Energy Efficiency Potentials in European Union and South Korea:
Toward Less Energy, a Better Economy and a Sustainable Environment

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〈 목 차 〉

[요 약]

유가가 배럴당 $60선을 오르내린다는 보도가 연일 계속되면서 우리 사회는 석유문명 속에 의존하고 있음을 더욱 실감하게 하고 있다. 저명한 에너지 학자인 Rifkin이 Boston Glove에 기고한 글과 미국 대통령 Bush가 유럽공동체에서 에너지 효율에 관한 Green Paper의 최근 발표는 에너지 소비국들이 상승하는 석유가격에 대처하는 에너지 청사진 만들기에 분주하게 하고 있다.

에너지 효율향상의 시도는 석유가격 상승 억제 뿐만 아니라 비용-효과적인 면에서 에너지, 경제, 환경, 공평성 및 안정성에 도움을 주고 있다. 에너지 효율은 에너지 생산과 소비에서 기술향상을 통하여 이루어지기 때문에 최종적으로는 소비자들의 생활양식에 큰 영향을 미친다. 에너지 생산 및 수송 과정에서 효율성 향상은 에너지의 집중적 생산 뿐만 아니라 연결망을 단축하여 분산형 에너지공급 체계를 구축하는 장점도 갖고 있다. 따라서 소비자는 에너지 효율향상을 통하여 건물, 전기가구, 공장, 교통 등에서 에너지를 보다 경제적으로 쓸 수 있다.

EU와 한국의 에너지절약에 관한 연구는 2020년에 약 20 퍼센트의 에너지 절약이 가능하며 한 가구당 연간 약 $240 - $1,200을 절약함을 제시하고 있으며 절약의 상당량을 석유수요로 대체할 수 있음을 보고 있다. 특히 유럽은 에너지 집약도가 낮음에도 불구하고 약20퍼센트의 에너지 절약 가능성의 시사는 그 의미가 자못 크다.

에너지절약 대체가능성에 대하여 일부 학자들은 문제를 제기하기도 한다. 기술적 에너지 효율 향상

은 "반동 효과"(rebound effect) 때문에 에너지소비를 자극하게 함으로써 오히려 전제적으로 에너지 소비를 증대 시킨다고 반박하는 학자들도 있다.

이에 대하여 "기술적 효율성"(technological efficiency) 제고와 "행위적 절약"(behavioral conservation)의 병합하면 20 퍼센트 에너지 절약 가능성의 실현은 물론 기술적 효율성 제고와 반동 효과를 줄일 수 있기 때문에 소비자는 지속적으로 증가하는 에너지 수요를 만족시킬 수 있고 에너지 절약 목표도 동시에 이룰 수 있다는 점이다.

더욱이 균형 잡힌 에너지 정책은 에너지 절약 가능성을 실현하는 핵심이 된다. 에너지정책은 그 시행과정에서 시장기능의 활성화의 장애물을 제거함으로써 에너지효율성 향상에 기여할 뿐만 아니라 절약기술의 촉진과 소비자들에게 에너지절약 습관도 유도할 수 있다.

하나의 에너지 정책이 에너지 절약 장애물을 제거할 수 없다면 본고에서 소개된 15개의 정책대안을 적절히 혼합함으로써 절약목표를 달성할 수 있다고 본다. 그러한 예는 선진공업국 뿐만 아니라 개발도상국의 많은 성공사례에서 볼 수 있다. 에너지 절약정책은 국가의 주요의제가 되어야 효력을 발생 시킬 수 있으며 기후 온난화 문제와 에너지 수급의 안정성문제는 지구공동체의 전략이 수립되어야 함이 중요하다. 이런 문제를 해결하기 위하여 선진국들은 개발도상국들에게 정책적, 기술적 협력관계를 맺음으로써 실천의 바람직한 선례를 보여주어야 한다.

에너지절약의 실질적인 효과를 거두기 위하여 정부, 산업체 및 소비자가 우선 자본을 투자함으로써 경제를 활성화에 일조하게 되며 일자리 창출에도 도움이 된다. 뿐만 아니라 에너지 절약으로 축적된 자본이 지속적으로 사회경제개발에 재투자됨으로써 견실한 경제를 구축하는 길이 된다. 그러나 선진국들이 말하는 이른바 "대규모 소비가 진보"(more with progress)라는 기본가정은 에너지 절약을 위해 새롭게 방향을 설정할 때이다.

따라서 에너지 분석가와 정책 결정자는 새로운 변화를 위한 패러다임 형성에 사회의 선도적 역할과 책무를 져야 할 뿐만 아니라 소기의 정책결과가 도출되도록 마무리 짓는 중요한 역할을 해야 함을 염두에 두어야 한다. 이제 우리는 21세기에 닥쳐올 에너지 저소비, 건전한 경제 및 지속 가능한 환경 문제를 해결하기 위하여 도전적인 자세가 필요하며 방관자적 자세는 금물이다.

With the price of oil hovering at $60 a barrel on world markets and scholars predicting that worldwide oil reserves will dwindle, our society is quickly recognizing that the whole world runs on oil. We are indeed an oil civilization: we rely on oil for our food, plastics, pharmaceutical products, and clothes, as well as for our transportation, power, heat, and electricity.

A noted energy scholar, Jeremy Rifkin,[1] indicated in an article appearing in the Boston Globe (October 13, 2005) that President George Bush and his team "do not understand the enormity of the energy crisis facing the United States and the World" and suggested that the President "should download the just published European Union Green Paper on Energy Efficiency" to lay out a roadmap for cushioning the cost shock of rising oil prices (Rifkin, 2005). The EU commission study says the average EU household could save between $240 – $1,200 per year in cost-saving energy efficient practices, thus offsetting much of the increased price of oil (EC, 2005).

1) Rifkin is author of "The Hydrogen Economy: The Creation of the World Wide Energy Web and the Redistribution of Power on Earth" and Principal Advisor to the European Union Parliamentary Leadership Group for Renewable Energy and a Hydrogen Economy.

Even without escalating oil prices, there are other significant reasons for pushing toward a re-invigorated energy efficiency programs. The cost-effective savings of energy means the enhancement in energy sustainability, economic development, environmental sustainability, equitable empowerment, and energy security, or E^5:

Energy Sustainability

- Decreased dependence on fossil fuel imports from third countries;
- Strong foundation for a sustainable future, bridging efficiency to a solar economy (Scheer, 2004).

Economic Development

- Reduced costs for the economy, boosting the economy and creating new jobs;[2)]
- Reduction in fossil fuel prices;[3)]
- Enhanced trade opportunity driving from the development and introduction of new energy-efficiency technologies;
- Positive multiplier effect from domestic efficiency investment.[4)]

Environmental Sustainability

- Greater environmental health, especially promoting climate sustainability;
- Reduction in air pollution and improvement of human health;
- Improved water sustainability through reduced water needs at the point of power production[5)] and reduced water consumption at the point of consumer demand.

Equitable Empowerment

- Significant savings on household energy bills, having a direct impact on the quality of life of all citizens, especially in developing countries;
- Reconciliation of exploding energy demand of the developing world, particularly in China and India (EC, 2005).[6)]

Energy Security

- Promotion of the security of energy supplies (Wiser et, 2005);

2) The United States used 10 percent of its GNP to pay the national fuel bill as compared with Japan's only 4 percent. The difference of $200 billion gives the average Japanese product an automatic cost advantage of about 5 percent in the U.S. market.

3) The National Renewable Energy Laboratory recently concluded that this price reduction effect can be significant as much-as 2% for each 1% of demand displaced (Wiser et al., 2005).

4) According to the Minnesota Energy Agency, a dollar spent on electricity, petroleum products or natural gas has a net local multiplier effect of $1.69, $0.55, or $0.59, respectively. A dollar spent on home energy conservation has a net economic effect of $2.21.

5) In the United States, the amount of fresh water withdrawn for electricity production is more than twice as much as the water used for residential, commercial, and industrial purposes (Garman, 2005).

6) An even more aggressive policy for technical efficiency ought to be pursued in developing countries, but it would be neither ethical, nor equitable to argue for restriction in overall energy growth in these countries. The onus should be on Europe, U.S., and other rich countries to change path.

- Reduction in energy imports from socio-politically vulnerable regions;
- A risk management strategy for energy suppliers (Rickerson et al, 2005).

Even though energy efficiency is imperative for E^5, a large proportion of energy continues to be wasted, whether by inefficient equipment or through lack of awareness of energy users. Improved energy efficiency implies both a better use of energy through improvements in energy efficiency and energy savings through changes in behavior. Energy efficiency essentially depends on the technologies used. Improving energy efficiency means using the best technologies to consume less, whether at the point of production (supply-side efficiency) or at the final consumption (demand-side efficiency).

1. Supply-Side Efficiency

A hard energy path "relies on rapid expansion of high technologies to increase supplies of energy, especially in the form of electricity" (Lovins, 1976: 65). The pursuit of the hard path involves immense inefficiencies. Two-thirds of the energy in coal, oil, or natural gas is lost in the production of electricity. Efficiency improvements in the centralized power sector are needed while making the transition to a solar economy with decentralized power generation.

Power Efficiency

Energy 'waste' levels in the processes of electricity generation are running at 66%, and the transport of electricity involves losses of up to 10% of the electricity produced (up to 2% by transmission and 8% in distribution). The electric power sector possesses great potential for efficiency improvements.[7] In many cases, cost-effective measures can be taken to significantly reduce the inefficiency of the power sector. Old inefficient plants could be taken off the market and replaced with the more fuel-efficient combined-cycle gas turbine (CCGT) technology with a yield close to 60%.

Cogeneration

Cogeneration offers a substantial potential gain in efficiency. Cogeneration technologies can be developed for energy efficiency, fuel flexibility, and the reduction of construction costs. It is also important to explore and develop cogeneration technologies that can increase the use of renewable sources. It is estimated that those district heating and cogeneration

7) At the point of energy supply, offering consumers the opportunity to opt for energy services could lead to price competition between energy service suppliers/distributors. This will lead to a reduction in the quantity of energy consumed by these services, since the cost of the energy would normally be a large part of the total cost of the service.

facilities, including industrial applications, already existing, may save 3-4% in primary energy use as compared with separate production (EC, 2005).

Distributed Generation

The current investment needs in electricity generation could be used to facilitate a shift in electricity generation away from the big power stations to cleaner, more efficiently distributed, on-site generation. Alternative, renewable energy sources can provide more efficient, dependable power more appropriately matched in scale and quality to their end uses. Because the energy source is direct, as with solar power heating a house, it is more efficient.

2. Demand-Side Efficiency

In case of the United States, the National Association of Regulatory Utility Commissions (NARUC) changed the rules of operation for state utility commissions in 1979. Since that time the ruling has encouraged companies to close their supply-side oriented building program and concentrate on generating negawatts or reduced electricity consumption through demand-side management programs. Utility companies demonstrating improvements in the efficiency of electricity use among their customers can take a larger percentage of their sales in profits.[8]

Energy efficiency improvements could benefit both customers and utilities. Buying the most efficient industrial equipment, new buildings, or household appliances, customers receive electricity at lower rates. Then the utility sells the surplus power to new customers, avoiding the costly investment necessary to expand production capacity with new generating stations.

Many efficiency measures can be taken at regional and local levels, close to the citizen. Action on energy efficiency will produce all its potential gains domestically because operations to be undertaken at national levels are reflected locally. Energy efficiency potentials by major end-use sectors, such as buildings, domestic appliances, industry, and road transport, are briefly described below.

Buildings

Providing and promoting energy efficient buildings in cities, significant energy savings can be obtained. The energy performance of buildings can be improved when they are being renovated. The biggest opportunity is in cou-

8) Utility demand-side management (DSM) programs have been downsized after electricity restructuring in the United States, but targeted DSM, or demand response programs, allow utilities to avoid upgrading needs of sub-stations in certain service areas.

pling measures for energy efficiency improvement with retrofitting. With cost-effective gains, the building sector alone could create full time jobs for highly qualified personnel and for the building profession in general. Such employment is mostly created in places where the changes to buildings have to be made.

Domestic Appliances

Major improvements could be made with a combination of measures taken to inform the consumer on minimum efficiency levels (including requirements for econ-design)[9] and by voluntary agreements. Also, special measures need to address the concerns over the stand-by function. Electricity used in stand-by mode can reach between 5 and 10% of total electricity consumption in the residential sector. Technologies must be developed to limit these losses.

Industrial Factories

Driven by economic incentives, it is to be expected that industry will make additional significant improvements in its processes and the machines it uses (e.g., electric motors, compressors). In the European Community, a large number of voluntary agreements in industrial sectors (e.g., the paper industry, the horticultural sector and the chemical industry) have already been taken. Such voluntary agreements by industry reinforce energy-efficiency measures (EC, 2005).

Road Transport

Increased R&D programs are needed in the development of electric vehicles, in testing those running on alternative fuels such as natural gas, and in advancing longer-term prospects for technologies such as fuel cells and hydrogen. As a demand-side program, a vehicle labeling system can be used for information on not only fuel consumption but also CO_2 emissions of new cars. Intelligent transport systems such as navigation technologies[10] and congestion charging can be also adopted to increase the safety and energy efficiency. Friction[11] and pressure[12] of tires need to be properly checked to save significant amounts of energy.

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9) One of the aims of eco-design is to apply requirements for energy efficiency while avoiding negative consequences on the environment or in other stages in the life cycle of the appliances.

10) The satellite navigation system will offer reliable and precise positioning systems for vehicles, offering traffic flow optimization in road transport. It will make it easier to put road-charging systems in place without causing long queues at entry points to the charging zones.

11) Friction between tires and the road accounts for up to 20% of a vehicle's consumption. Properly performing tires can reduce the latter by 5% and sales of such tires should be encouraged not only on new cars but also for subsequent replacements (EC, 2005).

12) Better pressure checks also lead to lower consumption. Estimates suggest that between 45 and 70% of vehicles are driven with at least one tire below the prescribed pressure, which causes 4% over-consumption. One option would be to consider a voluntary agreement with industry to install tire pressure sensors on the dashboard of cars (EC, 2005).

3. Energy Efficiency in EU and South Korea

European Union

Energy efficiency in EU is discussed in *Doing More with Less: Green Paper on Energy Efficiency* (in short, "The Green Paper") published by European Commission in 2005. The Green Paper is based on the studies conducted by numerous organizations in Europe, including Wuppertal Institute (2005), Green Business Letter (2005), WWF (2005), UNDP (2000 and 2004), and European Council for an Energy Efficient Economy Proceedings (2005).

The Green Paper intends to encourage more widespread use of new technology to improve energy efficiency and stimulate a change in European consumer behavior. The 25 member states of the European Union (EU-25) currently consume around 1,725 Mtoe (million tons of oil equivalent) of energy per year, with a high price tag of EUR 500 billion ($600 billion), or more than EUR 1,000 ($1,200) per person per year.

Of this EUR 500 billion, about one half (EUR 240 billion) falls on the trade bill of the EU. Even though Europe's energy intensity, the ratio of GDP to energy consumption, is approximately 50% less than that of the U.S., a large proportion of energy continues to be wasted, whether by inefficient equipment or through a lack of awareness of energy users. The enormous loss of capital could be put to other uses, including developing new energy-efficient practices, technologies and investments.

If the current trend continues, gross energy demand is projected to increase by 10% by 2020,

〈Table 1〉 Cost-Effective Energy Saving Potentials by End-Use Sector in EU

Potential savings in Mtoe	2020 Rigorous implementation of adopted measures	2020 Implementation of additional measures
Buildings: heating/cooling	41	70
Electrical appliances	15	35
Industry	16	30
Transport	45	90
CHP	40	60
Other energy transformation, etc.	33	75
Total energy savings	190	360

Source: European Commission. 2005. *Doing More with Less: Green Paper on energy efficiency*. p. 31.

reaching 1,900 Mtoe in 2020, compared with 1,725 Mtoe in 2005. These predictions are made under the assumption of an average GDP growth rate of 2.4% per year. According to the Green Paper, the EU could achieve a reduction of the energy consumption by 20% compared to the projections for 2020 on a cost-effective basis. Table 1 gives a general indication of the potential cost-effective savings of 360 Mtoe in 2020, equivalent to a 20% energy savings.

The cost-effective savings shown in the Green Paper represent a picture of the opportunities to explore. A concrete action plan should be established at EU Community, national, regional, and local levels and at the level of industry, of financial institutions, and of individual consumers to harness the identified potential energy-efficiency savings. The EU Community intends to propose a practical action plan for implementing beginning in 2006.

South Korea[13)]

In 1997, South Korea established the National Committee for Energy Conservation (NCEC) to improve implementation of energy efficiency and conservation policies for each energy-using sector. This means that an elementary policy structure to promote energy efficiency and conservation exists and can be marshaled for an efficient energy future. However, an objective evaluation found that the country's initiatives are no match for the forces of rapid growth in energy use and the concomitant waste, pollution and mounting social risks that dominate the energy picture. South Korea's energy intensity is 200-300% higher than that in Germany and Japan. More must be done.

The JISEEF team[14)] adopted a 'bottom-up' modeling approach, which employs engineering and economic estimates of energy savings, emissions and costs of different technologies, to assess the potential for energy efficiency. The JISEEF team turned to international databases prepared by U.S. and Japanese research organizations, while ensuring its applicability to South Korean circumstances.[15)] Two important

13) Energy efficiency in South Korea is discussed in the book *Energy Revolution: 21th Century Energy and Environmental Strategy* (authored by J. Byrne and Y-D. Wang et al) published in 2004 by Maeil Business Newspaper.

14) The Joint Institute for a Sustainable Energy and Environmental Future (JISEEF), created by the sponsorship of the W. Alton Jones Foundation, is composed of a highly respected international research team organized by the Center for Energy and Environmental Policy (CEEP) with South Korea's foremost experts in the energy and environmental fields led by the Research Institute for Energy, Environment and Economy (RIEEE) of Kyungpook National University, the Environmental Planning Institute (EPI) of Seoul National University, and the Citizens' Institute for Environmental Studies (CIES) of the Korea Federation of Environmental Movements.

15) The database was subjected to validation by energy experts in South Korea, including members of KEEI. This database is in a spreadsheet format, in which row entries have energy efficiency technologies, and column entries contain energy and economic savings information, including percentage energy savings, incremental costs (to install and operate the improved technology), cost of conserved energy and pay-back period.

factors justify the use of international data sets: market competitiveness and international policy trends.

The JISSEF team adopted the 1999 results of the KEEI/MOCIE model as the benchmark for its analyses (MOCIE/KEEI, 1999). This choice was dictated by our desire to evaluate sustainable energy options against the South Korean government's official business-as-usual (BAU) forecast for energy and CO_2 to the target year 2020. According to BAU projections, primary energy consumption will reach 332 Mtoe in 2020, or 1.7 times higher than that of 2000 (191 Mtoe). CO_2 emissions from the energy sector are projected to increase during the period of 2000-2020, from 104 million tons of carbon (MTC) in 2000 to 204 MTC in 2020.

The JISEEF team focused on specific technologies in each end-use sector as part of its construction of the *JISEEF* Scenario analysis. These technology categories were selected for two reasons: they are significant sources of energy consumption and detailed data are available on current technology stocks.[16] The technology categories targeted in *JISEEF* for efficiency improvements in each sector are listed below:

Industrial Sector: Heat Recovery Upgrades
- Space Conditioning Upgrades
- Boiler and Steam Efficiency Upgrades
- Motor Drive Efficiency Upgrades
- Fuel Switching
- Enhanced Cogeneration
- Lighting Upgrades
- Operation & Maintenance Upgrades

Transport Sector: Passenger Car Fuel Efficiency Upgrades
- Light and Heavy Truck Fuel Efficiency Upgrades
- Bus Fuel Efficiency Upgrades
- Rail, Air and Marine Transport Efficiency Upgrades
- Introduction of Alternative Fuel Vehicles

Commercial Sector: Commercial Space Conditioning Efficiency Upgrades
- High-Efficiency Commercial Lighting
- High-Efficiency Motor
- Building Shell Upgrades

Residential Sector: Residential Space Conditioning Efficiency Upgrades
- High-Efficiency Residential Lighting
- High-Efficiency Residential Refrigeration

16) In some instances, data limitations prevented the team from exploring energy efficiency improvements that have been found in studies of other countries to be significant (e.g., high-efficiency windows and doors, wall and roofing materials, and efficient building design strategies).

Fuel Switching for Water Heating

Housing Shell Upgrades

Modeled after the recently published U.S. national study by the Inter-Laboratory Working Group (IWG, 1998, 2000), the JISEEF team prepared three policy strategies for capturing the efficiency potentials identified in each end use sector: a Full Implementation Scenario in which all identified cost-effective, technically feasible savings are realized; a Major Policy Commitment Strategy which would seek to realize 65% of the identified energy and CO_2 savings under the Full Implementation

〈Table 2〉 Summary of Primary Energy Savings and CO_2 Emission Reductions in 2020 for the JISEEF Scenario by End Use Sector

(Unit: MTOE, MTC)

Sector	Full Implementation	Major Policy Commitment
Industrial Savings		
• Final Energy	32.1 (25.0%↓)	20.8 (16.3%↓)
• CO_2	19.1 (25.2%↓)	12.4 (16.4%↓)
Transportation Savings		
• Final Energy	16.5 (28.1%↓)	10.7 (18.2%↓)
• CO_2	13.3 (28.0%↓)	8.6 (18.2%↓)
Residential Savings		
• Final Energy	14.7 (33.8%↓)	9.6 (22.0%↓)
• CO_2	9.6 (34.5%↓)	6.2 (22.5%↓)
Commercial Savings		
• Final Energy	9.8 (35.8%↓)	6.4 (23.3%↓)
• CO_2	5.7 (35.3%↓)	3.7 (22.9%↓)
Reduced Electricity Lossesa		
• Energy Conversion	22.3 (28.7%↓)	14.6 (18.7%↓)
• CO_2	11.2 (28.7%↓)	7.3 (18.7%↓)
TOTAL SAVINGS		
• Primary Energy	95.4 (28.7%↓)	62.1 (18.7%↓)
• CO_2	58.9 (28.8%↓)	38.2 (18.7%↓)

Note : a Denotes avoided energy losses and CO2emissions from conversion due to end-use energy savings.

Source : John Byrne and Young-Doo Wang et al. 2004. Energy Revolution: *21st Century Energy and Environmental Strategy*. Seoul: Maeil Business Newspaper.

Scenario; and a Modest Policy Commitment Strategy which would capture 35% of identified savings of the Full Implementation Scenario.

A summary of energy and CO_2 savings from energy efficiency improvements is shown below by energy sector (see Table 2). Most significant savings are from the industrial sector, followed by the electricity sector. Total savings in primary energy use and in CO_2 emissions from full implementation (a 100% implementation) are 95.4 MTOE and 58.9 MTC, respectively. A Major Policy Commitment Strategy (a 65% implementation) is expected to achieve a 19% savings in primary energy use and a 19% reduction in CO_2 emissions.

The total investment cost for JISEEF efficiency upgrades under the Major Policy Commitment Strategy (65% implementation scenario) amounts to 3.4 trillion won ($2.8 billion), and the avoided CO_2 emissions are 38.2 MTC, yielding a marginal cost of approximately 86 thousand won ($72) per avoided ton of carbon. The net benefits to the South Korean economy would be 33.4 trillion won ($27.8 billion) in 2020. This is probably a conservative estimate because the uncertainties associated with petroleum prices, CO_2 abatement costs and multiplier effects are likely to favor higher benefit values (Byrne and Wang et al, 2004).

4. The Paradox of Efficiency

The pursuit of efficiency has been the one consistent and bipartisan cornerstone of national energy policy since the 1970s, but energy efficiency potentials have not been fully explored mainly due to lack of strong policy interventions. But increased price of fossil fuels, vulnerable security of energy supply, economic competitiveness, climate change and atmospheric pollution all make nations seriously reconsider energy efficiency as an inevitable instrument for a sustainable future.

As shown in both the European (2005) and South Korean (2004) studies, with rigorous policy interventions each could achieve around 20% energy savings in 2020. Viewed in terms of the relatively lower level of energy intensity in South Korea and specifically in the case of EU, such magnitude of savings is enormous. But some scholars are critically negative about the huge potential of energy efficiency. For them, efficiency raises demand, and waste of energy is virtue (Huber and Mills, 2005).

Wilhite and Norgard (2004) argue in their article published in *Energy Policy* that equating efficiency with reduction is a self-deception in energy policy. They assert that the policy and research at the center of the discourse on energy sustainability suffer from a self-deception, which revolves around the equation of 'efficiency' with 'reduction.' According to them, the perception of a de-coupling between energy consumption and GDP is erroneous contention. Energy consumption, no matter how efficient, is positively linked to economic activities, in the sense that growth in activities pushes energy consumption upward.

More efficient use of energy could actually lead to higher energy consumption by making the economy grow faster due to the increased growth in activities. This is the so-called rebound effect and, according to Wilhite and Norgard, its effect is probably less than 20% of the savings from the efficient technology. According to them, energy consumption, no matter how efficient, is positively linked to economic activities, pushing energy consumption upwards.

Huber and Mills (2005) have made a similar, but stronger criticism in their book *The Bottomless Well*. Efficiency may curtail demand in the short term, but its long-term impact is just the opposite. The more efficient we become, the more we built, and the more energy we consume overall. Efficiency has come, and demand has risen apace.[17] More efficient almost invariably means faster, and faster almost invariably means a higher burn rate, and more miles traveled, and more energy consumption overall (Huber and Mills, 2005).

The new technologies are efficient because they are quick, compact, light, and responsive, opening up new vistas of energy consumption that weren't possible before. Huber and Mills quote that "the Internet has the funny effect of increasing the amount of travel – people using it discover places to go and people they want to meet." Electricity initially supplied to power Edison's new bulb was soon tapped to power electric motors, then compressors in refrigerators, then air conditioners, and then microprocessors.

The American Council for Energy Efficient Economy (ACEEE) also expresses a concern over limited private investment in efficiency. Besides market and institutional barriers, more fundamental factor that keeps efficiency investment small has to do with the two trends in the U.S. economy: falling energy intensity and rising incomes (ACEEE, 2004). Falling intensity means we use less energy per unit of economic activity, making us less motivated to invest in energy savings. When people have more discretionary income to spend on the energy services, this income elasticity of demand factor tends to

17) While production, transmission and end-use technologies have all improved in efficiency, total energy use in the OECD countries has continued to increase, simply because growth in economic activities ate up the efficiency gains (Wilhite and Norgard, 2004).

work against efficiency.

As a matter of fact, there is significant difference between actual energy used to provide energy services (such as lighting, heating, refrigerating, etc.) and the level of energy efficiency that can be provided in a cost-effective way for the same services (Levine et al, 1996; Weber, 1997). A relevant question is how to close the energy efficiency gap and rebound effect to achieve the identified potential of energy savings. It is important to identify the bottlenecks presently preventing these cost-effective efficiencies from being captured and then identify options to overcome these bottlenecks.

5. Efficiency and Conservation

The bottlenecks can be addressed through a combination of technological efficiency and behavioral conservation. Focusing only on technological efficiency, the warning of energy paradox by Huber and Mills (2005) could be realized: the more efficient the technology becomes, the more energy society consumes. With a combination of behavioral conservation, the efficiency gap will be reduced and the rebound effect will be minimized, thereby achieving absolute reduction of energy consumption. Efficiency and conservation are sometimes interchangeably used, but there are differences between the two (Rubin, 2004):

Technological efficiency alone is not able to offset continued growth in energy services to the extent that deep reductions in energy use might. The full direct savings from more efficient technology could be realized if the goal were to provide for people a certain *sufficient* amount of energy services, and then level off

〈Table 3〉 Differences between Efficiency and Conservation:

Improved Efficiency	Conservation
More miles per gallon of gasoline	Driving less; using fewer total gallons
More lumens per watt	Less artificial lighting
Occurs only while using energy	Occurs while not using energy
Suggests no change in lifestyle	Questions need for end uses
Provided mostly by specialists	Provided mostly by end users
Dependent on energy suppliers	Creates independence from suppliers
Mostly technical	Mostly behavioral
Promotes growth	Promotes sustainability

Source: Compiled from Andrew Rudin. 2004. "Efficiency and Conservation." *Energy & Environment* 15(6).

(Wilhite and Norgard, 2004). A reduction in energy use will only come about by reining in the demand for energy services (e.g., indoor comfort, illumination, mobility).

A new policy paradigm is needed for Europe and South Korea, one that aims at combining *efficiency of technology with sufficiency in energy services* to reduce energy use by 20% in 2020. This is the reason for why technological efficiency and behavioral conservation need to integrate together in combination with rigorous policy interventions. Energy efficiency gaps are a market failure and we need to examine energy efficiency policies that have been used to overcome these market failures.

6. Actions Recommended

A national energy efficiency program can be successful if it has strong government backing and funding, works collaboratively with the private sector and other institutions, and focuses on technological improvement, public awareness, and market development. Policy interventions help to remove barriers inhibiting adoption and thereby increase sales of new technologies, which in turn results in unit cost reductions. This creates a positive feedback loop that can enable rapid market growth.[18]

There is no single silver bullet for overcoming the barriers to efficiency (Geller, 2004). Many policy initiatives are needed to overcome the barriers to a more energy efficient future.[19] High levels of energy savings through efficiency improvement have been achieved in both industrialized and developing countries, demonstrating that any nation can overcome the barriers inhibiting clean energy development through well-designed and well-implemented policy initiatives. To increase the availability and deployment of energy efficiency technologies and to level off the growth rate of energy demand, the following policy options should be considered.

Efficiency Action Plan

Establishing annual energy-efficiency action plans and monitoring performance at the national level is important in order to learn from successes and mistakes and to ensure the rapid spread of best practice throughout the nation.[20] Local energy agencies could dissemi-

18) The market transformation program could offer manufacturers a multi-million dollar reward for producing that is significantly more efficient than products on the market. A well-known example is the Golden Carrot Program for efficient refrigerators and clothes washers.

19) The combination of utility programs, appliance efficiency standards, and building energy codes has a significant impact on overall energy use in California during the past 25 years. California cut its electricity use per unit of economic output by nearly 30 percent from 1977 to 1999, compared to relatively constant electricity intensity in the other 49 states (Geller, 2004).

nate best practices, even to the general public. The recent consensus report from the U.S. National Commission on Energy Policy, which forcefully addresses demand-side policies, may be a positive starting point for a renewed dialogue on energy efficiency.

Information

Energy saving in the overall sense derives from a change in consumer behavior so that strong and sustained public awareness campaigns are needed. Through leveling programs, training, and energy audits, consumers are informed about the relative energy efficiency of different products. In the United States, the Energy Star® program has been very successful: savings of about 42 billion kWh per year have been worth about $3 billion in reduced energy bills (EPA, 2001). Information tends to be more effective when it is combined with other policies regarding financing, pricing, incentives, voluntary agreements, or regulations (Geller, 2004).

R&D Support

Several promising end-use technologies still require R&D support. A number of concerns such as an increased share of renewable energy, the efficiency of fossil fuel-based power production, more efficient electricity networks, and vehicle efficiency can only be alleviated through efficient R&D activities in connection with other regulatory and market-based measures. Government funded R&D is justified on the basis that the private sector usually underinvests in R&D from a societal perspective. Collaboration with research institutes and the private sector, and international cooperation could not only promote successful commercialization and market penetration, but also share costs and risks of innovative efficiency technologies.

Tariff

A progressive electricity tariff for households penalizes over-consumption without burdening low-income families. One of the unexpected consequences of progressive tariffs observed in Japan in the late 1980s was that these tariffs made people choose not only to buy more efficient electrical appliances, but also to buy fewer appliances. A similar but more stringent instrument is the introduction of quotas, based on energy consumption targets. Amounts consumed in excess of the allocated quota would increase dramatically in cost, in which sense the policy resembles progressive tariffs. Tariffs

20) Forming national energy efficiency (and renewable energy) center is critically important to carry out the wide range of activities, including assistance to private firms, demonstration of energy-efficient technologies, provision of energy management training, dissemination of information, and support for policy reform. South Korea has sound energy infrastructure, including the Korea Energy Management Corporation (KEMCO), the Korea Energy Economics Institute (KEEI), and the Korea Institute of Energy & Resources (KIER).

are also adopted in trade policies in which favorable treatment is negotiated for goods on the basis of their energy efficiency performance as proposed in WTO context by the European Commission in February 2005 (EC, 2005).

White Certificate

White certificate systems oblige suppliers or distributors to undertake energy-efficiency measures for final users. These systems have been partially implemented in Italy and the United Kingdom, are under preparation in France, and are being considered in the Netherlands (EC, 2005). Such certificates can be exchanged and traded. If the contracted parties cannot submit their allocated share of certificates, they can be required to pay fines that may exceed the estimated market value. By the introduction of this system in the tertiary and services sector, savings of 15% can be obtained at zero cost (EC, 2005).

Financing

Financing at attractive interest rates can help to diffuse and build markets for energy efficiency and renewable energy technologies. Other financing mechanisms can include a clean energy fund acquired from public benefit charges and financial arrangement by energy service companies. Some nations create an energy conservation fund through a small tax on the sales of petroleum products. In the United States, 18 states operate public benefits funds for efficiency. Energy service companies (ESCOs) provide financing, technology, installation, and performance guarantee for businesses or public agencies, thereby playing an important role in bridging the gap between different actors on the energy and technology supply side and among energy consumers.[21)]

Tax Incentives

Taxation can be either incentive or disincentive to energy consumers and suppliers. Taxation can be designed to ensure that the polluter really pays. Clean vehicles can be even de-taxed. Tax incentives are used for the range of energy-efficient technologies and products such as energy efficient new homes, high efficiency heating and cooling products, high-efficiency water heaters and furnace fans, high-efficiency systems that generate both heat and power (CHP), and advanced technology vehicles, including hybrid and fuel cell passenger vehicles. Using new or improved financing instruments to give incentives to both companies and households to introduce cost-effective improvements.

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21) Energy service companies (ESCOs) need policy support in the form of help for the dissemination of their activities, quality standards, and access to finance, as they are still in their infancy.

Pricing

Energy prices would have to rise to very high levels to cause enough pain to motivate major new efficiency investments. But, letting prices rise further risks serious economic damage. We can pursue vigorous energy efficiency policies to bring demand growth back into a sustainable range. This would help bring down energy prices in the next few years, boost the economy, and reduce air pollution and greenhouse gas emissions (ACEEE, 2004). The experience of London since introducing 'congestion charging' in 2003 has been that fuel consumption has gone down by 20% and CO_2 emissions by 19% in the charging zone (EC, 2005).

Codes and Standards

Minimum efficiency standards for buildings and appliances are a viable policy, and often simpler and less bureaucratic to implement. Efficiency performance standards for utilities and stronger fuel economy standards for vehicles can be used. Better building energy codes for new and renovated buildings need to be adopted.

The U.S. National Appliance Energy Conservation Act of 1987 established national efficiency standards for several appliances and required the DOE to issue other standards and to update all standards at defined intervals. The U.S. experience demonstrates the importance of updating efficiency standards and codes periodically as technologies evolve and older standards become outdated.

Voluntary Agreements

Government and the private sector can have voluntary agreements to improve energy efficiency. With the automotive industry voluntary agreement, the EU aims to reach an average CO_2 emission figure of 120g/km for all new passenger cars marketed. This translates into a reduction of fuel consumption of around 25% compared to 1998 (EC, 2005). In the Netherlands, over two-thirds of energy-intensive industries had signed a voluntary agreement as of 2000. It is estimated that the benchmarking program will reduce industrial energy use in the Netherlands by 5 to 15 percent by 2012. The voluntary program included both "carrots" and "sticks," promoting a high level of participation and compliance.

Public Procurement

Bulk purchases by government authorities or the private sector stimulate the introduction and successful market development of high-efficiency technologies. U.S. federal agencies are required to purchase Energy Star® products, leading to widespread production of energy efficient equipment such as personal computers. In Sweden, the purchase of 46,000 ballasts dropped the cost of high-frequency ballasts significantly and increased market share to 70 percent, generating the economic benefits about 20 times the cost (Neij, 2001). Government procurement can also be utilized to purchase energy services, renewable energy technologies or fuel cells.

Utility DSM Programs

Regulators at national or state levels might promote utility DSM programs. Utility restructuring and the continuation of DSM programs need not be incompatible. Utility programs that are in the public interest should be continued. The data so far suggest that utility DSM programs, when evaluated using measured data, can be cost-effective. Utility DSM is a means of opening up large markets for better energy technology, which will benefit energy users.[22] Promotion of lower consumption at peak times and in times of shortage could be considered through the targeted DSM or demand response programs in certain utility service areas, thereby postponing potential capacity additions and possibly improving the reliability of the electricity system.

Market Obligations

Market obligations are a form of mandatory agreement in which utilities or energy agencies are required to achieve a specified level of energy savings through energy efficiency or renewable programs (Geller, 2004). This approach establishes savings rather than spending targets. The systems benefit charge approach is used to stimulate energy efficiency in the United States. Market obligations are more popular for supplying or purchasing a specific amount of electricity from renewable energy sources, commonly known as a Renewable Portfolio Standard (RPS). Renewable Portfolio and Energy Efficiency Standards are now under consideration by the U.S. Congress (ACEEE, 2006).

Integrated Planning

Integrated planning techniques can be used to provide energy services as cost-effectively by identifying the mix of supply- and demand-side resources at the lowest cost while including consideration of environmental and health concerns. Energy efficiency is treated as a resource on par with supply-side options in this approach. Integrated planning can also be applied to land use and transportation. Finding solutions for the growing problems caused by city center congestion is important in the face of the deterioration in the quality of life that this problem causes, and which goes hand-in-hand with a truly enormous waste of energy.[23]

22) Green Lights program is a good example funded through utility DSM programs.

More efficient urban design and greater reliance on public transportation can be found in many cities, including Curitiba, Brazil and Freiburg, Germany.

Energy Restructuring

The opening up of energy markets has had a positive effect on energy efficiency and electricity prices.[24] Competitive pressure has driven electricity companies to produce in the most efficiency way, particularly through technology investments, (e.g., combined-cycle gas turbines). The experience in the United Kingdom shows that restructuring and increased competition in the power and fuels sectors can be compatible with environmental protection and declining CO_2 emissions. The U.K. government took specific actions, including cutting subsidies for coal mining, adopting stronger emissions standards, and promoting combined heat and power systems, to achieve the positive environmental results in conjunction with energy sector restructuring (EC, 2005).

7. Concluding Remarks

With today's most advanced technology, it is certainly possible to save around 20% of energy consumption as shown in the cases of EU and South Korea. Energy conservation is without doubt the quickest, most effective and most cost-effective manner for reducing greenhouse gas emissions, as well as improving air quality, particularly in densely populated areas. An effective energy-efficiency policy could also make a major contribution to nation's competitiveness and employment. By enacting tough energy conservation programs across European society, the European member states could have a net savings of 60 billion euros ($72 billion) per year (EC, 2005).

According to estimations made by the German Council for Sustainable Development, more than 2,000 full-time jobs could be created for each Mtoe that will be saved as a result of measures and/or investments specifically taken to improve energy efficiency as compared to investing in energy production (EC, 2005). It should be noted that this figure does not include jobs created as a result of increased exports of energy efficiency technologies, but does include job losses due to the lower demand of energy.[25]

23) Cities can introduce restricted access to central areas for polluting and high fuel-consuming vehicles, either by tolls or actual prohibition.
24) The opening up of markets has had an impact on electricity prices. Hence, for large industrial users, electricity prices fell in real terms by an average of 10-15% between 1995 and 2005 (EC, 2005).
25) EU studies show that with cost-effective gains, conservatively estimated at more than 70 Mtoe, the residential sector alone could create at least 250,000 full time jobs, equivalent to 3,570 jobs per Mtoe saved (EC, 2005).

Critics raise questions about the very existence of such win-win situations in which society can progress to protect the environment and continue to expand economic production through cleaner, more efficient technologies (Humphrey et al, 2002). They argue that if opportunities for increased energy efficiency and economic profit exist in tandem, corporate managers probably already seized them. Other critics insist that gains made through technological improvements do little to address the core issues of ever- growing energy demand and the rebound effect of efficiency (Huber and Mills, 2005; Wilhite and Norgard, 2004).

By combining technical efficiency and behavioral conservation, the rebound effect of energy savings can be minimized, and the targeted potential energy savings can be achieved through vigorous policy interventions identified above. One way to lower energy consumption would be to convert the increase in productivity into fewer working hours and to invest the savings from lower energy bills in even less energy intensive energy services (Wilhite and Norgard, 2004). This can be observed in France: despite some increase in recent years, oil use is still 10% lower today than it was three decades ago and its energy intensity is 30% lower than in 1973 (EC, 2005).

Energy efficiency is an issue in the interest of all countries and should be integrated into their global strategy for climate change and security of energy supply. With exploding energy demand in particular in China and India, energy efficiency must be one of the key policies to try to reconcile the increased energy needs of the developing world to power growth and improve living conditions for their citizens and combat global warming (EC, 2005). The developed world needs to set an example in this respect, leading to the development of new policies, cooperation and technologies that can assist the developing world to address this challenge.[26)]

While government, industry, and consumers will have to spend some money up front to usher in literally thousands of energy efficient "best practices," the investment will boost the economy by creating millions of new jobs. Moreover, the cost savings of improved energy efficiency will mean more money will be freed up to invest in other forms of sustainable economic development. But it is not easy to explore new directions especially because energy policy in almost every country is nested in a national political agenda, which equates 'more'

26) For the developing part of the world, the use of more efficient technology will through the rebound effect tend to speed up development towards satisfying basic needs, leaving more for economic and social development.

with progress.

It is incumbent on energy researchers and policy makers to be active agents in that change. Our society need not be a spectator on the sidelines as its destiny in the 21st century is shaped. We can, and we hope will, seize this opportunity for energy efficient leadership.

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26) For the developing part of the world, the use of more efficient technology will through the rebound effect tend to speed up development towards satisfying basic needs, leaving more for economic and social development.

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