, also have an effect. Consequently, no single production system is optimal in all countries or in all conditions within a given country. Under Finnish conditions, the operating environment of forest chip procurement is characterized by the following attributes:

- The majority of the forests belongs to private non-industrial owners, the size range of holdings being typically 20–200 ha. This means small average sales volumes, cramped landing areas at nearby road sides, and frequent shifting of machines from site to site. These drawbacks increase the cost of transactions and the scaling of biomass, decrease the operational availability of machines and so *place considerable demands upon control of large-scale chip procurement*.
- Up to 90 % of harvestable biomass potential is linked to the harvesting of industrial roundwood (Figure 10). The production of forest chips must therefore be *integrated with the existing timber procurement*, but the degree of integration may vary.
- All logging machines and timber trucks are owned by independent contractors. *The production of forest chips rests on private contractors* and the profitability of their enterprises.

- The Finnish forests belong to the Pan-European Forest Certification System (PEFC). *Good forest management practices* are essential also for the production of forest fuels.
- *The demand for chips varies seasonally*, especially in smaller heating plants. It is highest in the winter and lowest in the summer, which causes fluctuations in employment. In large CHP plants, the demand for chips is more stable.
- Only small plants can base their fuel supply exclusively on forest chips. To secure fuel availability, to reduce the costs, and to level out quality variation, *larger plants burn forest chips mixed with bark, sawdust, peat or coal*. To keep the fuel mixture constant, chip arrivals at the plant must be strictly scheduled. This requirement complicates the logistics of forest chip procurement.

Compatibility of equipment

The integration of forest chip production with the procurement of roundwood opens up possibilities for cost savings. It is feasible to use the existing transport equipment for forest biomass when possible. However, due to differences in handling properties and destinations, special equipment is also needed.

Forest machine contractors harvest over 40Mm³ of roundwood annually. Delivery sales by self-employed forest owners included, timber truck contractors correspondingly haul 55 Mm³ of roundwood. The Nordic cut-to-length system is the only technology employed when harvesting timber for the forest industries. The equipment used by different contractors is compatible, allowing organizational flexibility.

Unfortunately, *little machine compatibility has been achieved* in the procurement of forest chips, although the annual production is not yet much more than 1 Mm³. The lack of compatibility is because the logging conditions vary considerably from the early uncommercial thinning of young stands to the final harvest of mature stands, and because the technology is still new. Several alternative production systems are in use, and each system employs special equipment that is not necessarily compatible with other systems. *Poor compatibility increases the commercial risks* for contractors and plants when they invest in new equipment, and it may result in underemployment and unnecessary shifting of harvesting machines and trucks from one site to another.

Alternative systems

A forest fuel production system is built around the comminution phase. The position of the chipper or crusher in the procurement chain largely determines the state of biomass during transportation and, consequently, whether subsequent machines are dependent on each other. Comminution may take place at the source, at the road side or landing, at a terminal, or at the plant where the chips are to be used. Four alternative production systems have been studied in the Wood Energy Technology Programme (Figure 1).

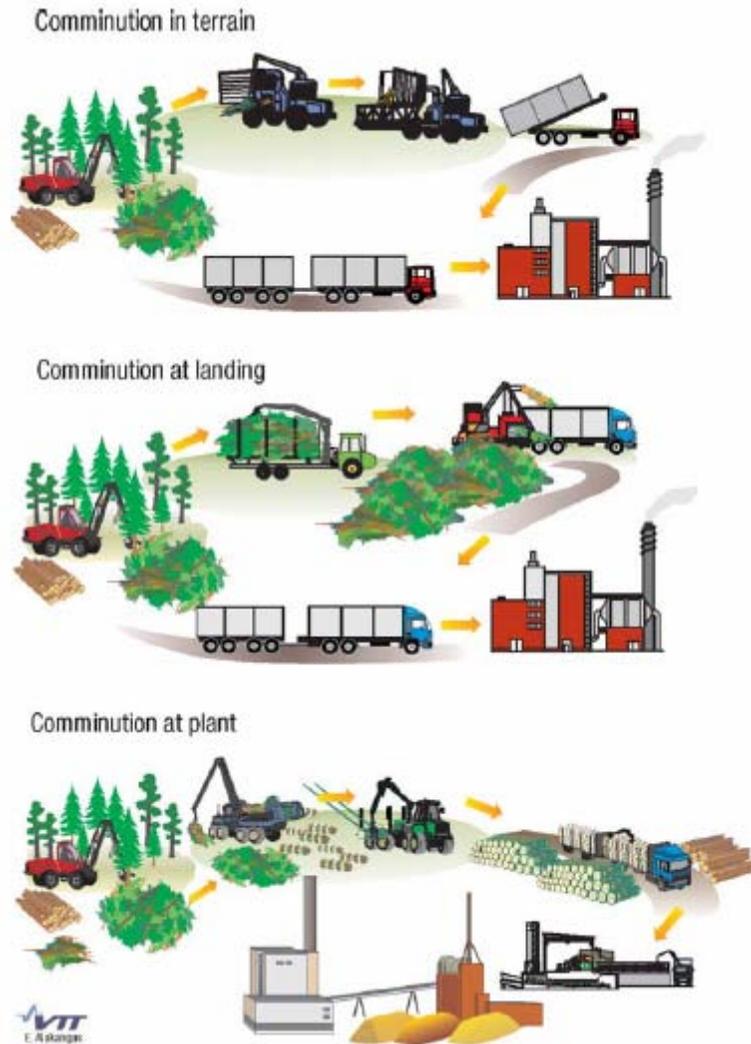


Figure 1. Alternative systems for the production of forest chips. Source VTT.

Comminution at the source, or in the terrain, requires a highly mobile chipper suitable for cross-country operations and equipped with a tippable 10–20 m³ chip container. The chipper moves in the terrain on strip roads and transfers the biomass with its grapple loader to the feeder of the chipping device. When the chipper container fills up, the load is hauled to the road side and tipped into a truck container, which may be on the ground or on a truck trailer (Figure 2).

As a single machine carries out both the comminution of biomass and the off-road transport of chips, the cost of shifting machines from site to site is reduced, and smaller logging sites become commercially viable. The use of containers weakens the interdependence between the chipper and the truck, although it is not entirely removed. Large landing areas are not needed, but a level and firm site is necessary for the truck containers.

For off-road operation, the chipper must be as light as possible, although its strength and stability may suffer. Even so, terrain chippers tend to be too heavy for use on soft soils, while use of crushing equipment in terrain is out of question. A terrain chipper requires flat and even ground and, because of its small load size and slowspeed, its range is less than 300–400 m. Snow causes

problems in the winter and results in an increased moisture content of chips, unless the terrain chipper operates at a landing.

When large volumes of forest fuels are produced, the terrain chipping system becomes difficult to control. At present, the role of the system is diminishing.

Comminution at a landing is performed in smaller operations with farm tractor-driven chippers and in

large-scale operations primarily with heavy truck-mounted chippers or crushers. The biomass is hauled with forwarders to the landing and bunched onto 4 to 5 m high piles. This facilitates operation in difficult terrain and in winter conditions and allows longer off-road hauling distances. The forwarder operates independently of the chipper. The comminuted biomass from the chipper is blown directly into a 100 to 130 m³ trailer truck, a process that makes the system hot and vulnerable, i.e. subsequent machines are dependent on each other. A wider landing area is required than in the alternative systems because of the large road-side inventories of biomass and the simultaneous presence of the chipper and the truck.

To avoid the system from over-heating, the *truck-mounted chipper and chip truck* can be replaced by a *single chipper truck* (Figure 3). This blows the chips directly into its own containers and then hauls the load to the plant. As the chipper truck is equipped with its own chipping device and crane, load capacity suffers and the operation radius around the plant is reduced.

Landing chippers do not operate off road and can therefore be heavier, stronger and more efficient than terrain chippers. If the biomass, such as stump and root wood, is contaminated by stones and soil, it is possible to use crushers that are more tolerant instead of chippers (Figures 4 and 5).

The close linkage of comminution and trucking results in waiting and stoppages and thus reduces the operational availability. On the other hand, the landing chippers are reliable and their technical availability is rather high. The system has so far kept its position as the basic solution of large-scale procurement of forest chips.

Comminution at a terminal or plant means that road transportation of the biomass takes place before the size reduction. The biomass is transported to the terminal or plant in the form of undelimited tree sections, whole small-trees, loose logging residues or bundles. Lowbulk density restricts the operation radius, unless the biomass is bundled.

At large plants, comminution can be performed with efficient stationary crushers at low cost. At satellite terminals or smaller plants, the use of transportable chippers or crushers is more feasible, although the productivity of comminution is lower and the cost higher.



Figure 2. Pika Loch 2000 terrain chipper (Courtesy of S.Pinomäki Oy)



Figure 3. TT-97 RMS chipper truck (Courtesy of Biowatti Oy).



Figure 4. Truck-mounted Giant chipper comminuting logging residues at a landing (Courtesy of LHM Hakkuri Oy).



Figure 5. Trailer-mounted Diamond tub grinder crushing stump and root wood at a landing (Courtesy of UPM-Kymmene Oyj).



Figure 6. Timberjack 1490D residue bundler in a clear-cutting area (Courtesy of Timberjack Oy)



Figure 7. Off-road transport of residue bundles with a conventional forwarder (Courtesy of Timberjack Oy).

Comminution at the plant, based on the *bundling of logging residues* and crushing of bundles with stationary equipment, has been one of the key areas of technological development in the Wood Energy Technology Programme. In this system, logging residues are compressed and tied into 60–70 cm diameter, 3 m long bundles or *composite residue logs* (CRL) (Figure 6). A bundle of green residues weighs 500 kg and has an energy content of about 1 MWh. Bundles are

transported to the road side using a conventional forwarder (Figure 7) and on to plant with a conventional timber truck. About 65 bundles or 30 tons form one truck load. Whether it will be necessary, for safety reasons, to equip the truck with rear and side walls, is still an open question.

Efficient process control

The CRL technology is still new and has considerable development potential. Although it was introduced in Finland as recently as in 2001, many of the major producers of forest chips have already started to employ it. The rapid success of the system is a consequence of the recent development of bundling techniques and the *many indirect advantages*:

- The machines involved operate independently of each other making the system cool and reliable.
- The integration of bundle production in the procurement of industrial roundwood is simple, as off-road and on-road transportation can be performed with standard equipment.
- The bundler produces accurate real-time information about the daily production and inventories. Scaling becomes cost-free.
- The storage of bundles is simple: storage space requirement is reduced, little loss or deterioration of the biomass occurs, and long-term buffer storage is possible.
- Bundles can be unloaded from a vehicle and stored at any stage of the production chain. This possibility, as well as reliable information about the biomass inventories, create *good conditions for efficient process control*.
- The noise, dust and litter problems, which may occur in conjunction with comminution at a landing, are avoided.
- The reliability of the fuel deliveries is greatly improved, while the overhead costs are reduced.

System building components

As a chain is as strong as its weakest link, *identifying and solving problem areas play a key role in system building*. This typically requires the development of new machines, but it may also require new working techniques and work organization. Although the system approach is the principle of the programme, some projects focus on narrower topics aimed at developing and demonstrating solutions for bottlenecks in a system.

The efficiency of comminution is one of the key areas. *Efficiency is understood in its broad sense*: high output, flexible adjustment in the system, reliability, good product quality, and minimum harmful environmental impact. Among the comminution equipment developed and studied are the Pika Loch 2000 chip harvester of S. Pinomäki Ky, capable of tipping its load from 4.2 m height directly onto a truck trailer; the truck-mounted Giant chipper of LHM Hakkuri Oy, capable of producing evensized chips from different kind of loose and bundled biomass; the farm tractor-mounted TT-97 RMT drum chipper and the TT-97 RMS chipper truck from Heinola Sawmill Machinery for carrying out both road-side chipping and chip transport; a two-phase crusher prototype; and the 1490D residue bundler of Timberjack Oy.

The programme has also participated in the development and demonstration of the Timberjack 720 and 730 multi-tree feller heads for the mechanization of small-tree harvesting from early thinnings; the Valtra farm tractor-based residue forwarder with enlargening load space from MetsäenergiaKy (Figure 8); the farm tractor based, load-compacting HavuHukka residue forwarder from Vapo Oy for transporting residues from source to satellite terminal (Figure 9),

and a forwarder-based prototype combi-machine developed by Antti Varis for collection and hauling logging residues and simultaneously preparing the site for regeneration.



Figure 8. A Valtra farm tractor-based residue forwarder with enlargening load space (Courtesy of TTS-Institute).



Figure 9. The load-compacting HavuHukka forwarder for transporting residues from logging site to satellite terminal (Courtesy of Vapo Oy).

Machine development is frequently accompanied by method development, including aspects such as work techniques and adjustments in the procurement system. As machine contractors are usually paid by piece rate, measuring the performance may become a source of friction in the procurement system. Measuring unprocessed biomass is difficult, and for a low-value product the cost of measurement must be kept low. Therefore, methods for the measurement of biomass must

be developed. One of the research projects concerned with adding crown mass estimation to the computerized stem volume measurement of a one-grip harvester, based on the diameter and taper of the stem. Another project concerned a simple estimation method for determining the performance of a forwarder in the off-road transport of logging residues from stump to road side. In the CRL system, measurement problems have been solved in an ideal way, as the volume and energy content of a bundle is sufficiently constant and the bundler produces cost-free real-time information about the number of bundles.

Assessing cost factors of chip production

While fossil fuels occur in large deposits and can be produced at a constant cost, forest fuels are scattered and must be collected from a large number of stands. Technical *logging conditions in these stands vary widely*, and the variations are reflected in the productivity and cost of work.

The cost factors of forest chip production are not known sufficiently. When the Wood Energy Technology Programme was established, this lack of elementary knowledge was recognized as a serious shortcoming from the viewpoint of technology development. The effect of factors such as stand conditions and hauling distances should be known for a number of reasons:

- to identify the most advantageous stands for chip production
- to estimate the change in the cost when the demand for chips increases or quality requirements of the fuel are tightened
- to focus on the key problems in machine and method development
- to collect relevant material for practitioners for decision making.

The effect of cost factors associated with the operating environment depends on the scale of operation, the technology applied, the source and quality requirements placed upon the biomass. At the end of the fourth year of the programme, cost factor information is only available for logging residues from final harvest, whereas cost studies on smalltree harvesting from early thinnings are still in progress. Examples of the results are presented below:

- The cost of recovery depends on the yield of biomass per hectare. The recovery of logging residues from the final cut of mature spruce stands is typically 20 % of the recovery of roundwood. For pine, the corresponding figure is not much more than 10 %. Halving the recovery raises the cost of off-road transport by 10 %. The cost of harvesting is thus lowest in spruce-dominated stands, and the availability of forest fuels is best in regions where spruce is the dominating species.
- The proportion of foliage in logging residues from mature stands is 30% for spruce and 20% for pine. The cost of chips increases if the residues are left to season on the site so as to improve the quality of fuel and reduce the loss of nutrients from forest soil through defoliation. The cost increase is caused by reduced biomass recovery, the delay in the harvesting schedule, and accompanied logistical disadvantages.
- If a plant's demand for logging residues increases, the average cost of procurement increases as well, because the operations must be extended to less favourable stands and at greater distances. [Figure 10](#) shows how the average cost of biomass at plant (cost of comminution excluded) increases with growing demand. Considerable regional differences result from differences in the structure of forests and species dominance. Furthermore, a plant with a coastal location has to operate within a semicircular procurement area, whereas plants in the interior typically operate within a circular procurement area.

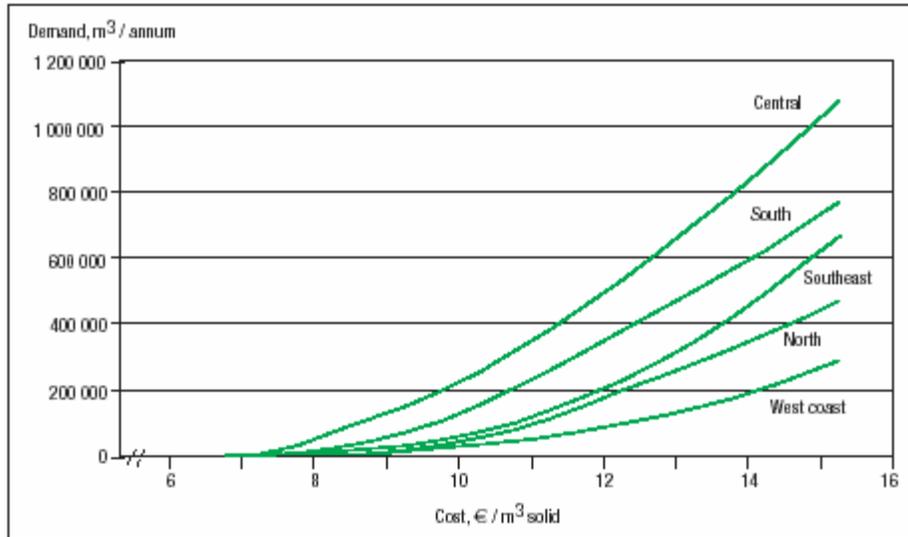


Figure 10. Effect of a plant's demand for logging residues on the average cost of transportation in different regions of Finland. Cost of comminution excluded. Source VTT.

- The small size of timber sales from private forest holdings is a serious cost factor. Proper timing and coordination of operations with neighbouring holdings could increase the harvestable fuel in a region by more than 10 % and reduce the average costs by 4 to 6 %.

Truck transport of forest chips

Truck transport is the largest single cost factor in the procurement of logging residue chips, constituting up to one third of the total cost at the plant. As the use of forest fuels grows, the average distance and the cost of transport will also grow further.

At present, forest biomass is delivered to the plant mainly in the form of chips. Most of the trucks used for hauling forest chips were originally designed for operating on better roads and for other materials such as sawmill chips, sawdust, debarking residues and peat. They are not ideal for use on forest roads and cramped landing sites. The *unsuitability of trucks strains the productivity* because of slower driving speed, increased waiting times and under-utilization of load capacity. Drivers of these trucks are often unaccustomed to side roads and therefore reluctant to use them. Consequently, shortage of trucks is not uncommon.

Along with the increase in the use of forest chips it has become necessary, but also easier, to employ special trucks for forest chips or even uncomminuted residues, and to develop efficiency by means of advanced logistic control of transport. The following topics have been studied in the programme:

- Compaction of chips to increase bulk density in conjunction with loading from the chipper. Compared with blowing, a belt conveyor equipped with a mechanical ejector was found to compress the load volume by up to 15 %.
- Truck transport of uncomminuted loose residues (Figure 11) and residue bundles.
- Logistics of forest fuel transport. The use of an internet-based, general-purpose logistics control system applying mobile terminals was studied. Among the aspects investigated were vehicle

control and terminal logistics, navigation of vehicles, and work planning and instruction delivery by internet to mobile terminals.

There is considerable *development potential in the logistics control system* (Figure 12). The advantages mentioned by the participants of the project under consideration are “paper free truck cabin”, decreased need of cellular phone calls, and GIS/GPS supported navigation. Technology should be developed further to support the whole business process of the truck entrepreneur so that the information needed in planning, operative work and invoicing could be monitored by the system.



Figure 11. Loading uncomminuted logging residues onto a special truck+trailer unit (Courtesy of Metsäteho Oy).



Figure 12. Internet-based logistics control systems help to reduce the cost of chip procurement and improve the reliability of fuel supply (Courtesy of Biowatti Oy).

Control of fuel quality

The quality of forest chips is dependent upon the source of the biomass and the techniques employed for comminution, handling and storage. Consistent particle size, as well as low contents of moisture, foliage and ash each improves the efficiency and economy of combustion. However, *different boilers demand different fuel properties*. The larger the plant, the more tolerant it usually is of random variations in fuel properties, mainly because large boilers employ the fluidized bed technology. Even so, knowledge of fuel properties and careful control of quality are essential to the operational reliability and efficient combustion of all boiler systems. *The most important single quality factor is the moisture content* of chips, as it affects the heating value, storage properties and transport costs of the fuel. Moisture content is thus a direct cost factor, and it is taken into account in the pricing of fuel. An excessive moisture content results in a price reduction, while a low moisture content may bring a bonus.

The moisture content of fresh biomass must be reduced to obtain the full energy potential. Moisture is a critical fuel property, especially in the winter time (Figure 26), as a reduction in the moisture content occurs only during the summer. Maintaining the reduced level of moisture during the autumn rains requires careful planning and timing of operations. During recent years, the procurement organizations have managed greater control of the moisture content, and truck loads of fuel with an excessive 55–60 % moisture content are no longer common. Nevertheless, energy is still lost because biomass arrives at the plant with an excess of moisture.

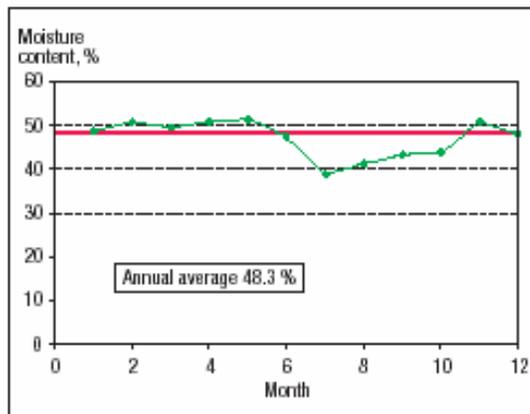


Figure 13. Seasonal variation of the moisture content (green mass basis) of forest chips arriving at plant in 2000. Average of several plants. Source VTT.

Forest chips that contain *high quantities of needles may cause combustion problems* because of their high contents of alkali metals and chlorides. Depending on the combustion conditions, the alkali metals can be oxidized or they can form sulphates or chlorides. If onlywood chips are burned, the sulphur content is low and chlorides are formed. The chlorides tend to be condensed on heat transfer surfaces of the boiler causing the risk of high-temperature corrosion. If the sulphur content of the fuel is increased, e.g. by mixing peat with chips, sulphates are formed instead of chlorides, and the risk of corrosion is avoided. Unless the needle problem in combustion is solved, forest chips cannot be allowed to contain a high needle content, which means friction in the logistics and increased costs. Therefore, this topic is given considerable emphasis in the program.

Examples of the projects dealing with the *quality yimprovement of forest chips* in the Wood Energy Technology Programme, as well as *quality aspects of industrial processing residues*, are:

- quality control of logging residues and small diameter trees by means of seasoning
- critical properties of wood fuels in respect of power plant availability
- chemical changes in wood fuels during storage and thermal drying, and the effects of the changes on fuel properties, occupational health hazards and emissions during storage
- flue gas emissions from cofiring by-products from the plywood and particle board industries
- boiler corrosion in conjunction with the cocombustion of wood and sludge
- improving the combustion properties of bark: reduction of moisture content prior to storage, removal of impurities, and optimizing storage
- use of forest chips in large fluidized bed boilers
- improving the particle size of chips through chipper development
- suitability of small-diameter wood for pulping, and setting of boundaries between pulpwood and fuelwood.

Receiving and handling forest chips

Wood fuels differ from peat and coal in respect of their handling properties, such as particle size, particle size distribution, bulk density, moisture content and fluidity. Differences also occur amongst the wood fuel. For example, forest chips and debarking residues behave differently as fuels.

Modern boilers, fluidized bed boilers in particular, make possible the efficient use of non-homogenous forest fuels, and to cocombust them with other fuels. In large plants, *forest chips are often blended with bark and peat* to homogenize and standardize the mixture.

Receiving, handling, mixing and feeding are problematic where the plant is not prepared for the special properties of chips and chip truck. As these operations are an essential function of a forest fuel production system, they are given an important position in the Wood Energy Technology Programme. The following topics are being addressed:

- Development of inbound logistics of arriving chip trucks in order to reduce the time used for queing and unloading.
- Adjusting plants designed for peat trucks unloading sideways to accept chip trucks unloading backwards.
- Making a homogenous mix from a variety of fuels. Mixing is usually performed at the receiving station of the plant, but it may take place also in conjunction with intermediate fuel storage when loading or unloading fuel silos.
- Adjusting handling equipment, such as disc screens and conveyors, to cope with chips containing over-sized particles, impurities and excessive moisture.
- Developing comminution of forest biomass with high-capacity stationary crushers at the plant.

When old technology is replaced, or a Greenfield plant is built to use forest chips, *participation of the forthcoming chip procurement organization in the planning phase is necessary*. Since the mid 1990s, a large number of heating and CHP plants have been refitted with the technology required to use forest chips. This has greatly increased the utilization capacity of forest fuels in Finland. It has been learned by experience, that *due consideration must be given to the differing properties of forest chips* and the specific demands of the forest fuel procurement system. Otherwise, the fluency of fuel deliveries, reliability of fuel feeding and the quality of fuel may suffer.

Impacts of biomass removal on forestry

The fundamental rationale for the promotion of forest energy is the reduction of greenhouse gas emissions, i.e. the protection of the environment. It follows that the *production must be in agreement with sustainable forestry*. Although the Wood Energy Technology Programme is primarily aimed at developing new technology for forest chip production, the impacts on the ecosystem and forestry can not be ignored.

Studying the effects of intensive biomass removal requires long-term biological experiments and permanent sample plots in forests. This is beyond the scope of short-term technological projects. However, credibility of the system development presupposes that its impacts are taken into account and evaluated. The goal must be prevention, or at least the minimization of possible harmful effects.

The greatest concentration of plant nutrient elements occurs in the parts of the tree, such as foliage, where essential life processes take place. It is thus inevitable that the extraction of crown mass means an increase in nutrient loss from the forest; more in fact than the increase in biomass yield would suggest. In comparison with conventional stem-only harvesting, each percentage increase in biomass recovery from crown mass with foliage incurs increased nutrient losses amounting to 2– 3 % for pine, 3–4 % for spruce, and 1.5 % for leafless hardwoods. Yet, particularly in managed forests, *crown mass represents such a large proportion of the fuel potential that large-scale bioenergy production would not be feasible without it.*

Yield studies show a decline in growth after crown mass removal. However, scientific experiments carried out in Finland and other Nordic countries do not correspond to the every-day practice in the following respects: crown mass has been completely removed from the experimental stands, which would never be achieved operationally; the growth loss caused by 4 m wide strip roads in thinnings has not been taken into consideration; and in the control plots representing stem-only logging, residual biomass has been distributed manually evenly across the whole site in an ideal way, which is not the real case in mechanized cutting operations. Results from scientific experiments only seldom include allowances for the differences between experimental treatments and actual harvesting practices, thus causing confusion among forest owners.

Even though the results may be exaggerated, the problem is real enough. The programme sees *the control of nutrient loss* to be an important aspect of the development of harvesting techniques. The following possibilities occur:

- No technology is able or intended to remove all crown mass from the site. For example, the salvage of logging residues from the final harvest, irrespective of the system applied, extracts only some 70 % of the crown mass.
- Summertime transpiration drying is an effective way of achieving the simultaneous reduction in moisture content and partial defoliation in small whole trees and logging residue heaps on the site. However, the flow of fuel from the logging site to the energy plants slows down, and the recovery of biomass is reduced.
- In small-tree operations, especially in young pine stands, topping the trees means compromising the principle of whole-tree logging, but it reduces effectively the loss of nutrients. If a 3 m top from a pine tree is left on the site in an early thinning, needle recovery is reduced by 52% but the overall recovery of whole-tree chips is reduced by only 8 %.

- Nutrient loss caused by intensive biomass recovery can be counteracted by *the recycling of ash*, the loss of nitrogen excluded. A precondition of feasible ash recycling is proper ash management at the plant. Cofiring of biomass with fossil fuels, municipal waste or peat results in diluting the nutrient content of ash and is therefore a serious constraint to recycling. So far, the programme has not developed ash recycling technology. But to assure the safe handling, storage and use of ash, an ongoing project is developing tools to predict the radioactivity of wood ash. A life cycle analysis of wood fuel use has also been carried out.

The negative effect of biomass removal on forest growth can be largely reduced by these means. From the viewpoint of the forest owner, possible *growth losses should be weighted against the silvicultural benefits* achieved:

- Precommercial thinnings, the Achilles' heel of the Finnish forestry, are encouraged. Tending young stands results in the increased growth of industrial timber.
- The removal of logging residues from regeneration areas improves the productivity and quality of site preparation and planting. A cost saving of €100/ha may be achieved.
- The removal of logging residues and stumps creates favourable conditions for the mechanization of planting. About 80 000 ha are reforested each year in Finland by manual planting, but a serious shortage of forest labour is becoming an insurmountable barrier. The effect of biomass removal on the conditions for mechanized planting is being studied in the programme.

INSTITUTIONAL FRAMWORK IN FINLAND

Background

Finland is the world leader in utilisation of bioenergy and currently about 20% of the primary energy is derived from wood-based fuels. Finnish forest industry has the central role in converting woodbased residues into heat and power.

However, meeting the challenges of the mitigation of climate change has lead to the commitment to double the use of the renewable energy sources by 2025, as compared to the situation in 1995. The main focus is on wood-based bioenergy. The main source of wood-based fuels is processing residues from the forest industries. However, as all processing residues are already in use, an increase is possible only as far as the capacity and wood consumption of the forest industries grow. Energy policy affects the production and availability of processing residues only indirectly.

Another large source of wood-based energy is forest fuels, consisting of traditional firewood and chips comminuted from low-quality biomass. It is estimated that the reserve of technically harvestable forest biomass is 10–16 Mm³ annually, when no specific cost limit is applied. This corresponds to 2–3 Mtoe or 6–9 % of the present consumption of primary energy in Finland. How much of this reserve it will actually be possible to harvest and utilize depends on the cost competitiveness of forest chips against alternative sources of energy.

A goal of Finnish energy and climate strategies is to use 5 Mm³ forest chips annually by 2010. The use of wood fuels is being promoted by means of taxation, investment aid and support for chip production from young forests. Furthermore, research and development is being supported in order to create techno-economic conditions for the competitive production of forest chips. The combustion capacity of the present and planned heating and power plants is sufficient to absorb practically all competitively priced woody biomass available. As a result of the recent

technological development, even stump and root wood can be used by large power plants equipped with modern fluidized bed technology.

Considerable progress is taking place in the technology of chip production, e.g. the successful CRL system based on bundling of residues and crushing at the plant. Nevertheless, the production of chips rather than combustion technology still remains the real bottleneck for the utilization of the bio-mass potential of the Finnish forests. The main barrier is the high price of chips.

Means to promote biomass based fuels

The objective of the Government's energy policy is to create circumstances that ensure the availability of energy, keep the price of energy competitive, and enable Finland to meet its international commitments with respect to emissions into the environment.

Wood fuels becoming available from industrial processes depends directly on the future growth of the forest industries. As a rule, using these by-products for energy is profitable, and the production technology is not a key issue.

Wood fuels derived directly from low-quality forest biomass. Here, the resource would enable an even higher increase than that outlined, and the availability of the biomass is not connected with future growth of the forest industries. Instead, a major barrier to the increased use of forest biomass as a source of renewable energy is its poor price competitiveness in respect to other fuels. Consequently, the development and commercialization of innovative forest fuel production technology is essential.

However, as the demand for forest chips increases, availability starts to cause concern. In addition to developing technology and reducing costs, non-technical barriers must also be addressed in order to encourage forest owners, forest machine entrepreneurs and chip producers.

The Government's aim is to make all forms of renewable energy economically competitive on the open energy markets. The following support measures are employed:

- ***Energy taxation on fuels used for heat production***

A carbon-based environmental fuel tax was imposed in 1990. Wood-based fuels are free of the tax because of their carbon neutrality.

- ***Support to electricity production***

A tax of 6.9 €/MWh is levied on electricity, whether domestic or imported, rather than on fuel input. If forest chips or wind are used for the production of electricity, the tax is refunded to the producer.

- ***Aid for investments***

Financial aid can be granted to development and investment projects in order to promote the conservation of energy, to improve energy efficiency, to promote utilization of renewable energy, to improve the security of energy supply, and to reduce harmful impacts of the production and use of energy. For special equipment used in the production of forest chips, the investment aid is typically about 20% of the costs. Projects involving innovative technology are given priority.

- ***Support for the production of forest fuels***

When small-diameter fuelwood is harvested from young forest stands, a subsidy of about 5.5 €/MWh is paid to chip producers. The stands must meet specific silvicultural criteria. No direct

support is awarded for the production of fuel chips from logging residues from late thinnings or final harvest.

• ***Public financial support to development and commercialization of technology***

The National Technology Agency, Tekes is responsible for technology R&D funding. Tekes allocates annually 10 million euros to the RES sector. The Ministry of Trade and Industry gives financial support to demonstration projects.

The main R&D programmes on bioenergy include:

A) Bioenergy Research Programme (1993–1998), which was aimed at the production, use and conversion of wood and peat fuels in 1993–1998.

B) Wood Energy Technology Programme (1999–2003), that is focused on the development of technology for the large-scale production of forest chips.

The availability of forest biomass is not a limiting factor since the potential greatly exceeds the target. The capacity of heating and power plants also soon exceeds the target: new wood fuelled plants have been established and old plants have been modified to receive, handle and burn chips. The real limiting factor is the production of chips at competitive cost.

The ultimate target of the Wood Energy Technology Programme is to create favourable conditions for increasing the use of forest chips. Consequently, the programme is aimed at developing the production technology and procurement logistics for forest chips. The emphasis is on system development for large-scale operations in conjunction with combined heat and power production.

Preconditions for a rapid increase in the use of forest chips are the reduction of costs, improved quality of chips, and reliable delivery systems. Chips must also be produced by environmentally sound methods that support sustainable forest management.

The primary targets of the programme are:

- to integrate energy production into conventional forestry and the procurement of industrial timber
- to develop production systems and procurement logistics for forest fuels
- to develop technology for comminuting, bundling, handling and storage of wood fuels
- to develop long-distance transport of chips, uncomminuted loose residues and composite residue logs
- to encourage the participation of forest machine and truck contractors in the wood fuel branch
- to develop quality control for forest chips and processing residues from the forest industries
- In 2002 the scope was expanded. A sub-programme was established for small-scale production and combustion of wood fuels.

The programme has set for itself an unofficial goal: increasing the annual use of forest chips from 0.5 Mm³ in 1998 to 2.5 Mm³ in 2003. Unofficial statistics show that the use of forest chips was about 2 Mm³ in 2003.

The organization of the R&D programme

The programme is composed of projects that typically last 1–3 years. There are three types of projects:

- *Projects undertaken by research institutes* address common and general needs. The results and know-how achieved are in the public domain. In research projects research organizations collaborate with industrial partners.

- *Projects dealing with product development*, i.e. industrial projects, are related to practical applications. They serve specific needs of a single company or company integrate. Examples include the development of a complete chip procurement system, a less corrosive combustion technique for chips rich in needles, or a chipper, bundler, feller-buncher for small trees, forwarder for biomass transport, and a special truck for forest fuels. An industrial project commonly includes a research component that requires cooperation with a research organization. The results and experience from company projects are not necessarily in the public domain.

- *Demonstration projects* are aimed to promote introduction and deployment of new technologies in forest fuel production and combustion. Funding is primarily investment grant-aid from the Ministry of Trade and Industry.

RAW MATERIAL BASE OF FOREST CHIPS IN FINLAND

(Source: TEKES; Wood Energy Technology Programme 1999-2003; Developing technology for large-scale production of forest chips)

The annual increment of the Finnish forests is 78 mill. m³ including bark. *The drain, which is composed of fellings and natural mortality*, is 65 mill.m³ per annum. The balance is positive, but as a part of the forest area is protected and many forest owners give priority to recreation and multiple use, the possibilities for increasing fellings are quite limited. There is potential, however, in young thinning stands where the silvicultural targets are not reached.

The fellings are composed of *stemwood removals* which are recovered, and *stemwood losses* which are left in the forest. Removals are divided into *industrial wood* and *fuelwood*. The traditional forest inventories are limited to stemwood only. Crown mass and stump and root wood are omitted (Figure 1).

Stemwood loss from logging operations

Apart of the stemwood drain fails to meet the quality and diameter requirements of industrial wood. Figure 17 shows the proportion of stemwood left at site as residue in commercial logging operations. It can be concluded that:

- The proportion of residues is 20–30% in the first commercial thinning but only 4–5% in the final cutting. The smaller the trees, the greater is the loss.
- The proportion of residues is in spruce stands higher than in pine stands. This is because the minimum diameter requirement of pulpwood is stricter for spruce, and small undergrowth trees are more common in spruce stands.

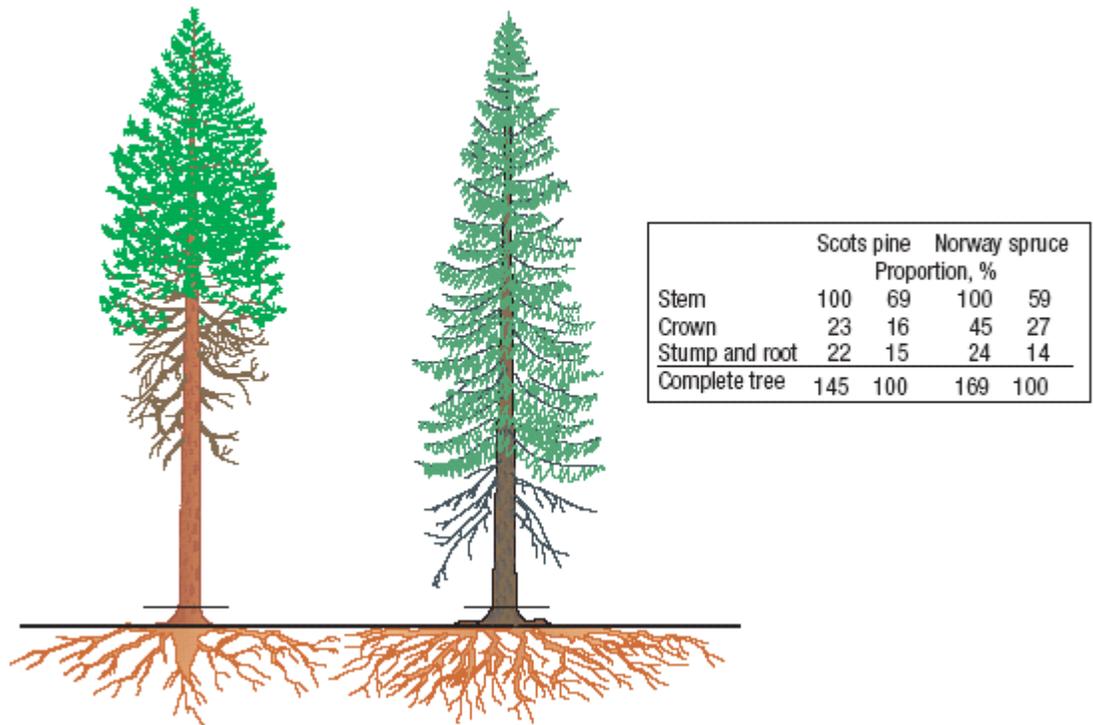


Figure 14 Distribution of biomass between stem, crown and stump-root system in final fellings

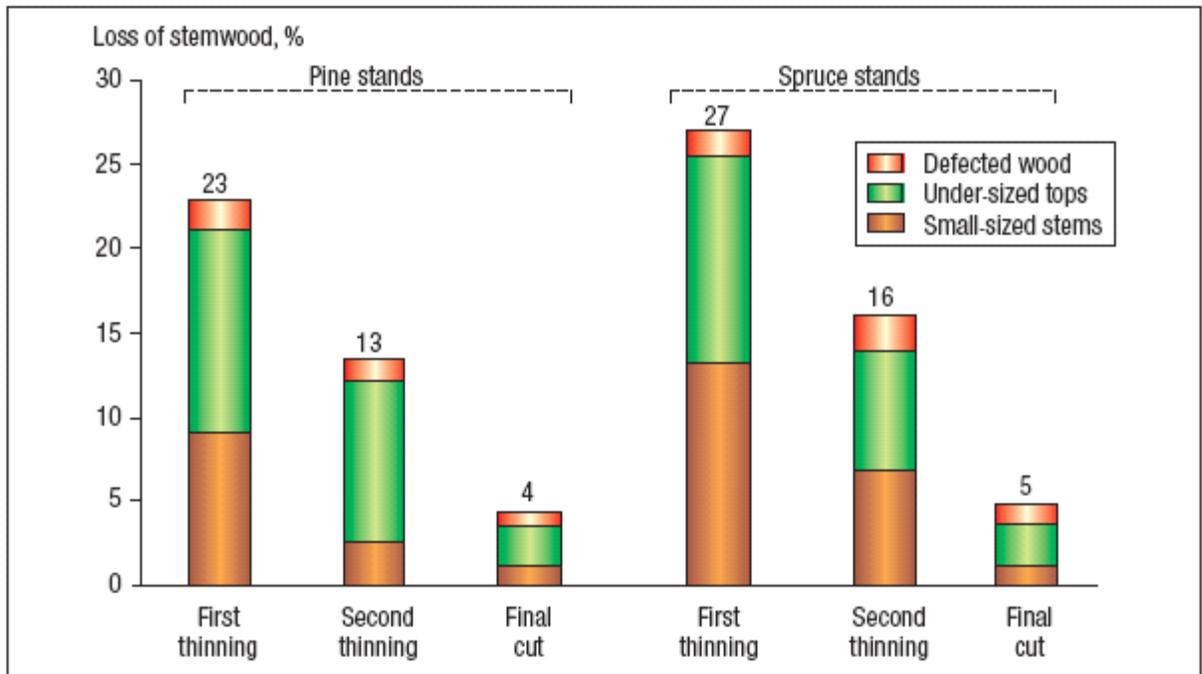


Figure 15 The relative loss of stemwood in commercial harvesting operations in 1997

- The primary source of stemwood loss is the undersized tops, especially in the first thinning, where a large number of trees is removed and the stem tapers slowly.

In the integrated harvesting of pulpwood and fuelwood, the *quality of both assortments is improved if the minimum diameter of pulpwood is increased*. The effect is opposite if the minimum diameter is decreased. This happened in 2001, as the minimum diameter of pine pulpwood was lowered to 6 cm.

The residual stemwood is potential fuel. The total amount of stemwood residues from annual logging operations in Finland is 4–5 million m³, but as it is scattered over an area of 600 000 ha, the yield per site is too low to make the salvage feasible. Profitable harvesting for energy requires richer yields. This is achieved with simultaneous recovery of residual stemwood and crown mass.

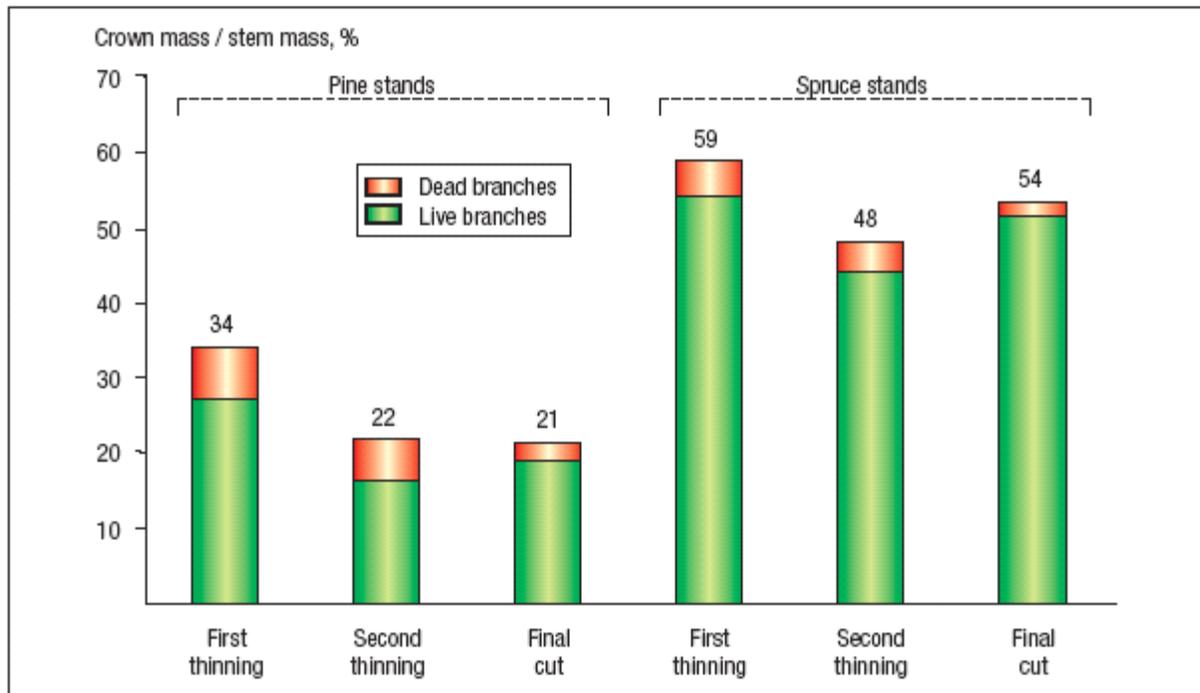


Figure 16 Crown mass in relation to stem mass. Dry weight basis.

Biomass residues from final fellings

As only stemwood has commercial value, crown mass and stump-root systems are not included in forest inventories. They are difficult to measure, and therefore biomass data on these tree components tend to be vague.

Crown mass refers to branches with leaves, live and dead. In conjunction with timber harvesting, the amount of crown mass residues is estimated using empirical crown mass/stemwood ratios. When crown mass is used for energy, it is feasible to compare dry mass rather than volume. Since the basic density of branchwood is higher than that of stemwood, the ratio is higher on the mass basis. The crown mass/stemwood ratio is typically 40–60 % for spruce and 20–30 % for pine (Figure 3).

Although the recovery of stemwood residues is not feasible as such, it becomes more attractive when the recovery of crown mass and stemwood residues are combined. Under Finnish

conditions, 80–90% of this mix is crown mass and the remaining 10–20 % is stemwood. The presence of stemwood facilitates the loading, feeding and baling of residual forest biomass. When the mix is comminuted with a chipper or crusher, the product is called *logging residue chips*.

The availability of logging residue chips is, in practice, not as plentiful as Figure 18 seems to suggest.

Some of the logging sites are out of question due to small size, long distance, difficult terrain or ecological restrictions, and in all cases it is recommended that 30 % of logging residues are left at site. If residues are left to season and shed part of the needles before haulage to road side, the yield of biomass is further reduced.

According to a common rule of thumb, the recovery of logging residue chips from regeneration areas of spruce is 0.5 MWh per m³ stemwood removed, and in pine stands 0.25 MWh correspondingly. In typical regeneration cuttings, the average yield of fuel from logging residues is 100–120 MWh/ha for spruce and 50–60 MWh/ha for pine.

Figure 4 shows the logging residue potential within a 100 km radius of plants in different parts of Finland. The national frontiers, coast lines, water systems, road networks, age structure of forests and species dominance cause great regional differences in the availability. In the central parts of the country, the availability of logging residue chips to a given location is more than 800 GWh per annum, unless there are competing users. Nationwide, the *technical availability* of logging residues from final harvests is about 11–12 TWh per annum, of which 6–8 TWh is presently *economically harvestable*.

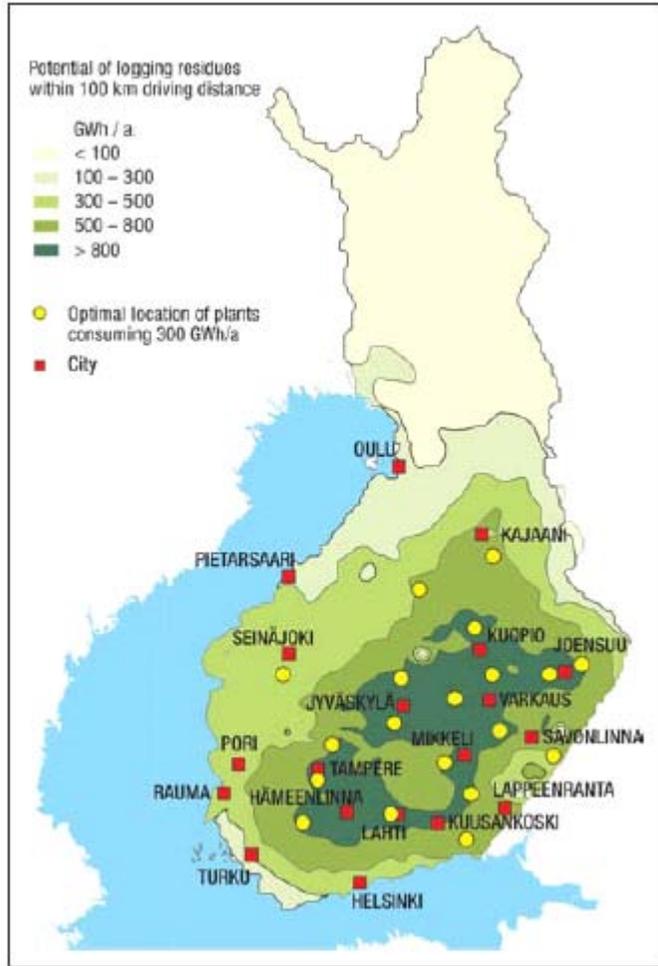


Figure 17 Logging residue potential from final fellings within a 100 km transport distance, and optimal location of power plants with an annual consumption of 300 GWh of forest chips. Smalltree chips and stumpwood chips are not included

Small trees from early thinnings

The production of forest chips for fuel was started in the mid-1950s. The primary raw material was then small trees from young thinning stands. Trees were carefully delimited, and the product was of high quality as required by the then existing chip feeding and combustion techniques.

As the cost of labor increased, the competitiveness of stemwood chips suffered, and the use of chips stagnated. The introduction of hydraulic crane in the 1970s made multi-tree handling possible. Only then could the production of small-tree chips be rationalized and delimiting was abandoned. The appearance of a new concept, *whole-tree chips*, resulted in many changes:

- The yield of chips increased 15–50 %
- The productivity of harvesting increased 15–40%
- The cost of procurement was reduced 20–40%
- The loss of nutrients from forest soil reduced 50–150 %
- The particle size distribution and other quality properties of chips suffered
- The machines had to be more robust.

The cost of small-tree chips nevertheless remained high. Production was subsidized for silvicultural reasons, but in the 1990s logging residue chips otherwise became more competitive. The increase in use was restricted exclusively to logging residue chips due to their cheaper cost, but a number of reasons have gradually appeared for extending the raw material base to young thinning stands:

- *Tending of young forests* needs to be intensified
- *Broadening the raw material base* improves the availability of forest fuels and shortens transport distances
- *Independence of the timber markets* assists the acquisition of fuel during times of depression in the forest industries when the production of other wood fuels is reduced
- *Independent chip producers* who are not involved in the harvesting of industrial timber have an easier access to raw material in young thinning stands
- *Seasonal fluctuation of employment* may be leveled by performing small-tree harvesting in the summer time when pulpwood and sawlog operations slow down
- *Diameter requirements of pulpwood* can be made more elastic to response the fluctuation of demand, if pulpwood and fuelwood are parallel products
- *Small-tree chips are of better quality* compared to logging residue chips. Small trees are easier to store and season, and they produce drier chips with a lower needle content. This is important, especially for small heating plants
- *Small-tree operations create more jobs* which are definitely needed in rural areas. However, in the long term the availability of labor is expected to decrease, and a higher need for labor may actually become a problem unless the operations are fully mechanized.

Under-sized small-tree material is available mainly in young stands where good tending practices have been neglected. Two types of fuel harvesting operations occur. If fuel is the primary product, the treatment is called *energywood thinning*. If the removed trees are thick enough to allow pulpwood to become the primary product, with fuelwood as a by-product, the treatment is called *first thinning*. In both cases, technical logging conditions are difficult because of the small size of the trees.

Stump and root wood from final fellings

The *stump-root system* is defined as all wood and bark of a tree below the stump cross-section. The use of stump and root wood for fiber and fuel was studied actively in Finland and Sweden during the 1970s and 1980s, but the cost was found to be excessive. UPM recently started to again develop the production of stump wood for fuel, and progress has been rapid.

Stump-root systems can only be salvaged from clear-cutting areas. Uprooting is carried out with heavy machines and, therefore, only stumps from saw timber-sized trees can be accepted. Moreover, thin roots break and stay in the ground. Sand and stones prevent comminution with sharp knives and so crushers are used instead of chippers. According to the earlier studies by the Finnish Forest Research Institute, the harvestable dry mass of a stump-root system is 23–25 % of the stem mass, when sideroots thinner than 5 cm are not recovered. In 2003, UPM harvested stump and root wood from an area of almost 1000 ha. The yield of fuel exceeded the FFRI research findings because stump height has increased following the replacement of manual felling by harvesters. A part of the root section thinner than 5 cm is also recovered. Figure 5 shows the dry mass and energy content of a stump-root system as a function of tree size. For example, if the breast height diameter of a tree is 30 cm, the stump-root system corresponds in pine stands to an energy content of 0.35 MWh and in spruce stands 0.40 MWh. If the number of trees is, say, 400 per hectare, the amount of harvestable energy is 140–160 MWh/ha.

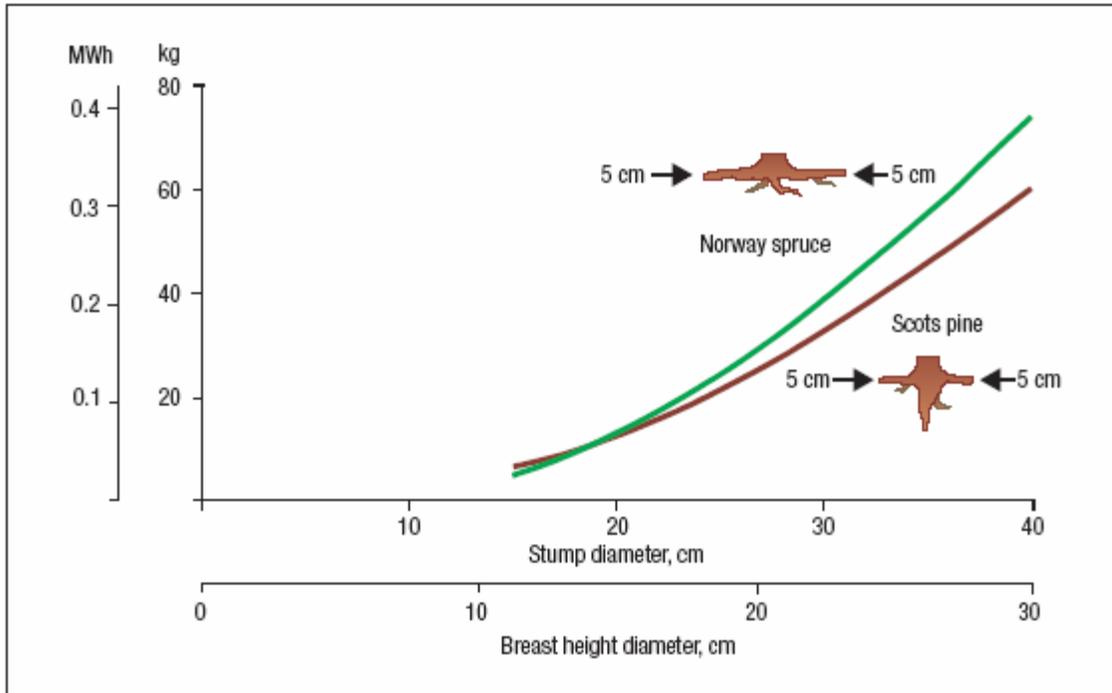


Figure 18 Dry mass and heating value of a stump-root system as a function of stump diameter. Stump cross-section at root collar height, under 5 cm root sections excluded.

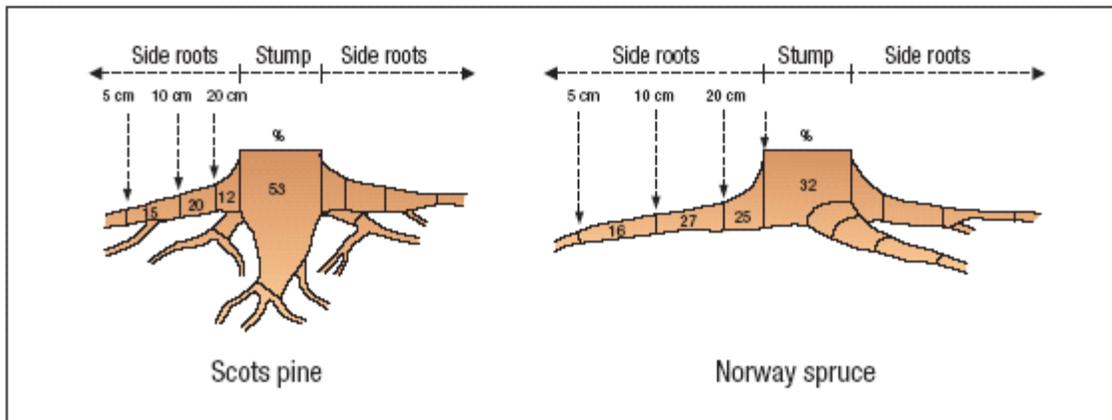


Figure 19 Distribution of dry mass in a stump-root system of sawtimber-sized trees. Under 5 cm root sections excluded.

There is an important difference in the structure of a stump-root system between pine and spruce (Figure 6). Wet peatlands and the northernmost Finland excluded, pine typically has a taproot, and only a half of the total mass is composed of lateral roots. Spruce, on the other hand, has no taproot at all, but thicker lateral roots. In spruce, therefore, the central section of the stump-root system covers only one third and the lateral roots two thirds of the total mass. The difference between the species affects the techniques of uprooting and splitting. A spruce stump is easier to harvest and causes only a shallow hole in the ground.

The removal of stump-root systems facilitates site preparation for regeneration. It also involves an opportunity to exterminate the root rot fungus from the stand, since the fungus survives in a regeneration area in the stumps and gradually infects the trees of the new generation. *Removal of stumps prevents the root-rot fungus from spreading and heals the infected site.*

Forest chip potential of the Finnish forests

Inventory data on forest resources are important for the planning of capacity, product lines and location of new forest industries. A national forest inventory has been carried out nine times since the early 1920s, and precise knowledge is available of stemwood resources.

The need for basic forest data now includes not only stemwood but all forest biomass because energy producers are prepared to invest in wood-fired heating and CHP plants, fuel producers are competing for market shares of raw material, and policy-makers are setting new targets for renewable energy. *Forest biomass, although it is renewable, is nevertheless a limited resource, and its use must be built on a sustainable basis.*

Estimations of availability begin from *the theoretical maximum potential*. This is composed of two major sources. First, it includes all residual biomass left in the forest in conjunction with timber harvesting. Secondly, it includes the small-tree biomass which is removed, or should be removed, for silvicultural reasons in precommercial thinnings of young stands. The former is dependent on the markets of forest products, whereas the latter is free of market fluctuations.

Only a part of the maximum biomass potential is recoverable. Many technological, socio-economic and environmental factors affect the availability:

- Price development of alternative fuels, taxes and subsidies
- Development of procurement technology and logistics
- Motivation of forest machine and truck contractors to participate
- Development of the quality requirements of forest chips. For example, will the foliage be taken or left?
- The acceptance of private forest owners, which is affected by the price paid for biomass
- The energy and climate policies at the national and EU levels. The trade of CO₂ emissions will be of utmost importance.

In Figure 7, the technological and environmental factors have been taken into account, but no price assumptions have been applied. The *technically harvestable potential* is estimated separately for five different types of logging operations:

- *Energywood thinnings* are tending operations in young stands in which the owner has earlier neglected good forest management. Because of the small size of the trees, the primary product is fuel. The age of the stands is typically 15–25 years and a majority are dominated by pine, but the removals may be composed of hardwoods. The cost of harvest is high, and subsidies are necessary to make the recovery possible.
- *First thinnings* refer traditionally to the first commercial logging operation of a stand, normally at the age of 25–40 years. Pulpwood is the primary product, but as 20–30 % of the stemwood drain does not meet the minimum dimensions of pulpwood, first thinnings may also yield substantial quantities of fuelwood.

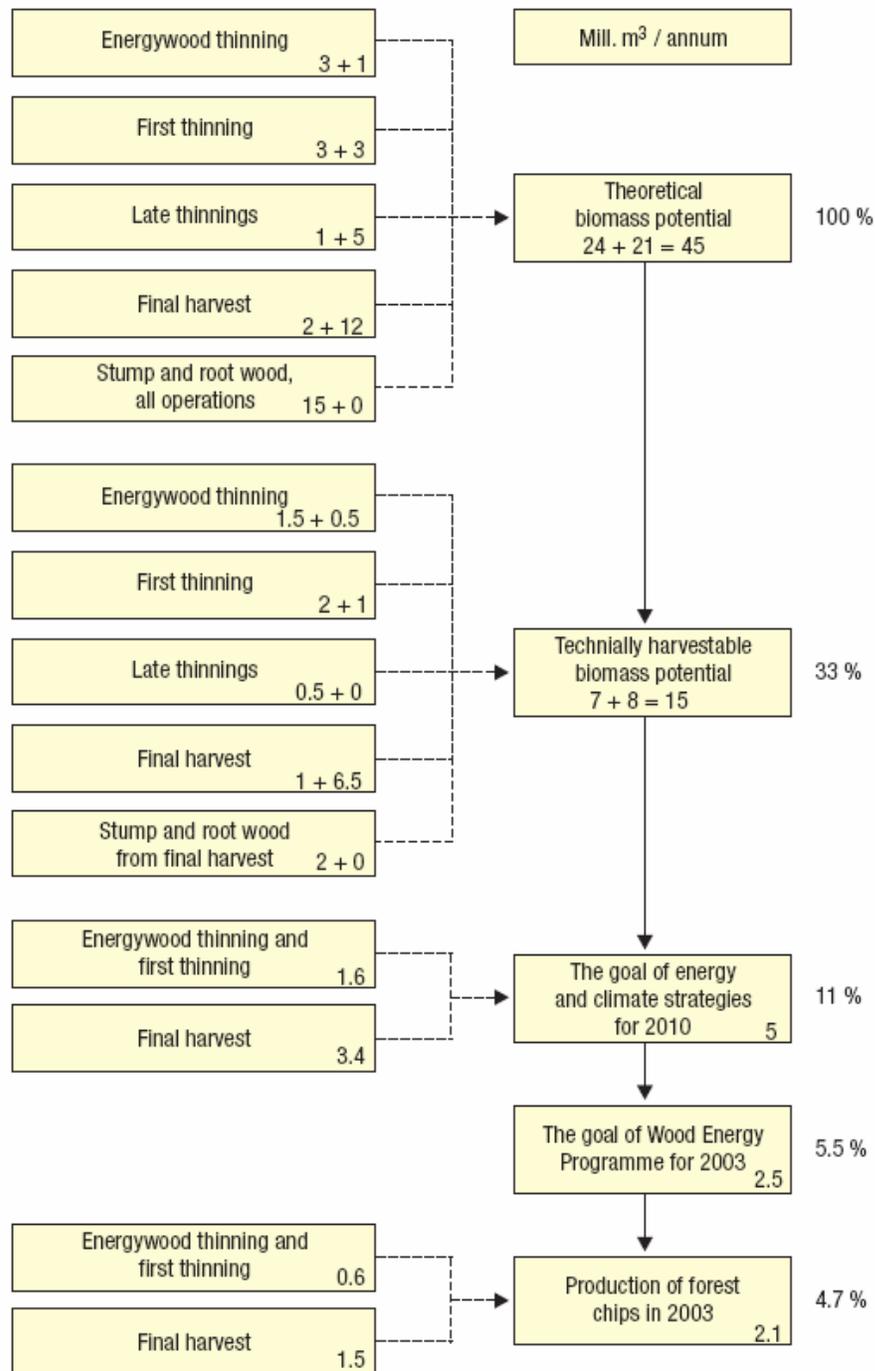


Figure 20 The biomass potential of the Finnish forests. The first part of the series of numbers refers to stemwood and the second part to crown mass (mill. m3/annum).

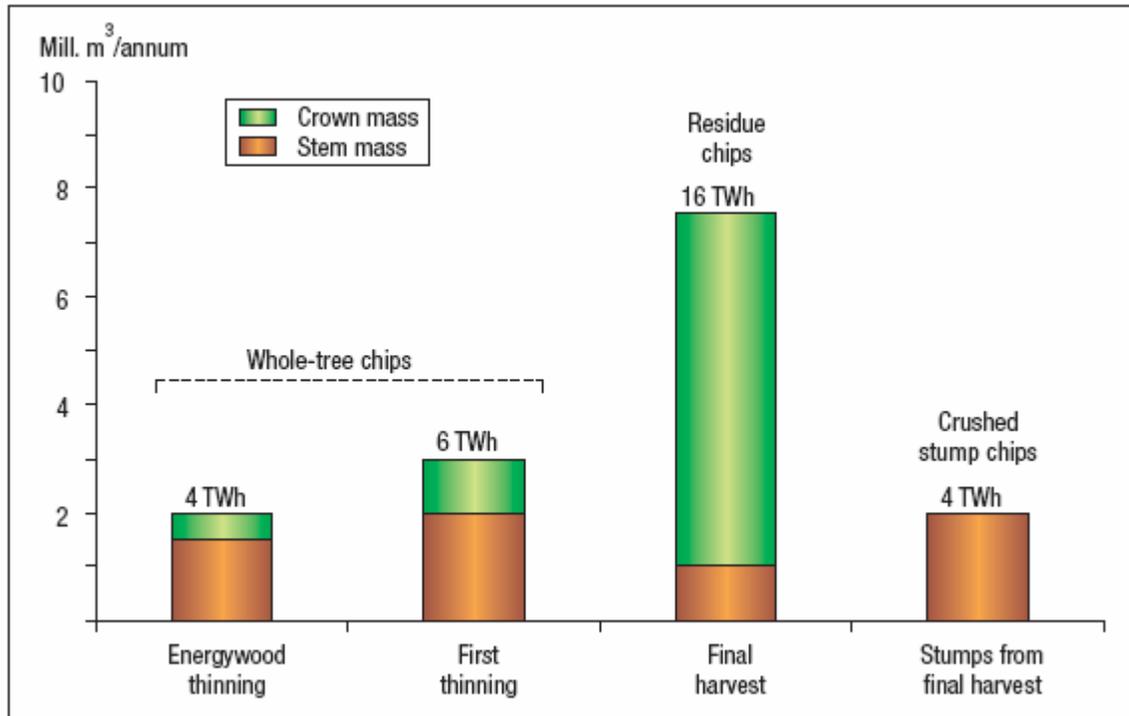


Figure 21 Technically harvestable biomass potential of the Finnish forests.

- *Later thinnings* leave only small amounts of stemwood at the site. Residues contain mainly crown mass, the separate recovery of which would cause logging damage to standing trees and unnecessary nutrient loss at a critical development phase of the stand. Production of forestchips is not recommended at this stage.
- *Logging residues from final harvest* are composed largely of crown mass which is abundantly available, especially in spruce stands. Logging residue chips are therefore produced mainly from the crown mass of spruce. Conditions of recovery are favourable. No subsidies are available.
- *Stump and root wood from final harvest* can be salvaged from clear-cut areas of mature spruce stands. Typically, logging residues have already been collected from the same site.

A summary of the amount and structure of the technically harvestable biomass reserve is presented in Figure 8. *More than a half of the harvestable reserve is crown mass* including foliage. If the targets set for forest chips are to be met, crown mass must be accepted as a source of fuel despite its inferior quality and accelerated nutrient loss. The technology of harvesting must be developed to keep needle removal at an acceptable level.