NATIONAL STRATEGIES FOR STIMULATING THE USE OF BIOENERGY: POLICY INSTRUMENTS IN SWEDEN

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(Received 26 April 1997; revised 2 November 1997; accepted 6 November 1997)

Abstract—This study examines strategies of national energy policy, focusing on measures taken from the 1970s onwards for increasing the use of bioenergy in the Swedish energy system. Emphasis is given to analyses of how administrative policy instruments such as the Building Act, which regulates the use of natural resources, and the Wood Fibre Act have affected the woodfuel market for the district heating sector. The government can influence changes in three principal areas of the energy system: energy use, industrial structure, and energy production. The tools the government may use to exert its influence are: support to research and development, support to demonstration and information dissemination, administrative policy measures, and economic incentives. These instruments may be applied separately or in combination. Knowledge about how these instruments affect the development of the energy sector is fragmentary; it derives more from empirical observation than from analysis. A systematic evaluation of the separate and combined instruments that have been used would increase the possibility of correctly assessing the national energy policy. Nevertheless, practical experience and the analyses that do exist indicate that: (1) research and development are necessary prerequisites for developing the energy system even though results can not always be achieved in time to meet the need for fast results; (2) economic policy measures are comparatively easy to administer, and energy taxation has largely met its goals. With investment support, markets can be skewed and development can be hindered if existing technology is subsidised; (3) administrative policy instruments are cumbersome to administer and frequently do not achieve their purpose.

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Keywords—Renewable energy; biofuels; national strategies; policy instruments; regulations; woodfuel markets.

1. INTRODUCTION

There is a strong interest in renewable energy sources in Europe. The major argument for increasing the use of renewable energy is a concern for our common environment, particularly for how greenhouse gases such as carbon dioxide, emitted by fossil fuels, may influence our climate in the future. However, the countries of the European Union, with their different backgrounds, cultures and conditions, do not constitute a homogeneous unit. Consequently, the strategies for reducing greenhouse gases have taken different forms and have advanced at different paces in each country.

Sweden is a country with substantial natural sources of renewable energy that began to be exploited by industry at an early stage. The Swedish energy supply has historically been based on various types of fuelwood combus-

* Biofuels are fuels originating from biological materials. Bioenergy is superordinate to biofuels.

In the early 1900s, hydropower underwent massive development. The use of biofuels*, which fell after the Second World War, has once again been on the upswing for the past two decades and currently accounts for 18% of the total energy supply of 1700 PJ.1 Adding hydropower and the modest energy supply from other renewable sources, such as wind power, brings the total share of renewable energy to 32% of the energy supply. Although the development of renewable energy sources in some other EU countries has resembled that of Sweden, most of these countries have a markedly smaller proportion of renewable energy in their energy systems; the average share of primary renewable energy production in EU15 countries was 9.9% in 1994.2

In a green paper from the Commission of the European Community,3 the goal is to double the use of renewable energy up to the year 2010. Of that increase, a significant share could be forecasted to be wood.
1.1. Scope and objectives

The aim of the present paper is to give an overview of different governmental strategies that can be employed to stimulate the use of renewable energy sources. Particular emphasis is put on the policy instruments developed in Sweden to stimulate the use of biofuels and on the ways in which administrative policy instruments have affected the process of price formation on the emerging Swedish market for woodfuels* in the 1980s and 1990s.

2. POLICY INSTRUMENTS FOR STIMULATING RENEWABLE ENERGY USE

The government may work to effect changes in three principal areas of the energy system: energy consumption (adaptation of volume, structural change, more efficient use), industry structure that affects both the demand and supply of energy, and energy production (adaptation of volume, structural change, more efficient production). The instruments the government may use to exercise this influence are: support to research and development, support to demonstration (including technology procurement), support to information dissemination, administrative policy instruments (regulations), and economic incentives (monetary or non-monetary). These instruments may be used separately or in combination.

This study focuses on the opportunities that the above mentioned policy instruments give the government to influence the energy system, primarily energy production. Today, the development of renewable energy sources for the production of electricity is underway — outside the scope of governmental influence on the energy system — but this development has not yet had any increased impact. Marketing renewable energy, i.e. green pricing, is one instrument used by some companies to create an environmentally friendly image. One of the most interesting cases of green pricing in Sweden concerns two McDonald’s restaurants near Stockholm, which annually buy about 1 GWh wind-generated electricity from the large Swedish power company, Vattenfall. Necessary conditions for such an arrangement include not only deregulation of the electricity market, which occurred in 1996, but also recommendations concerning environmentally friendly electricity that have been issued by the Swedish Society for Nature Conservation. The supply of renewable energy is still much larger than the demand, for which reason the investments in renewable energy capacity are still not commercial.

In a market economy, price formation is the most important instrument for stimulating development and efficient resource use. The price of a product or service gives households and businesses information about the costs, thus securing economical resource use. Prices also yield information about consumers’ willingness to pay and create a balance between supply and demand. Prices may also be used to influence the distribution of income and consumption within the economy.

Efficient prices are therefore equilibrium prices that reflect the scarcity of the margin for different goods and services; in this way, prices reflect the value of a resource for the best alternative use. Completely efficient pricing is rarely achieved in practice, however, which is why society, i.e. the government, has on occasion good reason to intervene in the process of price formation and set it moving in the desired direction.

As carbon dioxide from the combustion of fossil fuels has long-term effects on climate development, such a case for intervention arises. The use of natural resources such as air, soil and water has far-reaching consequences for the future. A rise in the global temperature may be seen as the result of using a free commodity which is not covered by market prices. Market prices may thus be seen to reflect a scarcity on the market of the day—a market that does not include free goods and future effects.

In recent years, policy instruments of an economic character, such as carbon dioxide taxes and nitric oxide fees, have been debated and subsequently introduced in some countries. These instruments have been designed to give price signals about future environmental impacts and thus to increase the competitive edge of biofuels in relation to fossil fuels, the price of which has gone up with taxes and levies. The policies include an internalisation of external costs of different fuels in today’s prices.

Economic policy instruments in the form of taxes and fees thus correct prices to reflect negative external effects. Price increases are then concentrated on those fuels which have

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*Woodfuels are biofuels based on trees or parts of trees.
undesirable external effects, e.g. fossil fuels that emit carbon dioxide. Measures such as these give price signals to the market and, provided they are correctly designed, stimulate the development of renewable resources such as biofuels in the energy system. The skewed resource consumption that often results from such administrative policy instruments as investment support is avoided. Moreover, economic policy instruments are generally easier and less costly to administer.

On all markets, information is to a greater or lesser degree asymmetrical. This means that different actors have different access to information. Thus, a large buyer may have better insight into the types of contracts for deliveries of, for example, biofuels than a small seller who is not very active on the market. The newer the market, the larger the risk of asymmetrical information. Information on market prices for biofuels is published regularly by the Swedish National for Board Industrial and Technical Development, Nutek.8

2.1. Swedish policy instruments

The use of policy instruments to control the industrial energy supply in Sweden dates back to the 18th century. At that time, wood was used on a large scale for mining activities, for charcoal production in the metal industry, and for the production of potassium.9

The production of metal (primarily iron) was based on energy from charcoal. Metal production was regulated by a system of licences issued by the Swedish Crown and by a system of maximum production quotas assigned to each factory.10 Since then, the Swedish government has periodically created policy instruments to regulate the national energy system. During the two World Wars, there was a large need for domestic energy sources and energy consumption was strictly regulated. Between the wars, governmental policy stimulated domestic energy generation by investment support and support for research and development. After World War II, fossil fuels became the dominant energy source, and major policy instruments were not used.

As a result of the OPEC oil embargo and the ensuing problems of limited supply and high prices — the 1973 “oil crisis” — policy instruments were brought to bear upon the supply and demand of biofuels and other predominantly domestic energy sources in order to make Sweden less dependent on imported oil/petroleum. Raw material from forestry and the forest industry, as well as the forest industry’s energy system, was identified as a resource strategic to this end.

Since the 1970s, the goals of national energy policy have altered. The primary aim is no longer to replace oil but to develop an energy system with as small net emissions of greenhouse gases as possible with respect to a future phase-out of nuclear power.

3. RESEARCH AND DEVELOPMENT

Governmental programs for energy research were launched as early as 1975. The principal research goals have varied over time, as Table 1 indicates.11

Between 1975 and 1993, energy research and development received just under 1.9 billion ECU (1990 value) or an average of 5.5% of the governmental R & D investments. The beginning of the 1980s saw the largest investments, amounting to about 10%. In the most recent period, 1990–93, energy research

### Table 1. The aims and resources of Swedish governmental energy research, 1975–93. Source12

<table>
<thead>
<tr>
<th>Period, year</th>
<th>Primary goals</th>
<th>Support, million ECU*</th>
</tr>
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<tbody>
<tr>
<td>1975–78</td>
<td>Energy policy tools</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Resources for industrial policy and oil</td>
<td>400</td>
</tr>
<tr>
<td>1978–81</td>
<td>replacement</td>
<td></td>
</tr>
<tr>
<td>1981–84</td>
<td>Resources for industrial policy</td>
<td>450</td>
</tr>
<tr>
<td></td>
<td>Long-term research in natural sciences and technology</td>
<td>300</td>
</tr>
<tr>
<td>1984–87</td>
<td>Phase-out of nuclear power and environmental</td>
<td>250</td>
</tr>
<tr>
<td>1987–90</td>
<td>adjustment</td>
<td></td>
</tr>
<tr>
<td>1990–93</td>
<td>Climate-change issues and long-term research</td>
<td>200</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1850</td>
</tr>
</tbody>
</table>

*1 ECU = 8.5 SEK; †Support includes funding for research and development and for development and demonstration of technology. Support for more efficient energy use, investment support to e.g. wind power, solar power and heating pumps, and support outside of these programs are not included.

Strategies for stimulating the use of bioenergy
equalled 4% of the governmental investments in R & D. The power industry’s R & D investments in the field of energy surpassed government spending. Vattenfall has invested significantly in R & D during the 1990s, sometimes in conjunction with governmental funding bodies.

3.1. Results and experiences

Research programs are evaluated by financing bodies, such as Nutek, on the basis of their internal efficiency. Evaluations of overall goal achievement and effects are not often made, partly because it is difficult to evaluate the external effects of such long-term projects. Recent comprehensive evaluations were made in 1995.

4. INFORMATION AND DEMONSTRATION

Different strategies for information and demonstration have been implemented with the aim of increasing the use of bioenergy. Substantial financial support has been granted by: industrial energy savings; investment support; the Oil Replacement Fund; investment support for production facilities, including systems for forest fuel production as tree sections; the Energy Technology Fund; energy efficiency. Activity in information and demonstration was intense during the early 1980s, and programs were administered by predecessors of today’s administrative authority, Nutek.

Technology procurement has not been used in the field of renewable energy sources. However, this strategy has often been used in energy efficiency programs at Nutek, for example, to develop energy-saving refrigerators.

4.1. Energy technology fund

In 1988, the Energy Technology Fund was established to co-ordinate government investments in the development of technology for renewable energy sources. Resources from this Fund have been granted to both research and demonstration projects, and the annual provisions are approx. 22 million ECU over the national budget. Through 1993, 220 projects were awarded grants, each normally equalling 25–40% of the costs for the projects. Nutek has estimated that the total costs for the projects come to 220 million ECU, of which the Energy Technology Fund has contributed 54 million ECU.

4.2. Promotion of electricity production from biofuels

In 1992, 74 million ECU were set aside for five years to promote pilot projects for the production of electricity from biofuels (Fabel). So far, Fabel has submitted 13 project applications, 9 of which have been granted funding from the government program. The total cost of the Fabel project up to and including 1996 has been 60 million ECU, 20 million (33%) of which the government has supplied. A half year before the application period expired, approx. 54 million ECU, or 75% of the originally budgeted funds, remained. Applications have been co-ordinated with other forms of support available through Nutek, such as the Energy Technology Fund and investment support for combined power and heating.

4.3. Baltic programs

Since 1992, various smaller programs have been conducted in the Baltic countries and in certain East European countries for technology transfer and making energy use more effective. Joint efforts between Sweden and the recipient country for increasing the use of renewable fuels in district heating are made to reduce carbon dioxide emissions. Support is mainly given in the form of a commercial loan accompanied by a smaller grant. Up to 1996, 33 million ECU have been granted to various projects. The intention is to funnel loan repayments to Nutek for continued support to projects in these areas.

5. ECONOMIC POLICY INSTRUMENTS

5.1. Taxes

Public energy taxation was introduced in Sweden in 1957 for reasons of government finance. After the oil crises of the 1970s, taxation was formed to advance the national energy policy. During the 1970s and 1980s, energy policy profiled the substitution of oil with other fuels and electricity. After 1990, taxation was given an environmental profile, and these taxes can now be said to be the strongest instruments for reducing carbon dioxide emissions, particularly for district heating. In 1991, a carbon dioxide tax, corresponding to 0.03 ECU kg\(^{-1}\) CO\(_2\) emission, was
The general energy tax was then reduced by 50% and a sulphur tax was introduced, equal to 3.5 ECU kg\(^{-1}\) emission. In 1991, the entire energy sector also became subject to business transfer tax.

An environmental levy on emissions of nitrogen oxides (NO\(_x\)) from boilers, gas turbines, and stationary combustion plants was introduced in 1992 at a level of 4.7 ECU kg\(^{-1}\) NO\(_x\) emissions. The levy applies to plants with an annual energy production of 90 TJ. Fees are neutral relative to the national budget in that repayments are made to operators of plants with the lowest emissions, while the operators with the highest emissions will be net payers.

Taxes in the energy sector have risen markedly since the mid-1980s. Industrial taxation was altered in 1993 when the energy taxation for the manufacturing industry\(^{26}\) was lowered for economic policy reasons.

During the past three years, taxes have been indexed and also used to finance Sweden’s EU membership.

Throughout this period, biofuels have remained untaxed (except for sulphur taxes on peat from 1991). Table 2 gives an overview of the development of running energy taxation according to refs.\(^4,27\).

### Table 2. Total energy taxation (excluding NO\(_x\) levy) for different fuels in current prices for non-industrial users and heat production

<table>
<thead>
<tr>
<th>Year</th>
<th>Heavy fuel oil (ECU m(^3))</th>
<th>Coal (ECU t(^{-1}))</th>
<th>Natural gas (ECU Mm(^3))</th>
</tr>
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<tbody>
<tr>
<td>1970</td>
<td>2.4</td>
<td>1.4</td>
<td>–</td>
</tr>
<tr>
<td>1975</td>
<td>5.2</td>
<td>1.4</td>
<td>–</td>
</tr>
<tr>
<td>1980</td>
<td>14.8</td>
<td>1.4</td>
<td>–</td>
</tr>
<tr>
<td>1985</td>
<td>62.7</td>
<td>17.6</td>
<td>36.2</td>
</tr>
<tr>
<td>1986</td>
<td>62.7</td>
<td>17.6</td>
<td>36.2</td>
</tr>
<tr>
<td>1987</td>
<td>89.2</td>
<td>37.4</td>
<td>36.2</td>
</tr>
<tr>
<td>1988</td>
<td>103.9</td>
<td>43.0</td>
<td>36.2</td>
</tr>
<tr>
<td>1989</td>
<td>121.5</td>
<td>51.5</td>
<td>38.7</td>
</tr>
<tr>
<td>1990</td>
<td>122.4</td>
<td>54.5</td>
<td>41.2</td>
</tr>
<tr>
<td>1991</td>
<td>161.8</td>
<td>132.2</td>
<td>83.5</td>
</tr>
<tr>
<td>1992</td>
<td>161.8</td>
<td>132.2</td>
<td>100.6</td>
</tr>
<tr>
<td>1993</td>
<td>138.8</td>
<td>138.8</td>
<td>100.6</td>
</tr>
<tr>
<td>1994</td>
<td>138.8</td>
<td>138.8</td>
<td>104.6</td>
</tr>
<tr>
<td>1995</td>
<td>146.9</td>
<td>146.9</td>
<td>107.3</td>
</tr>
</tbody>
</table>

### Table 3. Nitric oxide emissions, 1992–95. Source\(^{29}\)

<table>
<thead>
<tr>
<th>Year</th>
<th>Charged emissions NO(_x) (t)</th>
<th>Energy output (PJ)</th>
<th>kg NO(_x) TJ(^{-1}) energy generated</th>
<th>mg NO(_x) MJ(^{-1}) energy supplied</th>
<th>Refunding ECU TJ(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>15 305</td>
<td>135</td>
<td>0.11</td>
<td>99</td>
<td>0.53</td>
</tr>
<tr>
<td>1993</td>
<td>13 333</td>
<td>148</td>
<td>0.09</td>
<td>78</td>
<td>0.42</td>
</tr>
<tr>
<td>1994</td>
<td>13 025</td>
<td>163</td>
<td>0.08</td>
<td>70</td>
<td>0.36</td>
</tr>
<tr>
<td>1995</td>
<td>12 517</td>
<td>168</td>
<td>0.07</td>
<td>65</td>
<td>0.33</td>
</tr>
</tbody>
</table>

5.1.1. Results and experiences. The National Environmental Protection Agency’s evaluation\(^{28}\) of the effects of carbon dioxide shows that carbon dioxide emissions from the district heating, industrial, housing and office sectors have decreased by 8000 kt, or by 19%, from 1987 to 1994. In the transportation sector, however, an increase of 5,500 kt has occurred during the same period. Approximately 60% of the fall in emissions is considered to be a result of the carbon dioxide tax, and the district heating sector accounts for the largest share of the decrease, since it is the sector most sensitive to the current system of CO\(_2\) taxation. Industry, on the other hand, is less sensitive to the current taxation system, though it nevertheless shows a decrease in emissions.

Environmental levies on nitric oxides cover all types of fuels used in heating plants, with no special advantages for the use of biofuels. In the annual accounts of the National Environmental Protection Agency\(^{29}\) for environmental levies on emissions of nitric oxides from energy production, the figures for 1995 showed a total emission of 12,517 t for the entire nation. This implies a 500-t decrease from the preceding year. Compared to the point of departure in the late 80s, these figures...
indicate a decrease of 48%, from ca 25 000 t to 12 517 t. The tendency toward lower nitrogen oxide emissions is clear, and Table 3 shows the development of this trend over the years 1992–95, when the levies were in force. The table also shows that the reallocation of money (from large to small polluters) per unit of energy has decreased, which causes the profitability of investments in emissions mitigation to decrease as well.

In another evaluation of different environmental taxes and policy instruments, the Environmental Protection Agency concludes that there is a fulfilment of the aims of many of the taxes introduced during the 1970s and 1980s, i.e. the CO₂ tax and the NOx levies.

5.2. Investment support

Swedish energy policy has given rise to a number of forms of investment support. The sections below report some of those that have had a strong impact on the biofuel market, particularly on the demand for woodfuels.

5.2.1. Peat combustion support. Investment support to combustion plants primarily for peat was granted during the first half of the 1980s. Support for investments was provided to 78 plants between 1981 and 1986, equalling, in current prices, grants for 59 million ECU and loans for 28 million ECU. Most of these boilers are also suitable for the combustion of other solid fuels such as forest fuel and coal.

Hillring describes the projects that received peat boiler support in accordance with the National Energy Authority’s 1983–86 support to peat plants (46 million ECU in grants and 2 million ECU in loans, current prices). Support was awarded to more than 45 boiler owners, with an installed effect of more than 900 MW.

5.2.2. Combined heat and power production. Investment support for combined heat and power production was introduced in 1991. Designed to cover a 5-year period, the budget was 118 million ECU. The range of support was stipulated to be 176–471 ECU per kWel of installed electricity effect from combined heat and power in new heating plants as well as in existing plants and in industry. Support was given for existing technology and can be viewed as a subvention for investment in existing technologies that would stimulate the use of biofuels (peat was not included). One requirement has been that biofuels should be

<table>
<thead>
<tr>
<th>Technology</th>
<th>Investment (10^3 ECU)</th>
<th>Energy production</th>
<th>Effect</th>
<th>Energy production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MECU</td>
<td>MW electricity</td>
<td>MW heat</td>
<td>MW heat</td>
</tr>
<tr>
<td>Municipal CHP</td>
<td>455</td>
<td>304</td>
<td>152</td>
<td>152</td>
</tr>
<tr>
<td>Industrial CHP</td>
<td>27</td>
<td>25</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Waste</td>
<td>52</td>
<td>40</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Land fill gas</td>
<td>89</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Anaerobic digestion gas</td>
<td>476</td>
<td>34</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Total</td>
<td>1 456</td>
<td>726</td>
<td>756</td>
<td>756</td>
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</tbody>
</table>

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used for 85% of production during the five years following investment.

Projects that received this support are listed in ref. 4. There were 45 different projects with an installed electricity production capacity of 326 MWel. In Table 4, these projects are categorised in groups and include data for different technologies.

5.2.3. District heating. Investment grants for expanding district heating grids/networks were available between 1991 and 1996.32–34 The total project cost for the 261 projects that were awarded funds amounted to 63 million ECU, about 12 million of which came from investment grants. The additional effect in the Swedish district heating system of these grants was 540 MWh, with an estimated energy production of 1.4 TWh.

5.2.4. Results and experiences. Investment support does not benefit new technology and can skew competition between those who receive support and those who do not. In ref.35, arguments were advanced to terminating investment support for combined power and heating prior to schedule and for reallocating funds to support research on new technology. Investments can be expedited by support, however, and demand can quickly, though temporarily, rise.

6. ADMINISTRATIVE POLICY INSTRUMENTS

6.1. The Building Act

The 1960s directed attention to the development of industries that had a high consumption of natural resources. The dawning of environmental awareness and the fact that Sweden was in the process of building a number of heavy industrial complexes such as nuclear power plants, steel works, harbours, petroleum industries and combined/joint forest industries of a significantly larger size than before provided the impetus for a greater degree of public involvement in natural resource planning. In 1972, new regulations were introduced into the 1947 Building Act36 to ensure that new facilities for these industries would receive government approval.37

After 1973, energy issues became even more topical, leading to new regulations for economical energy use. The forest industry had at that time entered into a strong phase of expansion, which caused concern about the future wood supply and fears of a “wood slump”.11

The Act was amended once again in 1975.38 when an amendment was introduced to the effect that economical use of resources should apply not only to land, water, and energy, but also to wood fibre resources. The limit for the requirement for governmental approval of sawmills was lowered from 50 000 m³ sawn wood to 5000 m³ sawn wood. In 1976, the Act was amended again39 when regulations for expanding existing operations were introduced.

The competition for raw material for wood fibre grew stiffer during the 1980s as other large energy consumers began to look toward woodfuel as an alternative to oil.

In the early 1980s (on the basis of the National Forest Survey and other sources), the increment in Swedish forests was judged to be 75 million m³ total steam volume over bark per year compared to today’s increment of 100 million m³ total steam volume over bark. Certain categories of land owners (above all, non-industrial forest owners) were at that time thought not to be extracting their share of the growth. This question was examined in a government investigation that put forward different proposals for increasing government support to forestry, for introducing cutting requirements on forest estates, and for changing taxation.40

The rise in heating with wood fibre resources was analysed,41 and this investigation recommended the introduction of restrictions to direct the supply of raw materials — including the surplus of hardwood that then existed — to the heating sector. The main idea was for the forest industry to have priority in their access to raw materials over other more or less subsidised users, such as the heating sector. The imagined hardwood surplus was later recalculated as being a shortage.11 A study by Berg et al.42 indicates that, throughout the 1980s, cutting in some parts of Sweden may have closely approximated the annual growth of hardwoods, unlike the case of conifers.

As a result of governmental investigative commissions43 and other evaluations, Act 136a was expanded in 198344 to explicitly apply to producers and users of woodfuel. The lower limit for these users of wood fibre resources was set at 10 000 m³ solid volume.
The supervisory authorities for compliance with the Building Act were the municipal building commissions, the National Board of Forestry, and county forestry boards. Failure to comply with the specifications of statute 136a would lead to fines or prison sentences. A search of Statistics Sweden’s crime statistics failed to show a single person charged on these grounds.

Building Act 136a remained valid up through 1987 when new legislation for the allocation of resources was passed.

6.1.1. Results and experiences. The different applications and legal cases that concern the Building Act and that were handled by the National Industrial Board (Sind) — a total of 402 between 1973 and 1987—are accounted for in ref. 4. Information is divided according to year in Table 5, where the category of “forest industry” includes pulp and paper industries, sawmills, and other forest industries, where “heating plants” includes plants for biofuel combustion, and where “fuel production” applies to biofuel production. The category of “other” is reserved for cases that fall outside the other three groups. These include legal matters concerning the establishment of harbours, refineries, steel mills, car factories, or uranium mining.

The National Industrial Board has been the administrative authority in charge of Building Act 136a, while the government has been responsible for making decisions about legislation.

The number of applications has varied over time, and the categories have also varied according to changes in legislation. Consequently, there are almost no cases concerning the consumption of wood fibre resources during the early period of the Building Act, while the number of applications culminated in the mid-1980s when the Act was expanded to include virtually all wood fibre resources.

The interest in producing biofuels was greatest between 1983 and 1984. Licensing applications constituted 18% of the total number of cases handled and concerned production of both processed and unprocessed fuels. Applications for permission to use wood fuel resources for heating purposes constituted 19%; these were submitted primarily by municipal heating plants, although some industries also applied.

6.2. The Wood Fibre Act

Previous legislation for approving wood fibre resource use was analysed (Act 136a) by the Ministry of Industry in 1986. The task force concluded that continued assessment and approval was necessary. The report discussed the timber balance as well as the regional policies involved in the expansion of forest products industry and fuel production.

The regulations were simplified in relation to Building Act 136a and the group presented a proposal for government regulation of the use of wood fibre resources that included round wood and raw materials derived from round wood. This proposal was later implemented in the Wood Fibre Act, WFA, which was passed in 1987.

The Act regulated consumption in excess of 10,000 m³ solid volume per calendar year for heating purposes and in excess of 200,000 m³ solid volume per calendar year for forest industry. Round wood with a diameter of less than 5 cm was not covered in the Act, nor was bark or the internal consumption of by-products in sawmills.

In 1991, an amendment was passed that narrowed the requirement for government

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</thead>
<tbody>
<tr>
<td>Forest industry</td>
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<tr>
<td>Heating plants</td>
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<td>–</td>
<td>1</td>
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<td>–</td>
<td>–</td>
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<td>17</td>
<td>22</td>
<td>13</td>
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<td>Other</td>
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<td>19</td>
<td>3</td>
<td>9</td>
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<td>6</td>
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<td>–</td>
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<td>23</td>
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<td>57</td>
<td>73</td>
<td>54</td>
<td>45</td>
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*More cases have been handled than have been finally ruled upon.
approval to a consumption of more than 10 000 m³ solid volume sawdust and shavings for heating purposes.

In the public inquiry concerning a review of wood fibre resource legislation, it was concluded that the Wood Fibre Act’s regulations for government approval of wood fibre use in the forest industry could be revoked, but that some sort of regulation was required for the fuel sector. The report suggested the introduction of a 5-year system of restitution to regulate the chip market so that the chip board industry could adapt to the new policy instruments affecting the fuel market (especially the CO₂ tax). Restitution was never introduced, however. On July 1, 1993, the Act was repealed and the woodfuel market (including the chip market) was thus administratively deregulated.

Legal penalties of fines or imprisonment for failure to comply with the Wood Fibre Act have also existed. A search of Statistics Sweden’s crime statistics did not yield a single instance of this charge.

6.2.1. Results and experiences. The National Industrial Board (Nutek, from 1991) has been the authority responsible for processing licensing applications and other cases covered by the Wood Fibre Act and, together with the Swedish government, has made decisions. These cases and decisions are reported in ref. 4. During the period 1987–92, a total of 52 applications were processed, as shown in Table 6. The category of “forest industry” includes, as before, pulp and paper industries, saw mills, chip board industries, etc. The category of “heating purposes” here includes both heat and fuel production.

Table 6. National Industrial Board, Nutek, or government decisions pertaining to the Wood Fibre Act 1987–92*

<table>
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<td></td>
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<tr>
<td>Number of errands</td>
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<td>3</td>
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<td>Total of raw material, million solid m³</td>
<td>15,59</td>
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<td>4,15</td>
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<tr>
<td>Heating purposes</td>
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<td></td>
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<td></td>
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<tr>
<td>Number of errands</td>
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<td>6</td>
<td>2</td>
<td>7</td>
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<tr>
<td>Total of raw material, million solid m³</td>
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<td>0,16</td>
<td>0,05</td>
<td>0,03</td>
<td>0,11</td>
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</table>

*After 1992, no applications were processed under the WFA; †The Act no longer covered the forest industry.

Of the cases in which a decision was reached, nearly half (46%) approved the use of wood fibre in forest industries while slightly more than half (54%) approved wood fibre use in heating plants.

The forest industry’s total consumption of raw materials has been several times larger than that of the heating sector. This ratio does not imply that consumption of wood fibre for heating purposes has been insignificant, however, since it may have had strategic importance for regional competition for raw materials.

6.3. The Solid Fuel Act

The Solid Fuel Act was passed in 1982 and revoked in 1994. This Act stipulated that every owner of a newly built heating plant must have a boiler capable of burning solid fuel (e.g. coal, peat, or woodfuel). The Act applied to plants with an annual fuel consumption of at least 180 TJ, corresponding to approx. 50 GWh. This also applied to boilers that were part of a system with a fuel consumption of over 180 TJ.

6.3.1. Results and experiences. The National Energy Administration and, later, the Ministry of Industry have examined the formulation and significance of the Solid Fuel Act. Both investigations found shortcomings in the application of legislation and proposed that the Act be revoked. The report also shows that the Act largely failed to serve its purpose.

The main reasons why the Act did not meet its own goals were a transition to the use of electricity, which did not require approval under the Solid Fuel Act, and changes in the overall objectives of national energy policy. Energy policy ceased to prioritise decreased dependency on imported oil and focused instead on the environmental impact of green-
house gases — a change which was reflected by the introduction of carbon dioxide and other taxes. Biofuels, peat, and other solid fuels then became competitive commodities and for that reason they began to be used, in spite of legislation that was difficult to administrate and that failed to meet its goals.

6.4. The National Board of Forestry’s guidelines for regulating extraction of tree parts etc.

In 1986, The National Board of Forestry introduced recommendations for the extraction of biomass from forests. The guidelines concerned the removal of nutrients from forest land in connection with the extraction of leaves, needles, and small branches (not stem wood). Different restrictions were stipulated for different types of soil and stands and thus limited extraction primarily from nutrient-poor, dry lands with a coarse soil texture. Similarly, the restrictions applied to stands in areas characterised by early summer drought, cold climate, or acid rains. The National Board of Forestry’s recommendations still apply, but they are currently under review.

7. DISCUSSION AND CONCLUSIONS

In the latest government bill, which can be regarded as the starting point for the phase-out of the Swedish nuclear power, there is a mixture of traditional policy instruments embracing more than 1 billion ECU for the next 9-year period. The program mainly focuses primarily on research and development, and historical small amounts are allocated for information and demonstration and investment support.

In an evaluation of the Swedish energy policy, the International Energy Agency and the Organisation for Economic Co-operation and Development recommend further examination of the processes involved in energy policy. The report urges the Swedish government to make a clear and final decision about the use or phase-out of nuclear power and on this basis to outline a basic strategy for the future energy system. Further, tax legislation and subsidy schemes for supporting biofuels are advised to be subject to a cost–benefit analysis that facilitates an evaluation of the instruments used to attain Sweden’s policy objectives. Support and R & D efforts are recommended to be focused on reducing biofuel production costs to a level closer to costs on the commercial energy market.

Evaluations of the Swedish energy system have also been made in public inquiries. The two most recent of these were conducted by the National Energy Commission and the Biofuel Commission. These investigative bodies are generally composed of politically appointed members and serve more as a forum for working out differences between interested parties than for making impartial assessments.

7.1. Research and development

Government support to research and development is a long-term process that involves the co-operation of industry. The tendency for many industries that use a great deal of energy or produce energy for sale has been to invest little of their total turnover in R and D. Several Swedish forest companies and energy producing companies that are large consumers and producers of energy invest only a few percent of their turnover, in contrast to some pharmaceutical companies that invest 23% and leading telecommunications companies that invest 33% of their turnover. In other words, the government shoulders a relatively large share of the financial burden for research and development in the field of energy.

Earlier, there was over-confidence in the ability of fast research results to yield practical and useful methods for solving problems in the energy sector. A damper has recently been placed on this optimism, and long-term investments are now being made, often in different forms of research programs.

7.2. Economic policy instruments

Energy producing companies have reacted quickly and rationally to the introduction of economic policy instruments intended to influence the supply of energy. This applies above all to taxation and fees, but also to support for investment. When the taxation system was modified to favour heat production from biofuels, companies rapidly switched. The same applies to investments in anti-pollution equipment that decreases emissions of nitric oxides and thus can provide companies with a fast return. Fuel input for producing electricity is not taxed, and the cheapest fuel, usually coal, dominates as a result. The modest increase in the production of electricity from biofuels is
related to the requirement for support to combined heat and power production.

It has been difficult to generate an interest among investors in the support granted for demonstrating new technology for electricity production using biofuels. The reason is that the lack of a clear policy for nuclear power has created uncertainty about the future market for electricity production. One alternative form of support might be found in technology procurement from other areas that have had a positive experience.

Because of the high taxes on fossil fuels in Sweden and even more extensive waste legislation in some European countries, i.e. Germany, the import of different types of biofuels has increased dramatically during the past few years. This development has been facilitated by the stronger biofuel purchasing power that Swedish heating plants have in relation to foreign competitors whose use of fossil fuels is not taxed.

Prior to 1973, when oil was fairly inexpensive, there arose a surplus of wood fibre raw materials which was exploited by the fast-growing board industry. When later energy provision required greater utilisation of biofuels, competition arose for this material. The question is, how strong can policy instruments for stimulating woodfuel energy production be without creating unfair competition with those branches of the forest industry that lay claim to the same raw materials?

7.3. Administrative policy instruments

When administrative policy instruments are used to regulate a market by controlling the establishment of wood-consuming industries, there are no equilibrium prices to reflect the production and consumption value of resources. Prices are then set, in principle, by the supply, and customers are offered fixed volumes at given prices. There is a tendency in the woodfuel branch for regional dominance among a few producers, which can result in too low a supply and/or inflated prices, even without a regulated market. This tendency toward dominance of the few has, in a longer perspective, become less pronounced, since the number of producers has increased markedly over a 10-year period and since the sizes of companies have levelled out.

The policy instruments that have been applied to the forest fuel market originated in the belief that there was a shortage of wood fibre. The market was thus administratively regulated by legislation. Later, different investigations have reported that the supply of raw materials is adequate for both traditional forest industrial production and for heating purposes.

The study of administrative policy instruments such as the Building Act and the Wood Fibre Act has concluded that the regulations of these Acts resulted in a supply deficit that incorrectly signalled a shortage of woodfuels to the market; consequently, woodfuel prices became higher than they would have been in the absence of regulation.

7.4. Conclusions

Our knowledge about the different policy instruments for developing the energy sector is fragmented and based more on empirical observation than on conclusions derived from careful analysis. A systematic evaluation of the instruments that have been implemented, individually or in combination, would increase the possibility of drawing the correct conclusions about the policy that has been conducted.

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