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How to participate in sustainable development in Krakow — a European metropolis

KEY WORDS: agenda-21, demand for heat and electricity, cogeneration

Introduction

The Kraków Combined Heat and Power Plant S.A. (ECKSA) is bracing to meet the challenges of the electricity and heat market and new environmental protection standards, associated with Poland's access to the European Union. The programme tries to make optimal use of local fuel sources, the existing extensive infrastructure, and experience, procedures, know-how of the EdF Group, which respects the standards set out by Agenda 21.

Krakow's mission (the third largest city in Poland) is to strengthen its metropolitan functions as a European centre of art, culture, learning, services and modern industry. Since 1990, in the period of economic transformation, Krakow's development was marked by many actions that complied with sustainable development standards, one of them being a programme for rationalisation of heat supply and improvement in air quality, whose one of participants was the Krakow Combined Heat and Power Plant S.A. — ECKSA.

ECKSA is located in the central area of Krakow urban system, not far away from the Wawel Castle — the former seat of Polish kings. Since 1970 ECKSA has served Krakow by providing it with heat, covering over 50% of its heat demand. The construction process was parallel to the extension of the district heating system and was completed in 1986. The plant reached its current

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electrical and thermal capacities of 1470 MW_{th} and 460 MWe, respectively and at that time its entire capacity was allocated to customers.

Program for reduction of low emissions — a pioneer effort in support of Krakow's sustainable development

In the eighties Krakow was a particularly endangered area due to air pollution (the annual average pollution by particulates was three times higher than permissible values, where SO_2 exceeded permissible standards by a factor of 3.5. The pollution came in most part from over 1100 boiler houses fired with solid fuel. In early nineties the decrease in demand for heat, caused among other factors by an increase in energy price and recession in the housing industry, led to a systematic decrease of power ordered by MPEC S.A. (municipal district heating company) and in 1994 the surplus of thermal power was 300 MW_{th}. To counteract these phenomena and fully use both the transmission capacity of the district heating system and the generating plant's capacity, ECKSA and MPEC joined the program for reduction of low emissions, which recovered 160 MW_{th} and also reduced the SO_2 and dust concentrations to levels below the ceiling values. At that time MPEC modernised the district heating system, which also included modernisation of heat exchangers, their automation and control systems – these functions are now performed by central control stations. ECKSA, on its part, introduced the so-called qualitative and quantitative control system. All these actions, accompanied by thermo-innovation and thermo-control (done by house management) made it possible to save 20% of heat demand in the entire district heating system.

Sustainable development as part of EdF's and ECKSA's mission

The process of gradual privatisation and restructuring that began in the early nineties made it possible for ECKSA to create a structure, and adopt strategy involving its adaptation to functioning in the market economy. ECKSA's privatisation was a pioneering undertaking in the entire Polish power sector and its strategic investor was the French power concern Electricité de France, which acquired 57.9% of ECKSA shares. The EdF group, providing services to more than 51 million customers in various countries all over the world (of which 23% is outside France) and generating electricity about 470 billion kWh, is a major world electricity group. The Group takes care for the natural environment — EdF generates about 82% of its electricity in nuclear power pants, 14% in hydro power plants and only 4% in conventional plants. The nuclear power plants, in addition to the immense production potential, generate electricity that is clean and inexpensive. That is why the prices in EdF dropped by 27.5% in 1985—1996 and by the another 9% by the end of 1999. Both the EdF's contribution to the use of renewable energy sources and its accomplishments in the area of environmental protection (CO_2 emission of 85 grams/kWh_e) make it a world leader among creators of sustainable development, which was defined in Rio in 1992 in the following fashion: „Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

EdF fully supports this program and has modified its Agenda 21 since that time. That is why ECKSA, as a member of the EdF group, will observe the Agenda 21 standards in its work on the project entitled “ECKSA’s future production tools”, taking advantage of experience and procedures of the EdF group and its supporting research facilities, contemplating its development in a wider perspective, i.e., in the global, Polish and Krakow context.

Global context – total energy demand

The considerable increase in electricity demand in the years 2000—2020 is connected with both the increase of the world population from 6 to 7.4 billion, and with an increase in GDP by 3.1% in the same period. The economic development is particularly clear in OECD member countries (Organisation for Economic Co-operation and Development) — on the average by 2% annually in the period from 2000 to 2020, as compared to the annual increase of 3% in the years 1970—2000, and also in the Far East and is South-East Asia (in China it was 5.% annually throughout this period). The world hard coal and lignite reserves are still very large — the hard coal *reserve to output* ratio is about 220 years . The price of coal will remain at a constant level and it may even drop, considering its large world reserves and their distribution in the world, and also the increase in the extraction efficiency. In the global scale, natural gas reserves are estimated to last over 60 years, whereas those of oil are estimated to range from 27 to 43 years. Prices of both oil and gas should increase in the second decade of the period under consideration due to the inevitable serious investment needed for prospecting, construction of new wells, and the capital needed for pipelines, and condensation and evaporation stations. Due to the high transportation costs, the coal and gas markets are in most part regional markets, in contrast to that of oil. In all the development scenarios (according to I EA Agency) a considerable increase in natural gas and renewable fuels is expected.

Demand for electricity

According to the projections shown in the chart in figure 1, the world electricity use will double over 2000—2020. This means that in the next two decades it would be necessary to construct generation facilities of 3,000 GWe, which amounts to what was built in the 20th century. The demand for investment capital for the new production facilities will be 3,000 GU$.

Energy conservation and progress in technology

To reduce the impact of pollutants on the environment, the chief rule is energy conservation and the most rational use of primary energy contained in the fuel. Cogeneration and polygeneration are a response to this assumption, and in this case 85 to 90% of the chemical energy contained in the fuel can be utilised. In a similar fashion, to increase the efficiency of conversion of primary energy in electricity generating plants, more refined thermodynamic cycles are

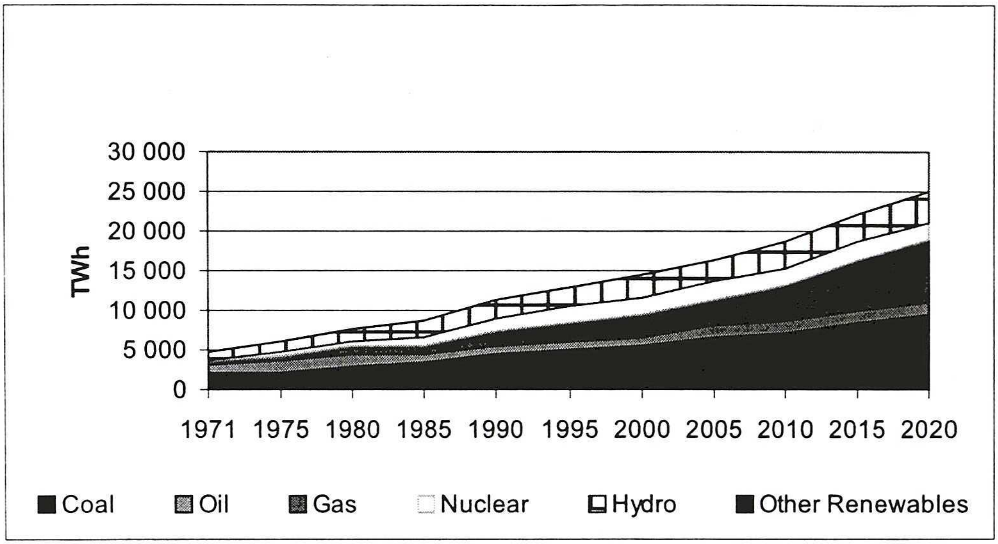

Fig. 1. World Electricity Generation, 1971—2020
Source: World Energy Outlook 2000 (IEA)

Rys. 1. Wytwarzanie energii elektrycznej w świecie, lata 1971—2020
Źródło: World Energy Outlook 2000 (IEA)

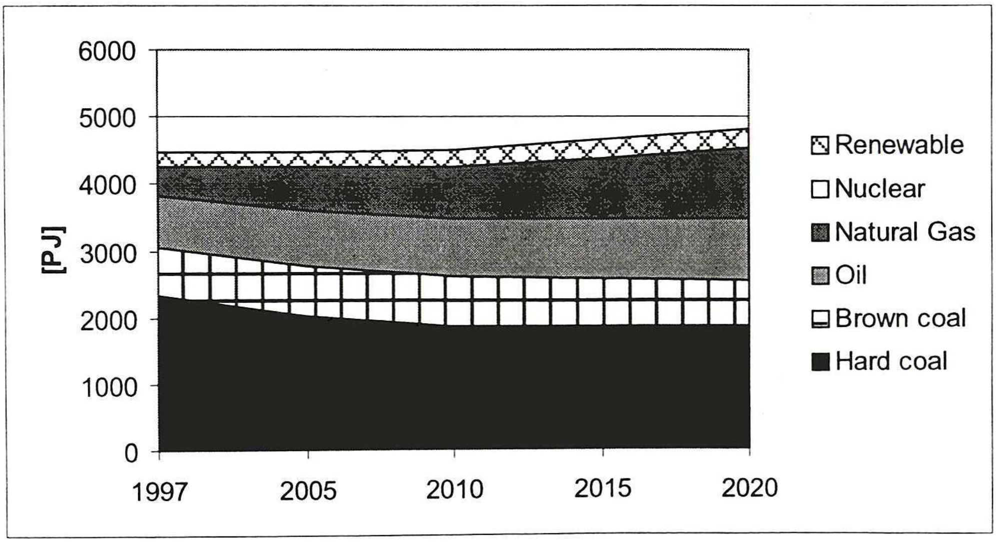

Fig. 2. Polish government primary energy demand projection
Reference scenario — February 2000

Rys. 2. Zapotrzebowanie na energię pierwotną według prognoz rządowych. Scenariusz bazowy — luty 2000

designed, for instance ones based on steam at high pressure and temperatures (supercritical cycle). One can assume that in the period from 2010 to 2015, coal-fired electricity generating plants, with efficiencies of 50% will be more extensively used. The value of 50% should be compared to efficiencies of about 35% of most currently used installations and the efficiency of 45% of state-of-the-art units installed in Japan, Germany and Denmark [9, 19, 11, 12]. Apart from the research and development studies undertaken mainly in the USA and Japan, it is conceivable that plants generating electricity from coal could reach efficiencies of 60 to 70% after 2020—2025. The latter would employ coal gasification process [13, 14] so that thus produced gas can be later converted to electricity in more efficient systems, such as gas turbines or fuel cells.

Environmental protection issues with the emphasis on CO_2 related problems

The noticeable climatic changes in the world, associated with the greenhouse effect, are caused by some gases released to the atmosphere in large quantities. These are mainly carbon dioxide (CO_2), nitrogen oxides (NO_x), and methane (CH_4). For the last 200 years the concentration of CO_2 in the atmosphere has risen by 76%, and that of methane by 115%. Very likely, the concentration of CO_2 in the atmosphere will double by 2050 relative to its level from before the industrial revolution [7]. To limit the increase in CO_2 concentration in the atmosphere, levels of reduction in CO_2 emissions in individual countries were determined in Kyoto in 1997. Unfortunately, it turned out that CO_2 emissions would not be reduced especially due to refusal on the part of the United States to ratify the Kyoto protocol, as it would hamper development on the US economy which is still based on mass use of oil and coal. The European Union has decided reduce in the years 2008—2012 the CO_2 emissions by 8% relative to the emission level of 1990. In addition to pollutant emission ceilings to be agreed upon, a system of emission charges or emission trade-off will be introduced. Estimates indicate that the initial tariff in 2005 for one ton of CO_2 will stand between 3 to EURO 5. Penalties will at the same time rise from 50—100 EURO/tCO_2. The introduction of such a system of charges will mean an additional increase in prices of electricity (generated from coal) amounting to 30% of the fuel cost. The European Union is facing a very difficult task of introducing a system of licences and charges, which are not free of risk, e.g., exposing European companies, in contrast to companies from other countries, not subject to such charges. On the other hand, the imposition of limits can change competitiveness between individual Union' countries [15]. The European system of charges for CO_2 emission should favour the implementation of least environmentally polluting production systems, and will favour the use of gas and some renewable energy sources in manufacturing processes. In the case of coal, the system of charges should also favour development of more efficient units (involving supercritical parameters, gasification). To support, on a wide scale, the development of technologies of complete capture and accumulation of CO_2, with the purpose of sequestration, the level of charges should increase even more after 2010.

Other air pollutants: dust, NO_x, SO_x

In contrast to the United States, Europe still has problems with establishing trading in emissions of such gaseous pollutants as dust, NO_x, and SO_x. Anyway, annual ceilings per country were set in Europe to be introduced in 1993, 1998 and 2003. The new European directive [1] now specifies the level of emissions per large combustion plants (LCP), with a rated capacity exceeding 50 MW_{th}.

TABELA 1. Reduction of emissions of some pollutants from large combustion plants (LCP) according to Directive 2001/80/CE of the European Parliament and of the European Council of 23 October 2001 [1]

TABELA 1. Redukcja emisji niektórych zanieczyszczeń z dużych źródeł spalania zgodnie z Dyrektywą Parlamentu Europejskiego i Rady Europy nr 2001/80/CE z dnia 23 października 2001 [1]

mg/Nm^3 (dry flue gas with 6% O_2)	SO_x			NO_x		Dust	
Rated capacity (MW_{th})	<100	100—500	>500	50—500	>500	<500	>500
Existing plants	2000	2000—400*	400	600	500	100	50
New plants (after 2003)	200			200		30	

* Linear decrease in thermal capacity

By-products from flue gas cleaning

The progress made in recent years covered technologies permitting reduction of dust, NO_x and SO_x emissions, yet, new problems have emerged, associated with storage and utilisation of wastes, the amount of which depends on the desulphurisation method adopted [19]. Experience has been exchanged, covering the whole process, from engineering phase, through operation and management of by-products of the process. This experience which was acquired trough international collaborations between manufactures, producers, engineering, companies and universities is particularly important for EdF group in the case of CFB (see chart) [20]. The main examples for EdF group are as follows: (i) regarding SO_x treatment in PF — wet desulphurisation in Le Havre and Cordemais power stations (ii) regarding coal gasification in IGCC — Puertollano Power Plant in Spain (iii) regarding LFC — Carling and Gardanne power stations.

Polish context

Due to the economic recession and restructuring of the heavy industry, the consumption of energy markedly decreased in the last decade in Poland. The much lower than expected economic growth in Poland justifies the supposition that energy consumption shall remain at the same level in the period from 2000 to 2010, followed by an about annual increase of 1% per year in the next decade. For the same reasons as for the future world trends, and based on projections made by the Polish government for the next twenty years [21], on can see in chart figure 2 that fossil fuels will almost completely meet the demand of Polish energy demand. Poland has almost none potential for hydroelectric power but has considerable deposits of gas, yet it is chiefly coal that makes Poland energetically independent, especially as regards electricity generation.

Energy demand

The energy demand evolution, as projected by the Polish government and the Polish Power Grid, is presented in figure 3. In contract to the total energy demand, a steady increase in electricity demand is noted in the entire period. According to recent projections [22] an annual increase of 1.3 to 1.7% seems realistic. Nevertheless, the current economic situation in Poland (GDP — 0.3%) and the new document entitled "Premises for Poland's energy policy until 2020" that was prepared by the government indicate, that a correction should be expected in the third quarter of 2002. According to recent projections, current coal reserves in Poland amount to 9 Gt, of which 4 Gt could be extracted at under current economic conditions. Reserves of lignite amount to 2 Gt. Coal extraction has decreased markedly in the last decade and amounts currently to 100 Mt annually. According to the government's exemplary scenario, coal extraction should go down and reach 80 Mt in 2020. Currently some 40 Mt annually are used to generate electricity. The price of hard coal in Poland should follow the world market projection and should be constant till 2020. The price to energy content ratio is three times higher for gas than that for coal, and this ratio will reach the value of 4 in 2005 [22]. This is one of obstacles for development of gas-fired power stations. The high price of gas from the national system does not, however, predetermine local prices, for which the prospect opens up in the south of Poland. Gas deposits in Poland are estimated at about 110 GNm^3. At the moment 30% of the demand is met by home production (4.0 billion Nm^3 per year of equivalent gas with a calorific value of 34.3 MJ/Nm^3). It is estimated that discovery of new gas deposits will balance its use in years to come and conserve/protect the reserves. According to government projections (fig. 4) the total demand for heat should decrease

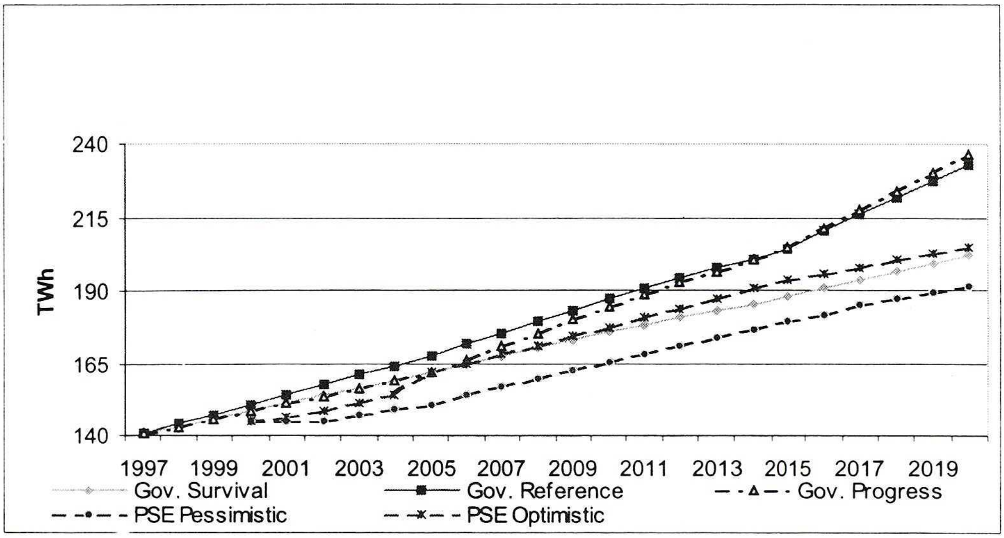

Fig. 3. Power demand projection from Polish Government and PSE
Source: Polish Government (Warsaw, February 2000); PSE

Rys. 3. Prognozy zapotrzebowania na energię według danych rządowych i PSE
Źródło: Polish Government (Warsaw, February 2000); PSE

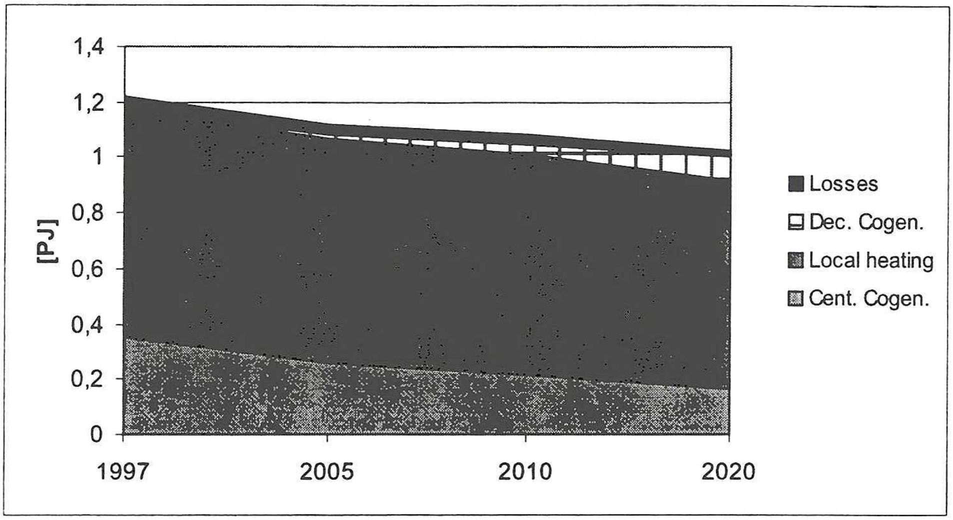

Fig. 4. Polish government prediction of heat demand
Source: Polish Government (Warsaw, February 2000)

Rys. 4. Prognoza zapotrzebowania na ciepło według danych rządowych
Źródło: Polish Government (Warsaw, February 2000)

as a result of its better use, better insulation of transmission lines and buildings. The same projections indicate a considerable decrease in demand for heat from central sources in favour of scattered, gas-based sources. Figure 4 marks the emergence of distributed cogeneration units around 2005.

Krakow heat market

The heat demand is planned to decrease in the next few years and to begin to rise again from 2005.

That differs from the government projections for total Poland, which is associated with Krakow's dynamic development. The hope for an increase in heat demand stems from the long-term co-operation between Town, ECKSA and MPEC. In expanding the heat market and implementing guidelines resulting from an OECD report, which indicated that there are 4,500 ha of post-industrial areas in Krakow, having good infrastructure, where the use of the so-called concise development will markedly reduce investor capital costs and may protect green areas around Krakow. Implementation of the transatlantic experience in such a European metropolis as Krakow will serve as confirmation of Krakow's participation in sustainable development.

Natural environment — standards for Krakow

Current emissions from ECKSA's individual production units and legal provisions concerning SO_x, NO_x and dust that have to be complied with currently and in the future are shown in table 2.

TABLE 2. Sulphur oxides (SO_x), nitrogen oxides (NO_x) and dust: (i) currently discharged and permissible, (ii) prospective permissible limits to be introduced by Polish legislation in 2008, (iii) limits to be introduced in conformity with the directive as of January 2008

TABELA 2. Tlenki siarki (SO_x), tlenki azotu (NO_x) i pyły: (i) aktualnie emitowane i poziomy dopuszczalne, (ii) przyszłe poziomy dopuszczalnych emisji, które mają być wprowadzone przez polskie prawodawstwo w 2008 roku, (iii) limity emisji, które mają być wprowadzone w styczniu 2008 dla zapewnienia zgodności z dyrektywą

mg/Nm^3 (dry flue gas containing up to 6% O_2)		Current emissions	Limits according to current license	License 01.01.2006	EU Directive 01.01.2008
SO_x	Units 1&2&3&4	1450—1550	2350	1200	1200
	HOBs	1450—1550	2350	1200	1200
NO_x	Units 1&2&3&4	350—450	540	540	600
	HOBs	400	540	540	600
Dust	Units 1&2&3&4	100—200	350	250	100
	HOBs	700	350	250	100

ECKSA's task is to meet the above-specified standards, obtain ISO 14001 certificate in accordance with actions undertaken for this end and to meet regulations and directives concerning waste management, ash storage and utilisation, use of water, noise.

As regards CO_2 emissions, it is expected that by 2001 Poland will come into compliance with Kyoto requirements and, consequently, will not be charged with penalties or other payment at the time of joining the EU in 2004—2006.

Yet, beginning at the present moment, one should keep track of the methods of determining limits prepared by the EU for individual Member Countries and air polluting industries. New ceiling values should be introduced after 2010, and they will be also binding on Poland after its access to the Union.

Adapting the existing plants to environmental protection standards

The four cogeneration units can be brought into compliance with the sulphur and dust emission standards by refurbishing the electrostatic precipitators and the use of low-sulphur coal or by constructing flue gas desulphurisation systems for two of the four power units.

Technical feasibility of implementing the system, the environmental and economic impact assessment of the two specified options are currently being considered on the basis of Polish experience. Regarding the heat-only boilers (HOBs) we assume that a European directive relating to emissions from such boilers will be introduced with some delay. But it is as early as now that the technical and economic impact of the change in fuel on the generating plant is studied.

Construction of new generating plant

At the moment, solutions optimising the existing plant and, if needed, construction of a new one are considered. This project should enable an increase in electricity production capacity while maintaining the current level of heat production. It is assumed that a two-stage approach, with an increase in production capacity of 250 MWe at each stage; the first stage will be completed as soon as possible, and the second around 2015. Around 2015 new generating plant may appear; the combine cycle (CC) and a clean combustion unit (PF or CFB). In the case of CFB, of particular importance will be the possibility of firing various fuels (deposits from wastewater treatment plants) and utilising the ash. In the case of these options and their start-up after 2010, particular attention will concentrate on the emissions of carbon dioxide.

Conclusions

1. The global demand for primary energy in the next twenty years will continue to rise and extensively rely on fossil fuels. According to current projections, no significant changes will take place in the pattern of fuel consumption by energy-producing utilities in the next two decades. The total world electricity production will continue to be based on coal (~ 40%) and share of natural gas as primary fuel will also increase. It is also assumed that scattered energy generation or low-emission reducing projects will increase by using renewable energy or natural gas. In Poland also in these areas pricing priorities should be expected.

2. The threat of greenhouse effect and the necessary reduction in CO_2 emissions will contribute to higher use of natural gas and renewable energy. One can hope and expect that a dramatic change will take place in production methods. The problem of reducing CO_2 emissions from large combustion plants (LCP) will occur in the period of 2010—2020; currently, technologies are being developed, aiming at "zero emissions" from coal combustion. One should be thus very cautious about implementing any serious coal-based projects in 2010—2020, as they could become obsolete before they pay back.

3. Poland's integration with the European Union is ECKSA's chief challenge, requiring adaptation to new environmental protection directives, as well as to the emerging market opportunities (emission trade-off), and managing the risk associated with liberated market for electricity and gas. The Polish Energy Law has also to conform to the Third Part Access (TPA) requirement of Directive 96/92/EC. On joining the Union, this principle will have to include energy generated in the EU.

4. ECKSA's privileged position in the historic city and in Malopolska region, rich in fuels and having direct electricity and gas links with Ukraine, the Czech Republic and Slovakia. That especially calls for pragmatic studies of electricity demand in the south-eastern Poland, in co-operation with local and EdF partners, precisely define potential benefits of producing electricity in cogeneration, with taking into account ECKSA's approach to main customers, other producers, and issues associated with the transmission grid under conditions of deregulated electricity market. Regarding gas, we are primarily interested in obtaining gas from sources scattered in the south of Poland, considering their competitive prices.

5. Profitability of ECKSA production stems from cogeneration that, in most favourable circumstances, allows 80% of the fuel's primary energy to be utilised. It is a matter of paramount importance to continue and even develop the current strategy aimed at maintaining, and even increasing the thermal load. One can hope that implementation of the OECD report directives, which provide guidance to Krakow's sustainable development by favouring intensified construction in areas with good infrastructure, are convergent with ECKSA's needs, and will result in a larger heat market.

6. The program for ECKSA development, in addition to adapting the generating plant to SO_x and dust emission standards, will also contain proposals for installation of additional capacity to ensure supplies resulting from increased energy demand. Such production can be implemented by a combination of gas and coal-based technologies.

7. ECKSA and EdF are well advanced in their preparation to implement a pilot cogeneration plant (microturbine) within the Krakow urban system. The purpose of this project is to determine all aspects associated with the market for such scattered sources. Universities will be invited to co-operate in this project. ECKSA, having ample professional experience in coal-based cogeneration, is gaining new experience to benefit from the opportunities offered by the gas market.

8. In taking advantage of the EdF group and its research and development facilities, ECKSA will be a pilot power plant in this part of Europe, employing EdF's pioneering experience in sustainable development. Since 1999, parallel to work on development and production, ED (economic development) effort has been underway, characteristic of all EdF units all over the world, to support sustainable development of the region. The ED programme is a kind of ECKSA's partnership-based actions, involving initiation, organization and implementation of local projects, including the initial work on Agenda 21 for Nowa Huta, Krakow's district stricken by a high unemployment rate, with areas degraded by industry.

Economical, social and environmental needs of the people and find customers represent the main aims of our activity.

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Abstract

During transformation of the Polish economy Krakow's development was associated with several important programs complying with sustainable development standards. One of them was the program for reduction in the so-called *low emissions* and rationalisation of heat supply, whose one of participants was ECKSA. In May 1998 ECKSA became the first privatised company in the Polish power sector and the French concern Electricité de France (EdF) became its strategic investor. Sustainable energy development is a major goal of EdF which has already furnished its "Agenda 21" for this purpose. The EdF's participation in ECKSA's development is a guarantee for Krakow that the procedures to be adopted will comply with Agenda 21.

This paper reminds IEA's projections concerning world energy needs and especially the huge increase in electricity demand and the emissions involved. Future quotas and emission trading mechanisms for CO_2 are being implementing by EU (Marrakech 2001).

Future demand for energy in Poland, and especially in the area of Krakow, is presented from the Polish government's point of view and according to municipal projections up to 2020. The use of primary energy, as foreseen for the country with deposits of gas and coal is also discussed.

In light of this context and considering the future demand for both heat and electricity, the paper discusses how Poland is implementing the new environmental standards, which will have to be respected at the time of joining European Union around 2004-2006. SO_x, NO_x and dust emissions from Large Combustion Plant (LCP), now defined in EU directive for Large Combustion Plants (LCP), could have a major impact on Polish energy sector. As most large cities in Poland are equipped with district heating systems, advantages of large CHP plants are then considered. It is also discussed how new equipment for distributed cogeneration can contribute to the reduction of emissions.

The paper also discusses future research needs concerning these technologies in the light of the previous context and considering the energy and environment competitiveness of either centralised or decentralised CHP plants.

Considering the continued use of coal, which is expected to remain economically competitive for the next decades, the paper discusses different possibilities of adjusting environmental standards concerning sulphur and dust emissions. This analysis has also to take into account the use of by-products. Two technologies are possible: either Pulverised Coal (PC) with Flue Gas Treatment (FGT) or Circulating Fluidised Beds (CFB). Both of them could use either sub- or super-critical steam conditions to get higher energy efficiency.

On the other hand, when natural gas is used as fuel, the Combined-Cycle (CC), which combines steam and gas turbines, is the most competitive technology.

For a later future, say after 2020, coal gasification could also become competitive as regards CO_2 capture and sequestration would be needed. In such a case the reference technology could be the Integrated Gasification Combined Cycle (IGCC).

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W jaki sposób uczestniczyć w zrównoważonym rozwoju Krakowa — metropolii europejskiej

SŁOWA KLUCZOWE: agenda 21, zapotrzebowanie na ciepło i energię elektryczną, kogeneracja

Streszczenie

W procesie transformacji polskiej gospodarki rozwój Krakowa był wspomagany kilkoma ważnymi programami uwzględniającymi zasady zrównoważonego rozwoju. Jednym z nich był program redukcji niskiej emisji i racjonalizacji dostaw ciepła, w którym jednym z uczestników była ECK S.A. W maju 1998 r. ECK S.A. stała się pierwszym sprywatyzowanym przedsiębiorstwem w sektorze energetycznym, a francuski koncern Electricité de France (EdF) został inwestorem strategicznym. Zrównoważony rozwój ener-

getyczny jest głównym celem EdF, dla realizacji którego zaimplementowano program „Agenda 21". Uczestnictwo EdF w rozwoju ECK S.A. gwarantuje, że procedury zastosowane będą zgodne z przewidzianymi w programie „Agenda 21".

Artykuł ten przypomina prognozy IEA w zakresie zapotrzebowania na energię w świecie, a zwłaszcza ogromny wzrost zapotrzebowania na energię elektryczną i związany z tym wzrost emisji. Limity oraz mechanizmy handlu emisjami CO_2 są aktualnie implementowane przez Unię Europejską (Marakesz 2001).

Przedstawiono rządowe prognozy zapotrzebowanie na energię w Polsce i prognozy władz lokalnych w rejonie Krakowa. Przedstawiono również prognozy zużycia pierwotnych nośników energii z uwzględnieniem wykorzystania zasobów gazu i węgla.

W tym kontekście, uwzględniając przyszłe zapotrzebowanie na ciepło i energię elektryczną, w artykule omówiono problemy standardów ochrony środowiska w Polsce, które będą musiały być przestrzegane w okresie łączenia się z Unią Europejską. Określone w dyrektywie unijnej dla dużych źródeł spalania (LCP) wielkości emisji SO_x, NO_x i pyłów będą miały znaczący wpływ na polski sektor energetyczny. Ponieważ większość dużych miast w Polsce posiada systemy dystrybucji ciepła, dokonano analizy zalet dużych ciepłowni. Przedstawiono również, jak nowe wyposażenie pozwalające na kogenerację powoduje redukcję emisji.

Artykuł przedstawia również niezbędne do przeprowadzenie badania w zakresie tych technologii, biorąc pod uwagę konkurencyjność scentralizowanych i rozproszonych ciepłowni. Uwzględniając kontynuację zużycia węgla, który pozostanie ekonomicznie konkurencyjny przez następne dziesięciolecia, w artykule omówiono różne możliwości dostosowania standardów ochrony środowiska w zakresie emisji siarki i pyłów. Analiza ta uwzględnia również wykorzystanie produktów pośrednich. Zastosowane mogą być dwie technologie: metoda pyłu węglowego z oczyszczaniem gazów spalinowych lub cyrkulacyjne złoże fluidalne. W obu tych metodach można zastosować warunki sub- lub superkrytyczne dla pary w celu uzyskania wyższej efektywności energetycznej.

Jeśli użyje się gazu ziemnego jako paliwa, cykl kombinowany, który łączy turbiny parową i gazową jest najefektywniejszą technologią.

W dłuższej perspektywie, powiedzmy po 2020 roku, zgazowanie węgla może również stać się konkurencyjne ze względu na wychwytywanie i magazynowanie CO_2. W tym przypadku właściwą technologią byłoby zintegrowane zgazowanie w cyklu kombinowanym.