analytical
Journal

Energy in the Western Balkans – The Path of Development

(from negative trends to positive developments)

Vol.3 No.2
December 2010

analytica
analytica
thinking laboratory...

Analytical is an electronic journal published twice a year by Analytica.

ISSN: 1857 – 6559

Analytica
Skopje, December 2010

Table of contents

Editor's Note

Analytica is happy to announce the sixed volume of our E-Journal. Continuing with the good practice of targeting important and ongoing issues, the sixed edition of ANALYTICAL is dedicated to ***Energy Security in the Western Balkans***. This edition of the Journal is also an integrative part of the Think and Link Programme for 2009-2010 funded by the European Fund for the Balkans. The project title is: *Energy policy, EU and the Western Balkans: challenges of reforms and accession - Republic of Macedonia as a case stud*y.

The importance of the energy security for the countries of the Western Balkans has occupied the central area of the political discourse in the region in the last couple of years. Being completely de-prioritized during the conflicting years of the last century, the issue of securing the energy supply in the Western Balkans has shifted from a mere rhetoric high to the economic, political and social agenda of the governments in this region.

In line with the global energy concerns and the EU energy agenda, and as a part of the EU conditionality, the Western Balkans countries have firmly embraced the reforms in their energy sectors. The priorities of security of supply, competitiveness and sustainable development, which the EU has taken as main objectives in its energy policy, have been the most salient issues of our neighbourhood. The features of the energy sectors in all of the countries of the Western Balkans are similar: depletion of indigenous energy resources, dependence on fossil fuels and high energy import dependence, old infrastructure and low level of investments in the energy sector, etc. Hence, the path towards energy development in the last decades has been a wobbly one.

Nevertheless, the Western Balkans is characterized with a strategic geopolitical position for the European energy security and it could play an important role in the 'energy war' between the energy produces and consumer countries over the routes of the natural gas. Furthermore, possessing untapped renewable energy sources the region has a promising 'green' future for its energy supply. But most important is that as small markets, the future of the energy development for these countries lays in their cooperation towards a common regulatory space in the energy policy.

Thus, the governments should seriously address the energy issues, and alter the current situation by horizontal and vertical institutional reforms, and by developing and implementing policies on different levels. Investments should follow the benefits of the PPP financing method; the governments should encourage energy efficiency projects, set the market rules and develop incentives schemes for the private sector. The large energy saving potential should be addressed through the social policy and development of action plans and programmes for consumers' protection. The sustainable development of the energy sector should include the protection of the environment and incorporate the climate change component in the energy development.

In the newest issue of ANALYTICAL the authors try to give answers to some of the issues raised above. Their perspective is regional like the market integration in the Western Balkans, national through case-studies (the support of the International Financial Institutions to the renewables and energy efficiency in Croatia, Macedonia, Albania, etc.) and global, concerning the globalization effect of the newest developments of the global market of energy on individual countries and regions, such as the development of shale gas in the USA.

Nadica Pavlovska argues that the energy security in the countries of the Western Balkans depends heavily on the diversification of the energy sources, particularly in diminishing the oil and gas import dependence, while the integration of the oil and gas infrastructure is the most viable pattern of regional integration and market integration at this stage. The role of the international financial institutions in the financing of renewables and energy efficiency in South-eastern Europe is being discussed in the paper of **Ana Colovic Leskoska, Fidanka McGrath** and **Pippa Gallop.** The shale gas 'revolution' and the potential to be used as a diplomatic tool by the US in the try to lessen Russia's and other suppliers' influence is being argued by **Peter Kiernan.** And **PhD Toni Mileski** focuses on the role of NATO in the field of energy security, the approach of polarization and securitization of energy supply, the involvement and NATO's role in the field of energy security as well as the difficulty in defining the role of the Alliance. **Maja Lazareska** claims in her research that it is essential to work on the development of new bioenergy industries, so clean energy services could be provided to millions of people who currently lack them and to generate income in poorer areas of the world. **Ksenia Petrichenko** concentrates on Greece as a case study for higher energy efficiency. The tertiary sector is the sector in which the research is conducted. She tries to contribute to the understanding of sustainable development, sustainable bioenergy and energy security, as well as the co-relation between them. In the paper of **Md. Adil Chawdhury, Dr. Khamid Mahkamov** it's being said that biomass gasification has been receiving increasing attention as a potential renewable energy source for the last few decades as the downdraft gasifiers like JRB-1 are comparatively easy to build and likely to be the most appropriate technology for developing countries as a source of decentralized power supply and for development in agricultural sector.

We hope you find our selection of papers relevant and engaging. Enjoy reading this issue of Analytical and do not hesitate to share your thoughts, comments and suggestions with us at: journal@analyticamk.org.

ENERGY DIVERSIFICATION AND MARKET INTEGRATION: MEANS FOR ACHIEVING SECURE ENERGY SUPPLY IN THE WESTERN BALKANS

Nadica Pavlovska

nadica.pavlovska@gmail.com

Abstract

The challenges most of the Western Balkan countries are facing in regard to secure energy supply are rather similar. The outmoded or non-existent energy infrastructures, lack of market integration, as well as the low-levels of electricity/gas market liberalization and interconnection have prevented these states to follow suit of the EU patterns of energy consumption. On contrary rather than increasing their demand on gas supply and investments in the renewable energy sources most of the Western Balkan states have continued to be increasingly dependent on coal and lignite.

In light of these energy challenges confronting the Western Balkans, this paper attempts to discuss the diversification of the energy resources and suppliers as well as the market integration and interconnection between them as main challenges to the energy supply both in the short and the long run. The argument put forward is that addressing these more immediate points of concern can lead to solutions for more sustainable energy supply in the region, but it can also bring to bigger economic cooperation and regional development, creating an atmosphere for political and economic inter-dependence in the region.

Key words: energy supply, Western Balkans, diversification

Introduction

For a region wrecked by wars, as the Western Balkans is, a secure energy supply and development of energy projects hold high potential to act as accelerator for regional cooperation and re-integration, but also for a creation of a better climate for economic development. Needless to say that the reverse could be expected if these projects are mishandled or if energy supply is used as tool in foreign policy of the respective states.

The increase of energy efficiency, investment in renewable energy sources (RES), and energy supply diversification are only some of the challenges that the Western Balkans states are sharing with the EU. However, the degree of energy dependency if analyzed by taking into consideration indicators as the origin of the energy, the availability and number of suppliers as well as the availability of alternative energy options put the Western Balkans in incomparably critical category even when compared with the most energy dependant EU member states.

The current reality in most of the Western Balkans states is such that the entire energy infrastructure (e.g. oil, gas and electricity infrastructure) is by and large inherited from the former Yugoslavia, and since the independence little has been done for modernization or investment in this area. Therefore, it is not a paradox that since the disintegration of Yugoslavia the Western Balkans countries plus Albania have showed reversed pattern of energy consumption in comparison to the EU. Whilst majority of the EU countries today are reducing the use of hard coal and lignite and are increasingly resorting to the use of renewables, nuclear energy, and overwhelming use of natural gas, the Western Balkans states are becoming over-dependant on coal and lignite utilization for electricity generation. Evidently, the lack of energy infrastructure, market integration but also the low levels of electricity/gas market liberalization and interconnectivity are only some of the reasons that have caused this reverse pattern of energy mix consumption in the Balkans.[1]

The list of challenges and obstacles for achieving energy security in the Western Balkans is long. Therefore, this paper will endeavor to focus on and discuss two main challenges, which if not addressed in due course could continue to pose threat to the energy supply both in the short and the long run. Namely, the argument put forward is that long-term stability and sustainability of the energy market in the Western Balkans can only be achieved through diversification of the energy resources and suppliers but also through bigger market integration and gas interconnection between states.

Addressing these points of concerns promptly can have positive leverage in other spheres of the economic, environmental and regional development. The trade and exchange of energy will lead to stability and economic development, and the market stabilization will be an incentive for direct investments in the oil and gas infrastructure. Investments in the infrastructure can have positive impact first on the diversification of the energy mix in the countries but also can affirm the Western Balkans

[1] Energy in the Western Balkans: The Path to Reform and Reconstruction. 2008. International Energy Agency.pg. 17, http://www.iea.org/textbase/nppdf/free/2008/Balkans2008.pdf (accessed: 24/11/2010)

region as a stable one for alternative transit route for energy supply to the EU countries. Lastly, diversified energy mix will not only lead towards a more sustainable energy future but will also address some environmental challenges, emanating from the heavy dependence on coal and lignite of nearly all Western Balkans states.

Diversification of energy resources and suppliers

Some of the main identifiable vulnerabilities of almost all Western Balkans states, excluding Croatia to some degree, are the lack of diversified energy resources and heavy reliance on coal and lignite for energy generation as well as oil and gas import dependency on one supplier. Coal and oil consumption make up for the largest percentage of the total Primary Energy Supply, and this is mostly in the electricity. The figures for coal/lignite share in the electricity generation mix vary from complete coal use as in Kosovo of 100 % and Macedonia around 80 % to 60 % in Serbia and Bosnia and Herzegovina, and to lesser extent in Croatia and Montenegro's electricity generation reaching an average of 20%. The only country in the region that satisfies its electricity needs through hydroelectric power is Albania, and Croatia is the only gas producing country in this region, with production which satisfies around 60% of its gas needs.[2]

The massive use of coal and lignite primarily in the energy sector in a time when both developed and developing countries are trying to promote low-carbon or zero-carbon technology solutions Western Balkans' coal dependency and lack of energy sources diversification places them as laggards in the European energy market in absolute terms. The best strategy for diversification of the energy mix and attaining energy self-sufficiency for this region could be through diversification with natural gas and oil.

The production of oil and gas in this region is significantly low. As mentioned before, Croatia is the only gas producing country, whose production of 2 bcm covers around 80% of its gas consumption. The biggest natural gas consumers in the region remain to be Croatia and Serbia. Croatia's daily production of gas is around 4.8 mcm and imports around 3.1 mcm from Russia. Serbia, on average consumes 2.4 bcm natural gas per year, and domestically produces only 8%, whereas the rest 92% are imported from Russia through Ukraine.[3] In Macedonia, only 1% of the energy consumption comes from natural gas and annually imports around 120 million cubic meters Russian gas. Bosnia does not produce nor holds reserve of natural gas and the annual consumption of gas in Bosnia of 350 million cubic meters, mostly comes from Russia. Albania, Montenegro and Kosovo are not connected to the gas grid that supplies the Russian gas. Apart from Albania, which produces negligible amounts of gas, the other two countries do not have natural gas in their energy mix.[4]

[2] Re-linking the Western Balkans: The Energy Dimension, *CSIS-EKEM Policy Report*, September 2010 www.csis.org (accessed: 27/11/2010)
[3] FACTBOX- West Balkans gas supply disruption. *Reuters*. 6 January 2009 www.in.reuters.com (accessed: 27/11/2010)
[4] Energy in the Western Balkans: The Path to Reform and Reconstruction. 2008. International Energy Agency.pg. 17, http://www.iea.org/textbase/nppdf/free/2008/Balkans2008.pdf (accessed: 24/11/2010)

The situation regarding the region's gas industry is further exacerbated by the fact that there is a lack of gas storage facilities; the gas network either does not exist or is underdeveloped; the gas consumption is very low, and lastly supply of it comes only from one supplier (Russia). Forecasts for global energy demand indicate that in order to meet consumption the production of natural gas will have to increase by 48 tmc between 2006 and 2030.[5] The estimates are that non-OECD countries will account for over 80% of the increase in world production. In a context of this, the gas consumption in the Balkans is also expected to grow exponentially to offset the over-dependence of coal and lignite. All countries with insufficiently developed gas infrastructure, as Albania and Bosnia and Herzegovina, are expected to have the highest increase in the consumption of gas. And, countries like Serbia and Croatia are expected to be most affected by the shortage of gas supply.[6]

Presently, all gas exports are fully imported from Russia through Soviet-time Hungarian pipeline to Croatia, Serbia, and Bosnia and Herzegovina. This 'single-supplier source and single-route dependency' became visible during the largest energy crisis from January 2009, when due to the Russian – Ukrainian energy row, Russia decided to discontinue gas supply to Ukraine on 1 January. Subsequently, in order to compensate for the losses emanating from the gas cuts, Ukraine tapped into the gas meant for Europe in particularly Slovakia, western Hungary, Slovenia and Croatia, and Serbia. The total amount of gas flowing to these countries was only 10% of the normal gas flow, and by 7 January all gas exports to West Balkans was cut off.[7]

Croatia was the only country equipped to deal with this energy crisis promptly by increasing own production and by borrowing some exports from Germany's gas facilities, which from Slovenia were transited to Croatia. Serbia, on the other hand, had some diminishing amounts of gas storage but this was insufficient for the country to deal with the crisis. Thus, it had to resort to massive utilization of lignite and fuel oil to offset the lack of gas supply. This gas crisis only further accentuated the main structural weaknesses that almost all West Balkans states face. And these weaknesses are the lack of diversification of energy sources and suppliers, and lack of interconnectors in the region. If these countries were better connected through interconnectors in particular with Romania, which is the only Balkan country that has gas storage and limited dependency on import, this short-term gas crisis could have been prevented.

In a similar vein to the gas 'single route and supplier' dependency, the Western Balkans states experience high oil import dependency, which is also characterized by limited diversification of import sources and routes. The only oil producing countries among the West Balkans states are Serbia, Croatia and Albania. The production of petroleum in Serbia and Croatia petroleum production covers only 20% of their petroleum consumption. Whereas, Albania's own production covers 24% of its fuel needs and it does not import any crude oil. Bosnia and Herzegovina and Montenegro get oil supplies through the refinery

[5] An increase of 1.6% per year on average.
[6] Milanovic, M.Z. (2008) Energy Security in South-East Europe in Light of Russian Energy Policy, International and Security Affairs Centre http://www.isac-fund.org/publishing.php#analysis (accessed: 28/11/2010)
[7] Re-linking the Western Balkans: The Energy Dimension, *CSIS-EKEM Policy Report*, September 2010 www.csis.org (accessed: 27/11/2010)

installations in Serbia and Croatia, Albania supplies Kosovo, and Macedonia obtains oil supplies through the Thessaloniki-Skopje pipeline from Greece. Around two-thirds of the overall crude oil imports are coming from Russia. [8]

Market integration and interconnectivity between Western Balkans states

Secure supply of energy is best enhanced not only by development of diverse supply sources but also through market integration and ultimately through building of gas interconnectors, which also contribute to the market integration and import diversification. The pace and level of trade in terms of volumes of exchanged, but also the level of investment in this area have significantly receded since the disintegration of Yugoslavia. The two major arteries for supply of crude oil in the region are the Croat (Janaf) and Serbia (Nafta) co-owned Adria pipeline system, and Thessaloniki-Skopje petroleum products pipeline, owned by Hellenic Petroleum (Greece).

The Adria pipeline system that provides crude oil is crucial for the survival of Serbia's oil market. This explains why Serbia has delayed the extension of a reverse West-East direction pipeline before the Romanian-Serbian owned Constanta-Trieste Pan European Oil Pipeline (PEOP) does not become fully operational. The operational capacity of this pipeline, which extends into Slovenia as well as there is a branch that connects Croatia to Hungary, is 680,000 barrels per day (bpd). But the total exports are only 400,000 bpd. During the 1991-1995 war this pipeline was damaged and ceased working until 2000 when it began operating at one-third of its capacity.

The second major pipeline system, which was commissioned in 2001 is Thessaloniki-Skopje petroleum products pipeline, which links Thessaloniki with the OKTA refinery near Skopje. The total output capacity of the pipeline is 50,000 bpd but it currently operates with only 16,000 bpd. In 2007 Hellenic Petroleum began constructing an extension pipeline of 60 km to increase fuel oil and diesel exports to Kosovo and Serbia. [9]

Both these pipelines operate with only one-third of their total operational capacities and the situation is relatively the same with the oil refineries in the region, which currently operate with only 40% of their operational capacity. Most of the refineries in the region lack the adequate maintenance and are in serious need for investments for modernization. They operate with very low energy performance, and with harmful environmental outcome, yet their output is of a very low quality.[10]

The market integration after the Adria's re-starting in 2000 and the commissioning of the 2001 Thessaloniki-Skopje pipeline has been in the decline, or better said non-existent. Major oil investments in

---

[8] Tsakiris, T. and Ifantis, K. (2010). Secure Gas Supplies will Empower Balkan Integration. *Transconflict*. www.transconflict.com (accessed: 27/11/2010)
[9] Re-linking the Western Balkans: The Energy Dimension, *CSIS-EKEM Policy Report*, September 2010 www.csis.org (accessed: 27/11/2010)
[10] Energy in the Western Balkans: The Path to Reform and Reconstruction. 2008. International Energy Agency.pg. 18, http://www.iea.org/textbase/nppdf/free/2008/Balkans2008.pdf (accessed: 24/11/2010)

the region are still lacking and this also has been the case with the natural gas infrastructure that for over 30 years now has been intact. The two major gas consumers Serbia and Croatia are not connected, and in case of gas crisis Serbia would not be able to obtain gas imports from Croatia, or from the increased gas imports from Austria or the prospective L.N.G. terminal in Krk (currently under construction) unless these two countries are connected by gas interconnector, which could also extend to Bosnia.

At present, the only major investment in the gas sector is the construction of a new interconnector that would connect Croatian future Krk L.N.G. to Hungary. But the sole purpose of this interconnector would be increase of Hungarian import diversification away from Russia, and not to enhance West Balkan market integration. The building of the Krk L.N.G. also put on hold some of the planned gas projects in the region as the Trans-Adriatic Pipeline/ Ionian-Adriatic Pipeline (TAP/IAP), which principally was intended to supply gas to Italy, not the Western Balkans. The TAP's project, however, additionally envisaged expansion through the West Balkan market as IAP project. The project aspired to supply approximately 10 bcm Caspian and Iranian gas per year to Italy and Switzerland via Turkey, Greece and Albania. TAP's vision of extension of Ionian-Adriatic Pipeline project that would transverse through the Adriatic coast, through Albania to Montenegro, Croatia and Slovenia was abandoned after Croatia embarked on the Krk LNG project. Yet, this project was not feasible from the very start as gas was only secured from Iran, and had no regulatory transit arrangements with Turkey and Greece, but it is also in competition with two planned pipelines Nabucco and Interconnector Turkey –Greece-Italy(ITGI) project, in terms of access to Azerbaijan's gas reserves.

Owning to the lack of energy projects as well as lack of possibilities to connect to Nabucco or the Interconnector Turkey –Greece-Italy, Serbia decided to join the Russian-Italian South Stream project. This decision for joining the South Stream project cost Serbia acquisition of 51 % of the shares of N.I.S., Serbia's oil and gas state company by Gazprom. In light of the implementation of this project, Russia has already signed intergovernmental agreements with Bulgaria, Serbia, Hungary, Greece, Slovenia and Croatia, and as of recently Macedonian government officials announced that there is a possibility that Macedonia joins this project as well. [11] The South Stream pipeline has been evaluated as one that can have positive impact over the energy security of the region, in particular because it would give possibilities for penetration of natural gas in the region's energy mix and thus will diminish the risk of future interruptions.

Conclusion

The recent energy crisis in the West Balkan region resulting from the breakdown of the Ukraine-Russia energy relations, only served to emphasize that energy underpins national security, economic prosperity and stability in the region. The attainment of secure energy supply in the West Balkans region can be achieved first by oil and gas import diversification. This, consequently, will reduce the over-utilization of the hydrocarbon resources. Secondly, the participation in major oil and gas infrastructure projects that

[11] Macedonia may join Russia's South Stream pipeline, SETimes 18/06/2010 http://www.setimes.com/cocoon/setimes/xhtml/en_GB/newsbriefs/setimes/newsbriefs/2010/06/20/nb-05 (accessed: 01/12/2010)

will connect regional players will further strengthen the energy market integration in this region. And, to put it in a nutshell, energy projects hold key potential to enhance and accelerate regional integration but also political and economic inter-dependence between these countries, which will facilitate political rapprochement and reconciliation by establishing strong bonds and mutual interest between former enemies.

References

Energy in the Western Balkans: The Path to Reform and Reconstruction. 2008. International Energy Agency.pg. 17, http://www.iea.org/textbase/nppdf/free/2008/Balkans2008.pdf

FACTBOX- West Balkans gas supply disruption. *Reuters*. 6 January 2009 www.in.reuters.com

Macedonia may join Russia's South Stream pipeline, SETimes 18/06/2010 http://www.setimes.com/cocoon/setimes/xhtml/en_GB/newsbriefs/setimes/newsbriefs/2010/06/20/nb-05

Milanovic, M.Z. (2008) Energy Security in South-East Europe in Light of Russian Energy Policy, International and Security Affairs Centre http://www.isac-fund.org/publishing.php#analysis

Re-linking the Western Balkans: The Energy Dimension, *CSIS-EKEM Policy Report*, September 2010 www.csis.org

Tsakiris, T. and Ifantis, K. (2010). Secure Gas Supplies will Empower Balkan Integration. *Transconflict*. www.transconflict.com

Nadica Pavlovska *until recently worked as Research Assistant for NATO's PA in Brussels for the Science and Technology Committee and the Committee on the Civil Dimension of Security. Her research ranged from issues related to energy security for the Alliance and climate change challenges to NATO's involvement in the Western Balkans and NATO's evolving partnership with the Contact countries. She holds MA degree in Central and South East European Studies from University College London (SSEES). Her research interests include institutional design in multiethnic states, nationalism and ethnic conflict, as well as the political systems of South-eastern Europe.*

CAN THE INTERNATIONAL FINANCIAL INSTITUTIONS DO MORE TO SUPPORT NEW RENEWABLES AND ENERGY EFFICIENCY IN SOUTHEAST EUROPE?

Fidanka McGrath, Pippa Gallop, Ana Colovic Lesoska

fidankab@bankwatch.org, pippa.gallop@bankwatch.org, ana@bankwatch.org

Abstract

As Europe is "greening" its economy and gearing up to decarbonise by 2050, most southeast European (SEE) countries still view energy efficiency and renewable energy as greens on the side of their main dish. Coal power and large hydropower are still the favorites on the menu, as they depend on indigenous resources and keep energy import dependency lower. At the same time other abundant indigenous resources – the renewable ones – are not utilized, due to a lack of incentives for investors, public institutions and households. SEE countries, driven by EU harmonization processes, have been developing primary and secondary energy legislation in the last few years. Production and distribution of renewable electricity is still very complex in the region, which continues to discourage investors. Legislation on renewable energy certification is yet to be approved and implemented in most countries; agencies and procedures are needed to implement support mechanisms, and licensing procedures tailored to RES projects are lacking. A significant number of renewable energy projects are planned in SEE but it is unclear how many will find financing. The International Financial Institutions are playing a crucial role in the energy sector in the Balkans. The European banks – EIB and EBRD, which will be the focus of this paper – have made considerable investments into improving energy efficiency of transmission and distribution of electricity, and rehabilitation of district heating and existing hydropower plants. Some EE/RES credit lines have been developed via commercial bank intermediaries, along with direct lending facilities, however in the western Balkans these have started only recently and as yet the results are unclear. The IFIs, like other investors, point to legislative and administrative barriers to new renewables and expect that investment will increase as soon as these are removed. At the same time the EBRD and EIB have supported a number of fossil fuel projects and the EBRD is framing as "sustainable energy" projects that may demonstrate some efficiency benefits, but are ultimately keeping the region locked into its carbon "addiction". In line with EU objectives, national and regional energy strategies should set ambitious aims and mandatory targets for decreasing energy intensity and CO_2 emissions and increasing the share of sustainable renewable energy sources (excluding large hydropower plants). EE/RES solutions should be promoted on both the industrial and local/household level, with the active support of the IFIs, where other sources of financing are not available.

Key words: Energy, IFIs, investment

Introduction

The Western Balkans countries face significant energy challenges, namely the need for investment in infrastructure to provide a reliable supply of energy, and for institutional and policy reform to enable the development of a modern and efficient energy system. Since the fall of Communism the energy sector in the region has suffered from underinvestment. The projected investment needed in generation, transmission, and distribution in South Eastern Europe from 2006 until 2030 is USD 82 billion.[12] Sustainable energy solutions need to be promoted by policy makers and by international donors in the Western Balkans, in order to assist economic development, to address energy poverty and to reduce environmental impacts.

Energy intensity levels of the Western Balkan economies are high, ex. in Serbia it is up to 2.5 times higher than the average for European OECD countries, and the overall efficiency of the energy systems ranges from 58% in Serbia to 80% in Croatia. Croatia's estimated energy saving potential is significant – in the range of 25% of TPES (Total Primary Energy Supply). Extrapolating such levels across the region would produce savings equivalent to Serbia's annual imports of oil and gas combined.[13] According to the World Bank, every additional USD 1 invested in more-efficient electrical equipment and appliances could avoid more than USD 2 in supply-side investment.[14]

The Western Balkans is a diverse region, yet the low level of exploitation of the potential of renewable energy sources (RES) and energy efficiency (EE) is a common feature, as well as the low uptake of IFIs and EU Funds for such projects. Barriers to RES/EE development are the lack of pro-energy efficiency policies, legislation and regulatory frameworks, lack of experience with large scale energy efficiency projects, regulated energy prices and low awareness of the potential of energy efficiency and renewables among decision makers at all levels. At the same time the SEE region is becoming a major transit region for oil and gas, and potentially an EU supplier of electricity generated either through the burning of fossil fuels or the destruction of invaluable ecosystems for large hydro power plants.

While governments have focused on increasing generation capacities and stabilising the transmission and distribution systems, progress in institutional and policy reform is lagging behind and there is a need for SEE countries to co-ordinate their energy sector strategies with those for poverty reduction, human development, governance and the environment.

Little progress has been made towards ensuring greater transparency in SEE's energy sector, and new investments are often made without clear strategic justifications, and with terms and conditions which are extremely favourable to the companies involved but not necessarily to the local people and environment or the state economy. In spite of the lack of accurate data and predictions, in recent years there have been

---

[12] http://siteresources.worldbank.org/ECAEXT/Resources/258598-1268240913359/chapter3.pdf
[13] IEA, Energy in the Western Balkans, The Path to Reform and Reconstruction, 2008
[14] http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/ECAEXT/0,,contentMDK:22497075~pagePK:146736~piPK:146830~theSitePK:258599,00.html

increased investments in electricity generation capacity, and the coming years are likely to see yet more. For example:

- The Albanian state energy company has constructed a combined cycle thermal power plant in Vlora. The Porto Romano coal-fired power plant in Durres is under consideration. Enel has announced a plan to assess the feasibility of building a nuclear power plant in Albania. Several large scale RES projects have been announced, however, most of them are intended to produce electricity for export. Examples include new wind energy parks, including two wind parks in the Lezha energy park for 234 MW and the 500 MW wind farm at the pristine Karaburuni peninsula near Vlora. Large hydro projects are under way on the Rivers Drini, Vjosa (Skavica HPP, 350MW), and Devoll (3 HPPs, up to 370MW).[15]
- Bosnia and Herzegovina has ambitious plans for several hydro power plants, eg. on the Neretva and Drina and a cascade on the Bosna River, and new coal power plants in Stanari and Gacko.
- The Croatian government has developed its new energy strategy, which foresees investments in coal, gas, hydropower and possibly nuclear, in spite of the country's lack of coal resources. Renewable energy is marginalised and there is no commitment for an overall increase by 2020.
- Macedonia is planning a series of hydropower plants at Cebren (3x110 MW) and at Galishte (3X64 MW).
- Montenegro is moving ahead with plans for a new 240 MW installed capacity HPPs on the River Moraca (tender underway) and a 170 MW one on the River Komarnica. These investments are associated with a planned cable for export of electricity to Italy.[16]
- Serbia plans new lignite power plants at Kolubara and Kostolac.
- UNMIK plans to build the Kosova e Re lignite power plant alongside the existing Kosova A and B units, as well as a large HPP at Zhur (292 MW).[17]

In spite of their renewable energy potential, Western Balkan countries are highly dependent on energy imports, in 2005 ranging from 32% for Serbia and BIH to 51% and 58% for Albania and Croatia[18]. In addition to the challenges of adequately providing for its own energy consumption, SEE is also becoming a

[15] Albanian Ministry of Economy, Trade and Energy, presentation "Investing in energy efficiency and renewable energy in the Energy Community" at the Investment Conference on EE and RES, Energy Community of SEE and EBRD, Vienna, March 2010

[16] Ministry of Economy of Montenegro, presentation on "Renewable sources in Montenegro" at the Investment Conference on EE and RES, Energy Community of SEE and EBRD, Vienna, March 2010.

[17] Gabriela Cretu, Energy Community Secretariat, presentation "The Driving Role of the Energy Community for a Sustainable Development of the Western Balkans, The World Bank Regional Conference on Business Environment Reform in SEE "Growth and Competitiveness: Weathering the Crisis and Looking Ahead", Tirana, 17-19 November 2009

[18] IEA, Energy in the Western Balkans, The Path to Reform and Reconstruction, 2008

transit zone for oil and gas for western consumption. Several oil and gas pipeline projects are under discussion, including:

Oil

- The Bourgas-Alexandroupolis oil pipeline (Bulgaria-Greece) - 30-50 mt/year
- The AMBO oil pipeline (Albania-Macedonia-Bulgaria) - 30-40 mt/year
- The Pan-European Oil Pipeline (PEOP) (Romania-Serbia-Croatia-possibly Slovenia-Italy) - 60-90 mt/year
- The integration of the existing Druzhba and Adria pipelines (Croatia-Hungary-Ukraine-Russia) (This project was halted several years ago as environmental concerns relating to the Adriatic Sea had not been overcome. However the new Croatian energy strategy opens up the possibility of reviewing the project).

Gas

- Nabucco (Turkey-Bulgaria-Romania-Hungary-Austria) - up to 31 bcm/year
- South Stream (Russia-Bulgaria then Greece-Italy and Serbia/Romania-Hungary-Austria/Slovenia-Italy) - around 30 bcm/year
- Trans-Adriatic Pipeline (Greece-Albania-Italy) 10-20 bcm/year
- Poseidon (Greece-Italy), at least 8 bcm/year.

SEE governments are engaging in an energy reform agenda framed by the Energy Community Treaty, a regional cooperation framework for rebuilding energy networks and the creation of a regional energy market. Until recently EE and RES have been rather marginal in the Energy Community for SEE (ECSEE), however in the last two years some steps have been taken to promote the significant potentials for energy savings and harnessing renewable power in the SEE region. The Energy Community has set up EE and RES task forces, and together with IFIs, such as the EIB and the EBRD, organised a series of workshops and investment conferences about EE and RES. Additionally, the ECSEE has commissioned a number of reports, ex.:

- a study on the implementation of the new EU RES Directive in the Energy Community: currently under finalisation. Based on the study outcomes, the Renewable Energy Task Force of the ECSEE will prepare a final report that includes recommendations on the adoption of the Directive 2009/28/EC in the Energy Community. The report shall be submitted for adoption at the Ministerial Council meeting in 2010.[19]
- a study on the potential for combating climate change in power generation in the ECSEE: the outcomes of the study will be delivered at a planned workshop in the 2nd half of 2010.

[19] Ibid.,

The European Investment Bank (EIB) and the European Bank for Reconstruction and Development (EBRD) are also influential players in the energy sector in southeast Europe, particularly during the current financial crisis when commercial financing for energy investments has become particularly hard to obtain. The European Investment Bank, being the EU's house bank, has a duty to promote EU policy such as the targets to reduce greenhouse gas emissions by 20 percent by 2020 and to achieve 20 percent of renewable energy by the same date in the EU. The European Bank for Reconstruction and Development is also majority-owned by the EU states, although its mandate is somewhat different - to promote the transition from centrally planned to market economies and to promote sustainable development.

This paper aims to examine the investments made by the international financial institutions in the energy sector in the region so far. It will show that there have been very few IFI investments into renewable energy in the Western Balkans and make recommendations on how the banks could do more to stimulate this sector.

Western Balkans energy landscape

Import dependency

The region in total is dependent on imported energy, primarily oil and natural gas, as there are some countries which are import dependent to a very high degree[20]. Energy insecurity and high import dependence highlight the importance of increasing energy efficiency and diversifying energy resources in the Western Balkan countries. Better utilisation of indigenous renewable energy resources will decrease the vulnerability of the region to geopolitical instability and global price increases.

One of the major challenges that the region faces is the lack of reliable supply of electricity, which can sometimes cause shortages and blackouts. Bosnia and Herzegovina is the only country in the Western Balkans that produces a surplus of electricity and the region as a whole is an importer. The main trading pattern in the region is a flow of electricity from the north to the south. Import is mainly provided from Hungary, Romania and Bulgaria, via Serbia, which is the main transit country with a relative balance. Some countries are heavily dependent on import of electricity, ex. Albania, which relies solely on hydro power, in years of drought[21].

Electricity generation

The total electricity generation in the Western Balkans region is predominantly a mix between thermal generation (mostly coal) and hydro power plants (mostly large scale ones), as the generation structure is very diverse in the different countries. For example, Albania gets more than 95% of its domestic electricity

[20] Pöyry Energy Consulting and Nord Pool Consulting, Report "SEE Wholesale Market Opening", commissioned by the World Bank, April 2010
[21]Ibid.

from large HPPs, while BiH, Croatia and Serbia get at least a third of their generation from hydro power. UNMIK, on the other extreme, is almost entirely reliant on generation from lignite TPPs.[22]

According to UCTE and Platts data, the current generation capacity in the region is about 54 GW, however a recent World Bank study[23] argues that "the firm capacity in the region would be approximately 40 GW particularly for lignite plants the actual available capacities are substantially lower than the reported figures."

The World Bank study points to the fact that some generation capacity is either not producing or unreliable, due to the lack of maintenance. Additionally most of the generational capacity in the region needs to be replaced, which is especially concerning when it comes to old lignite power plants. With 4 000 MW of coal and lignite fired plants exceeding 30 years of age, and with increasing electricity demand in the region, decision-makers are continuously raising the argument that the region needs to invest heavily into more generation capacity. There are three questions, however, that surround this rhetoric:

The first question is:

Should increased generational capacity become a priority number one, pushing the great need to improve energy efficiency further down the to-do-list?

The economies in the region generally have high energy intensities, which is a result of the degraded state of energy infrastructure, high energy losses in transformation, transmission and distribution and inefficiency in the end-use sector. The countries have high carbon intensities compared to OECD averages. Serbia has the highest level of carbon intensity (1.2) which corresponds to its high dependency on coal and Albania the lowest (0.3) due to its high usage of hydropower resources.[24]

Transmission network losses in the SEE region are generally quite large ranging from 14% in Croatia, up to 37% in UNMIK, with an average of 23%. Additionally, distribution losses in the region are comparatively high, and although they are showing a decrease in recent years, there is a long way to go before they will reach the average European levels. For example in UNMIK around 45% and in Albania around 30% - 40% is lost in distribution, mainly resulting from low collection rates.[25]

At the same time energy prices per unit in the region need to rise, in order to cover the production cost and to introduce incentives for energy savings. Additionally the expected growth in energy consumption will translate into further strain on household budgets - it is estimated that 16% of people are already

[22] Ibid.,
[23] Ibid.,
[24] Ibid.,
[25] IPA Energy and Water Economics, Report "Study on Tariff Methodologies and Impact on Prices and Energy Consumption Patterns in the Energy Community" to Energy Community, March 2009

exposed to energy poverty.[26] In this situation urgent actions are necessary to increase energy efficiency and energy savings, in order to mitigate the negative economic impact of the expected increases in electricity prices.

The second question is:

*Should new generation capacity come from conventional means – i.e. large hydro and thermal power? Or should it come from new renewables***?**

Low quality lignite is considered a competitive source of energy in the countries that have their own lignite reserves. However, it has obvious climate and pollution drawbacks.

If we exclude large HPPs as unsustainable source of energy that causes irreversible damage to natural ecosystems, then we can state that renewable energy sources currently play an insignificant role in the region.

It is questionable to what extent it is sustainable to continue the exploitation of the abundant water resources in the region for more hydro power, as ambitious energy planners often disregard the potential to use these resources for purposes different than electricity production. Particularly in countries like Albania, the need to diversify the production mix is highlighted by estimates of high vulnerability to climate change (valid for most of southern Europe).

Albania, BiH, Croatia and Montenegro have HPPs dominating their RES generation mix and contributing for half or more of national electricity production - app. 95%, 50%, 60%, and 50% in different years, respectively. In Serbia hydro power accounts for less - a mere 25% of the generation mix, yet it still dominates the RES capacity. At the same time all countries have significant potentials for biomass, wind and solar, according to USAID's Stocktaking report for regional assessment of RES[27].

And the third question is:

What is the purpose of increasing of the generation capacity: to secure a sufficient and reliable supply on the national and regional level, or to satisfy demand coming from richer neighbouring countries and the EU?

Several SEE governments are developing new electricity generation projects for electricity export, including in Bosnia and Herzegovina, Kosovo, Montenegro and Albania - a somewhat surprising candidate for energy exports given the unreliability of its own electricity supply.

However these plans do not appear to be based on thorough analyses of the real costs and benefits of electricity exports, nor even in most cases of the needs of domestic and target markets. These plans threaten to turn SEE into a source of 'dirty energy' from nuclear, lignite, and large hydropower plants,

[26] IEA, Energy in the Western Balkans, The Path to Reform and Reconstruction, 2008.
[27] USAID, Stocktaking report for regional assessment of RES**.** Regional Findings and country Summaries, April 2009

with the region's people and environment paying the real costs of the exported electricity without assurance that domestic needs will be fulfilled.

The European Commission is sending mixed messages regarding such electricity export plans. On one hand, it purports to promote the implementation of the EU acquis on issues such as environmental protection, public access to information and public procurement, yet on the other it tolerates SEE governments plans to promote electricity generation projects which in several cases conflict with the EU environmental acquis. It also does not require governments of candidate and potential candidate countries to develop energy strategies in line with the EU long-term goal of decarbonisation of the economy.

The European Investment Bank, on the other hand, in its recent Special report "Partnering with the world" presents a case study on RES projects around Mostar, Bosnia and Herzegovina, expressing hopes for strengthening the country's role as a net exporter of RES electricity - "a plus point for joining the EU."[28]

Does it matter if the region exports renewable energy, which causes much less damage to its environment than coal or nuclear-based electricity exports? Even though renewable electricity exports are clearly preferable to coal ones, it should be borne in mind that the first investors get the best sites. By allowing large-scale new renewable developments for export, SEE countries are restricting their own possibilities for developing their RES capacity for domestic use.

Energy policy in the Western Balkan countries

SEE countries, driven by EU harmonization processes, have been developing primary and secondary energy legislation in the last few years. All of the countries covered with this paper (Albania, Croatia, Macedonia and Serbia) are signatories of the Energy Charter Treaty and Energy Community Treaty and have adopted a general Energy Law and National Energy Strategies.

Albania for example has an Energy Strategy from 2003, and in 2006 it updated it, but never approved the new document. The Action plan for its implementation is from 2007. Even the 2006 strategy has gone out of date already as the government has been handing out permits for electricity generation developments which were not foreseen in the strategy. The country has also developed a dedicated Energy Efficiency Law, but it has barely been set in force and even though there is an existing National Energy Efficiency Program on paper, there is no special authority to implement it.

Croatia last year approved a new and very controversial National Energy Strategy including the construction of new coal, gas, and potentially nuclear capacity, with no overall increase in the proportion of new renewables foreseen by 2020.

[28] EIB special report "Partnering with the world", May 2010
URL: http://www.eib.org/about/publications/eib-information-1-2010-n137-special-edition.htm

In Macedonia, a Strategy for Energy Development was adopted in early 2010. The main pillars of the strategy are the construction of new thermal and hydro power plants, analysis of a potential nuclear power plant and natural gas supply and the improvement of energy efficiency by 30 per cent in 2020 compared to the base year 2006[29]. According to the strategy, the main energy efficiency measures on the production side will be the construction of cogeneration power plants. The Strategy is focused on fossil fuels and does not consider a major decrease of dependency on fossil fuels or a significant shift toward more sustainable ways of energy production. Renewable energy use is elaborated in more depth in a Strategy for renewable energy use, currently up for adoption by the Government.

Regarding legislation for energy efficiency, the countries have either a dedicated legislation in place (Energy Efficiency law in Albania) or tackle the issue within the existing energy strategies or legislation. Most of the countries have already adopted a Building Act, or procedure on energy efficient constructions of buildings, but their implementation is either very slow or not happening. Regarding renewable energy, Albania and Macedonia are currently in the process of developing/approving laws and strategies for the use of renewable energy sources. Croatia has gone the furthest with the legislation development and has so far the legislation closest to the EU acquis.

As regards incentives for investments in the sector, Croatia and Serbia have an Environmental Protection and Energy Efficiency Fund established on the national level. However in the Croatian case the majority of the money has been used for waste management projects so far and in the Serbian case, this Fund is facing capacity barriers and is not able to disburse the entire amount of allocated funds. Other than a few programmes and projects which support energy efficiency and renewable energy use, incentives are limited to national credit lines and feed-in tariffs and in Albania these do not exist.

In countries where feed-in tariffs are developed (Croatia, Macedonia and Serbia), there are still few investments in renewables. In Croatia two wind farms (with total installed capacity of 5.95 MW) were already in operation before the feed-in tariffs were implemented and another with an installed capacity of 9.6 MW started operating at the end of 2009. Currently there are several new projects under development but they have been slowed by the financial crisis.

In Albania there are still no public funds allocated to support energy efficiency or renewable energy projects. Moreover, there are no incentives for energy efficiency and renewable energy initiatives in the residential sector and there is no support scheme for other renewable sources apart from small hydro. This does not stop investors applying for (and obtaining) permits for renewable energy projects, although it is unclear how many of these projects will actually be realised. In 2006, electricity generation in Albania amounted to 5.443 GWh, 98 per cent of which is produced through hydro power plants[30]. Albania has 7 large hydro power plants with a total capacity of 1.4 GW. Generation from small HPP from 1990-2001

[29] http://www.economy.gov.mk/WBStorage/Files/precisten_tekst_Strategija_za_energetika_na_RM.pdf
[30] International Energy Agency (IEA). http://www.iea.org/Textbase/stats/electricitydata.asp?COUNTRY_CODE=AL

declined from 50 GWh to 6.7 GWh, due to lack of maintenance and their old technology.[31] As for planned hydro projects, since March 2007, more than 170 new projects on small hydro power plants have been considered and 60 concessionary agreements have been approved. Additionally, there are 4 large hydro power plants, several wind farms and a biomass plant planned, for which 9 licenses are already issued. The focus of the Albanian Government appears to be mainly on the export of electricity, although this is not reflected in the 2006 national energy strategy. According the Albanian Energy Regulatory Authority, 2 percent of the electricity produced from all the renewable projects planned will remain for consumption in Albania[32]. Albania has taken the path of new construction and energy production without much of a strategy to support the process, while other countries are harmonizing their legislation in line with the European acquis, and struggling with obstacles in implementing the laws.

The lack of investment in the sector can be explained by numerous barriers in the region, mainly legal, institutional and administrative ones, but also financial and economic barriers. Such barriers include the complexity and lack of transparency of the regulatory framework, difficult grid connection procedures, regulatory instability and discontinuity, caused by uncoordinated updates and revisions of the current policy framework. For example, in Macedonia, the Energy Regulatory Commission, soon after announcing excellent feed-in tariffs for photovoltaic energy production, decided to decrease the tariff from 0.46€/KWh to 0.38€/KWh and decreased the contract period from 20 to 15 years, creating an uncertain climate for investments.

Overall, in the countries in the region there is a lack of operational instructions, tools, standards and procedures necessary to implement primary legislation or strategic programmes, there is inefficient bureaucracy, non-transparent administrative procedures up to widespread corruption in public administration, and the authorisation procedures for new projects are excessively complex. There is also lack of cooperation between different ministries and agencies involved in energy policy as well as between ministries and local administrations which makes the implementation of these laws and regulations even more difficult.

On the economic side, there is a lack of availability of state or private funds for financing initiatives and programmes: premium tariffs for renewable energy sources are developed but often not operational and frequently they are of limited extent (e.g. they apply only to certain technologies or have restrictive requirements, an example being Albania where a feed-in tariff is in only place for small hydro). Energy efficiency funds, if they are operational, have limited resources; no alternative incentive measures such as soft dedicated credit lines, tax exemptions or support schemes for third-party financing are in place[33]. According to the United Nations Development Programme[34], the Environmental and Energy Efficiency

[31] Draft National Energy Strategy for Albania, 2006, p.12

[32] Regional Analysis of Policy Reforms to promote Energy Efficiency and Renewable Energy Investments, on the basis of personal interview with the Albanian Energy Regulatory Authority.

[33] Regional Analysis of Policy Reforms to promote Energy Efficiency and Renewable Energy Investments

[34] Ibid.,

Fund in Serbia has managed to disburse only EUR 3 million out of EUR 15 million. Moreover, the fund has not received any requests for financing energy efficiency and renewable energy sources projects so far.

Can the International Financial Institutions do more to support new renewables and energy efficiency in southeast Europe?

International Financial Institutions - mainly the European Bank for Reconstruction and Development (EBRD), and the European Investment Bank (EIB) - are playing a major role in financing energy projects in southeast Europe. The question is whether they are playing a sufficient role in the financing of renewable energy and energy efficiency in the region, and whether they could do more to promote transition to an energy-efficient, low carbon economy. This section will, after introducing the EBRD and EIB, look at what their role should be in this field, what it has been so far, why they have not done more, and what in our opinion they should now do.

Introducing the EBRD and EIB

The EBRD was founded in 1991 to promote the transition from centrally-planned to market economies in the former Eastern Bloc, and also has the mandate to promote sustainable development throughout its activities. It is owned by 61 countries - including European countries, the countries of operation, the USA, Japan and others, plus the European Commission and European Investment Bank, and operates in 29 countries. Between 1991 and 2009 the EBRD invested a total of nearly EUR 12.5 billion in southeast Europe[35] in all sectors, with nearly EUR 1.9 billion in 2009 alone.[36]

The EIB is the European Union's house bank, created by the Treaty of Rome in 1958 in order to "contribute towards the integration, balanced development and economic and social cohesion of the EU Member States."[37] The EIB operates on a non-profit basis and lends at close to the cost of borrowing. Transport and credit lines through financial intermediaries were by far the most heavily financed sectors between 2000 and 2009.[38]The EIB also lends outside of the European Union to future EU Member States and EU Partner countries. Between 1991 and 2009 it lent EUR 16.9 billion in southeast Europe, of which EUR 3.3 billion was in 2009[39].

[35] Defined as Albania, Bosnia and Herzegovina, Bulgaria, Macedonia, Montenegro, Romania, Serbia and Croatia. The EBRD categorizes Croatia as Central Europe and the Baltic States however we have chosen to include it in southeast Europe.

[36] European Bank for Reconstruction and Development: Annual Report 2009, p. 4

[37] European Investment Bank website: http://www.eib.org/about/index.htm, accessed 01.06.2010

[38] European Investment Bank website http://www.eib.org/projects/loans/sectors/index.htm?start=2000&end=2009, accessed 01.06.2010

[39] Calculated from data from the EIB website at: http://www.eib.org/projects/loans/regions/index.htm, accessed 01 June 2010. Southeast Europe is defined by the EIB as including Turkey and Croatia but not Romania or Bulgaria, however we have here used figures including Croatia, Romania and Bulgaria, but excluding Turkey.

What is the role of the EBRD and EIB in energy financing in southeast Europe?

Both the EBRD and EIB exist primarily to fill gaps left by the commercial banking sector and to finance projects that would otherwise not be financed. It is therefore worth briefly outlining why we consider that they should play a role in promoting energy efficiency and renewable energy in southeast Europe at all.

Putting aside the economic crisis, which has dampened private financing across the board, renewable energy and energy efficiency were reliant on public financing in southeast Europe long before the crisis, and will no doubt be for several years to come. Why is this so? If renewable energy is a desirable thing and energy efficiency is a win-win solution, why doesn't the market take care of them?

As examined above, renewable energy and energy efficiency face many barriers in the region which prevent them from competing effectively on the market. These include:

- legal and administrative barriers, for example difficulty in obtaining permits and arranging grid connections
- policy barriers: most of the countries' energy strategies are still heavily reliant on coal/lignite, gas and large hydropower plants and show limited support for a significant switch to renewable energy.
- political barriers: promoters of fossil fuel and large hydropower generation have more political influence than those promoting renewables and energy efficiency
- economic barriers: coal/lignite is still cheaper than renewable energy because it does not pay its external costs, and economic incentives for renewables and energy efficiency *are not operational in all countries, or are insufficient.*
- general resistance to change and unwillingness among decision-makers to believe that renewable energy can make up a significant proportion of the energy mix; prestige and relative ease of building new generation capacity compared with implementing many smaller energy efficiency projects.
- difficulty of implementing residential projects due to decision-making procedures in multiple occupancy dwellings.
- lack of ability in many cases to control amount of energy used eg. for space heating and therefore to impact on energy bills.

These factors make renewable energy and energy efficiency less attractive for commercial banks and private investors than the region's large potential would suggest. Yet unlike most other new areas of investment, it is absolutely crucial for the region that energy efficiency and renewable energy investments increase and succeed.

These are the key to energy independence and ability to resist fossil fuel price or supply shocks, as well as reducing climate impacts and other pollution and increasing employment. As we have seen, efforts to create conditions for sustainable renewable energy and energy efficiency investments are at various stages in southeast Europe, but in none of the countries examined have governments created conditions which would encourage consistent private sector support for renewables and energy efficiency. Given the urgency of increasing such investments the international financial institutions need to be actively involved in financing projects and encouraging governments to remove barriers and increase incentives for sustainable renewables and energy efficiency.

EBRD and EIB financing for the energy sector in southeast Europe

Both the EBRD and the EIB have recognised the importance of financing renewable energy and energy efficiency and adopted targets. In its 2006 energy strategy the EBRD committed to lend or invest a minimum of EUR 1 billion in energy efficiency and renewable energy projects between 2006 and 2010.[40] Also in 2006 it launched its Sustainable Energy Initiative (SEI) Phase 1 (2006-2008), which aimed at EUR 1.5 billion worth of sustainable energy investments[41] during the period but was in fact exceeded, with EUR 2.7 billion invested. However, this initiative has unfortunately muddied the waters somewhat in terms of what is regarded as sustainable energy, with energy efficiency elements of projects in any sector included, even if the project involves prolonging the life of a coal thermal power plant or expanding a heavy industry facility. Phase 2 of the Sustainable Energy Initiative (2009-2011) is now underway, with a target of EUR 3-5 billion in investments.[42]In 2009 EUR 1.3 billion was invested under the SEI, out of a total annual business volume of EUR 7.9 billion[43].

The EIB has set itself several renewable energy targets, such as 50 percent renewable share of total new generation in the EU by 2010. However its newer targets are aimed only at the EU and its renewables investments elsewhere are much lower - between 2002 and 2008 its energy investments in non-EU, non-European Free Trade Area countries comprised only 4 percent renewable energy[44] (26). More generally, the level of EIB investments into renewable energy – EUR 1.39 billion in 2008 for the EU member states – needs to be set against the estimate of around EUR 40 billion per year required to meet EU targets over the next decades.[45]

The EBRD's energy investments in SEE.

[40] European Bank for Reconstruction and Development: Energy Operations Policy, 11 July 2006

[41] European Bank for Reconstruction and Development: Sustainable Energy Initiative brochure, May 2009

[42] European Bank for Reconstruction and Development: Sustainable Energy Initiative Phase 2 (2009 - 2011) factsheet, May 2009

[43] European Bank for Reconstruction and Development: Annual Report 2009, p. 1
[44] CEE Bankwatch Network: Change the lending, not the climate, 02 December 2009, p.19
[45] Ibid., page 21.

The graphs below show the EBRD's energy lending in southeast Europe, which amounted to EUR 1.962 billion in 2000-2009[46]. The figures are subject to interpretation depending on categorisation of projects and which projects are included. The methodology used is as follows.

The calculations cover the period 2000-2009. This was deemed to be long enough a period to get a good overview of what the banks have been financing without going back into the 1990s when investments in some countries may have been influenced more by immediate post-war repair needs than anything else.

The project data comes from the EBRD.[47] However we use our own project categorisations as outlined below. The project data for energy efficiency from 2006-2009 covers components of projects rather than whole projects, whereas such detailed data from pre-2006 was not available and the EBRD's list of energy efficiency projects was used.

Rather than using the EBRD's categories, it was deemed important to see what kind of energy sources the EBRD is supporting, so projects have been according to energy source, or where two energy sources are involved and cannot be clearly separated, they have both been named. In a few cases such as district heating rehabilitation it was not possible to ascertain which energy source or sources was involved and projects were therefore categorised as 'other'. The 'other' category also includes projects such as transmission projects with no clearly stated energy efficiency component and no clarity about which energy source is being supported. Those pre-2006 projects categorised as 'other' may include an energy efficiency component, however it was not possible to quantify these.

It was decided to include energy efficiency due to the great role this needs to play in moving the region towards sustainable energy use.

This includes energy efficiency across various sectors, not only energy production and transmission, as this is the nature of the changes needed.

However this leads to difficult questions. In the energy sector, if a coal thermal power plant unit is replaced with a more efficient unit, should this be counted as energy efficiency? While it may indeed be argued that the plant is now more efficient than before, it is not clear that it would result in fewer emissions compared to non-coal alternatives. Given that such investments are likely to increase the lifetime of the plant and to make coal generation more efficient, we believe that such investments tend more towards supporting the coal industry than moving towards truly sustainable energy. The same

[46] Excluding investments categorised by the EBRD as energy efficiency investments in the transport sector.

[47] The basic figures come from the EBRD's own project database at: http://www.ebrd.com/pubs/general/ar09.htm (accessed 28 May 2010). Figures for energy efficiency projects 2006-2009 come from a database provided by the EBRD on request. Figures for energy efficiency projects from 2000-2005 come from the project list at: http://www.ebrd.com/projects/signed/index.htm (accessed 28 May 2010)

applies for projects to increase the efficiency of oil facilities. In the energy sector this has mainly applied to one project - the EUR 80 million Turceni thermal power plant rehabilitation in Romania. Thus variants are presented below with both Turceni as a coal investment and Turceni as an energy efficiency investment.

A similar problem arises with the transport sector: Should transport projects with an energy efficiency component be categorised as energy efficiency projects? The EBRD has undertaken several transport projects with an energy efficiency component. Some of these are relatively clearly reducing overall greenhouse gas emissions, for example by increasing the efficiency of trolley buses, while some are more questionable. Most notably, EUR 22.3 million of the EUR 180 million loan for the Corridor Vc motorway in Bosnia and Herzegovina is categorised as an energy efficiency project although it is hard to imagine that the motorway will not induce traffic and that it will not cause an overall increase in greenhouse gas emissions, even if relieving congestion in a few locations. It is beyond the scope of this paper to examine the greenhouse gas impacts of each project overall, and data is in many cases not available, it was decided to exclude transport-related energy efficiency from the calculations, although recognising the great scope for its contribution to reducing greenhouse gases and increasing energy efficiency.

Energy source	**EUR million**	**%**
Fossil fuels	1023	52
RES/EE	541	28
Other	398	20

Table 1 - EBRD investments in the SEE energy sector 2000-2009
(without transport, Turceni as coal)

Energy source	**EUR million**	**%**
Fossil fuels	943	49
RES/EE	600	31
Other	398	20

Table 2 - EBRD investments in the SEE energy sector 2000-2009
(without transport, Turceni as energy efficiency)

Energy source	**EUR million**	**%**
Coal	286	15
Gas	343	17

Oil	248	13
Oil/Gas	146	7
RES	102	5
RES/EE	113	6
EE	326	17
Other	398	20

Table 3 - EBRD investments in the SEE energy sector 2000-2009
(without transport, Turceni as coal) - a more detailed version of Table 1

Energy source	**EUR million**	**%**
Coal	206	11
Gas	342	18
Oil	248	13
Oil/Gas	146	7
RES	102	5
RES/EE	113	6
EE	386	20
Other	398	20

Table 4 - EBRD investments in the SEE energy sector 2000-2009
(without transport, Turceni as energy efficiency) - a more detailed version of Table 2

In both cases EBRD financing for fossil fuel projects outweighs financing for renewable energy and energy efficiency. In the variant including Turceni as coal, support for fossil fuels makes up 52 percent of the total, and support for renewable energy and energy efficiency 28 percent. Including the Turceni as an energy efficiency project makes 48 percent support for fossil fuels and 31 percent for renewables and energy efficiency.

It should be noted that the situation may be even more tilted in favour of carbon-intensive development than shown here because this analysis does not include expansion of heavy industry or transport-intensive developments, whereas it does include the energy efficiency components of projects in all sectors after 2006.

While the EBRD has financed quite a large number of energy efficiency projects both directly and through financial intermediaries, (particularly in Bulgaria) it has financed very few renewable energy projects so far. It is not possible to trace exactly which smaller projects have been financed as the bank does not disclose the final beneficiaries of its financial intermediary lending.

A closer look at the Albania, Croatia, Macedonia and Serbia shows that the lending has also been uneven, with very little energy efficiency and renewables lending in the Western Balkans.

Albania

Energy Source	EUR million
Oil and gas	68.445
RES/EE	21.75

The majority of energy efficiency and renewables lending is accounted for by one EUR 16 million investment into upgrading electricity substations. The rest consists of an energy efficiency component of a shopping centre development, a private equity fund to invest into renewables and energy efficiency and a credit line for energy efficiency. No information is publicly available about the sub-investments made through these latter two projects.

The oil and gas projects comprise supporting oil extraction at the Patos-Marinza oilfield, and the construction of the controversial 97 MW Vlora thermal power plant, which was heavily opposed by local people. It is now constructed but it is not clear whether it will even be used regularly or only for back-up.

Croatia

Energy source	EUR million
Gas	70
Oil	32.377
RES/EE	16.4

There have been few energy investments by the EBRD in Croatia. The gas investment is a single gas storage project, while the oil projects comprise a refinery rehabilitation and two very small oil spill protection projects.

The main energy efficiency projects are loans to a sugar producer, a private equity fund to invest into renewables and energy efficiency and a credit line for energy efficiency. No information is publicly available about the sub-investments made through these latter two projects.

Macedonia

Energy source	EUR million
Energy efficiency	37.5
Oil	17.338
Other	57.021

In Macedonia the EBRD has supported electricity distribution network efficiency improvements and since 2009 has supported energy efficiency credit lines. The oil investment comprised support for the Thessaloniki-Skopje pipeline. Out of the four countries covered by this study Macedonia is the only one where energy efficiency investments outweigh the bank's support for fossil fuels. If a EUR 5.9 million energy efficiency component of a road maintenance project is included the figure increases to EUR 43.4 million for energy efficiency, however in our opinion, although road maintenance is important, it is difficult to justify the inclusion of a component of a road transport project as an energy efficiency project.

Serbia

Energy source	EUR million
RES/EE	23.8
Coal	60
Other	120

The picture in Serbia is rather unclear, as it is not known which energy sources, in which proportions, some of the older loans supported. They have therefore been categorised as 'other'. According to the project summary documents on the EBRD's website they are likely to have comprised a combination of support for coal-based thermal power and large hydropower, with some efficiency improvements. The coal loan was for modernisation of lignite mine equipment and upgrade of the power system.

There has been more potential support for new renewables in Serbia compared to the other countries - out of the EUR 23.8 million for energy efficiency and renewables EUR 11.25 million may potentially be used for renewables projects. However as the credit line and private equity fund were supported by the EBRD only in 2009, and since no information is disclosed about the final beneficiaries of such financing it is unclear whether it has been used for renewable energy or energy efficiency, or indeed whether it has been used at all. The remainder of the energy efficiency projects was for relatively small industrial energy efficiency components and an energy efficiency credit line.

In addition to the figures quoted above, the EBRD includes EUR 99 million out of a 2009 EUR 100 million loan for new trains under energy efficiency. While this is a worthwhile and welcomed investment, including almost all of it as an energy efficiency investment is debatable. In addition, from a climate point of view it makes little sense to look at public transport investments that save energy without also looking at investments into unsustainable modes of transport - road and aviation.

This is particularly important in Serbia, which is a major transit country for goods travelling between Turkey, Greece, Bulgaria and most of the EU. Almost double has been invested by the EBRD in Serbia into road traffic compared to rail. No financing has been provided by the EBRD for sustainable transport modes other than rail, such as trams, trolleybuses, or buses.

It is often argued that it is logical that there should be more road investment than rail because the road network is more extensive and used by more people. However, while well-maintained roads are clearly needed, it is highly debatable how much investment should be made into constructing new ones.

Most of the EBRD-financed road projects in Serbia involve new construction or significant upgrading of existing roads rather than maintenance. Transport is the main sector in which European countries are failing to stem greenhouse gas emissions. In European Economic Area (EEA) countries, greenhouse gas emissions from transport (excluding international aviation and maritime transport) - far from being reduced - *grew* by 28 percent between 1990 and 2007, and now account for around 19 percent of total emissions.[48] Southeast European countries are already following these unsustainable trends, and making road transport quicker and more comfortable while it does not pay its external costs will inevitably lead to its further expansion.

The EIB

Between 2000 and 2009 the EIB invested EUR 1029.5 million in the southeast European energy sector - just over half as much as the EBRD invested. So far we have obtained data on EIB energy efficiency projects in non-energy sectors only from 2007 onwards, so any which took place before that are excluded. The 'other' investments comprise improvements to the electricity transmission and distribution network. Transport-related energy-efficiency investments are excluded in the graphs below, but there were 2 x EUR 20 million components in rail projects in Romania during the period

Energy source	**EUR million**	**%**
Large hydro	51.5	5
Oil/gas	520	50

[48] European Environment Agency: Towards a resource-efficient transport system, TERM 2009: indicators tracking transport and environment in the European Union, EEA Report No 2/2010

Energy Efficiency	88	2
Other	370	36

Table 5 - EIB SEE energy investments 2000-2009

Energy source	EUR million	%
Large hydro	51.5	11
Oil/gas	40	4
Gas	480	46
RES	11.5	1
Energy Efficiency	78.5	7
Other	370	36

Table 6 - more detailed EIB SEE energy investments 2000-2009

The large hydropower investment was rehabilitation, and the oil/gas project was the same power plant in Vlora that was financed by the EBRD, as well as the World Bank. As can be seen gas has been by far the dominant energy source supported, comprising investments in the Croatian distribution network and construction of a gas power plant in Romania. **Support for new renewables has been conspicuous by its near absence.** The renewables investment shown is part of an investment into a biofuel production plant in Romania, plus five EUR 0.3 million sections of energy efficiency credit lines. In 2009 the EIB did approve one EUR 130 million loan for the Mostar wind and hydro project in Bosnia and Herzegovina[49], however at the time of writing this has not been signed. It is also controversial because of the plans to site a small hydro plant on the picturesque River Kocusa.

Albania

Energy source	EUR million
Other	30.00
Energy efficiency/RES	3
Oil/gas	40

[49] European Investment Bank website: http://www.eib.org/projects/pipeline/2007/20070438.htm?lang=-en, accessed 1 June 2010

The EIB has made much-needed investments in the Albanian transmission and distribution network. More controversial, however, is its investment in the oil and gas-fired Vlora thermal power plant. Few conclusions can be drawn from such a small number of projects, however there is a clear lack of support for new renewables, with only EUR 0.3 million of a EUR 3 million energy efficiency credit line dedicated for this purpose.

Croatia

Energy source	**EUR million**
Gas	280
Energy efficiency	5

In Croatia the EIB has mostly invested in the gas distribution network, with very little for energy efficiency and apparently nothing for renewables.

Macedonia

Energy source	**EUR million**
Other	13
Energy efficiency and RES	3

In Macedonia the EIB has made relatively small investments in the energy sector, and has supported power transmission and distribution and energy efficiency, with only EUR 0.3 million for RES.

Serbia

Energy source	**EUR million**
Other	116.5
Energy efficiency and RES	3

In Serbia the bulk of the EIB's investments have supported power transmission and distribution, along with a small energy efficiency credit line project. Regarding transport projects, which are not included here, but to which attention was drawn in the EBRD section, above, the EIB portfolio in Serbia is less imbalanced than the EBRD's.

Could the IFIs do more to support new renewables in southeast Europe?

The most notable conclusion from the above analysis is that the European Investment Bank has invested very little into new renewables in southeast Europe. A EUR 10 million biofuel project component plus 5 x EUR 0.3 million credit line components cannot be considered a serious attempt to invest in the sector in the region. While the EBRD has done more, particularly in Bulgaria, its renewables investments in the Western Balkan countries have been small, very recent, and hidden, because they have been carried out through credit lines and a private equity fund whose final beneficiaries are not disclosed. The EBRD has also supported more climate-damaging fossil fuel projects in the region, as well as road construction projects in Serbia, which have not nearly been matched by financing for public transport.

Both banks have made some energy efficiency investments, particularly in the power transmission and distribution sector. Investments in this sector need to be further developed, particularly to include residential energy efficiency and energy efficiency in public buildings.

The EIB is perhaps even better placed than the EBRD to make loans for renewable energy projects in southeast Europe because its loans are made at cost price and thus have lower interest rates than the EBRD's, and it is thus particularly of concern that it has barely done so thus far. If the EBRD has managed to finance at least some renewable energy projects, at least in Bulgaria, why has the EIB done even less?

Regarding the barriers faced by the banks in the region, the EBRD has explained its lack of renewable energy financing in Croatia as follows: *"The lack of renewable energy projects was due to the combination of slow licensing of projects and lack of sufficient equity capital of developers who were not prepared to share the potential profits with an external shareholder."*[50] Similar explanations may well apply for other countries in the region. An investor in a wind energy project in Croatia, which started operating in 2006, also stated that the EBRD was approached to back the project but quoted a higher interest rate than commercial banks and declined to finance the project as the necessary paperwork was considered to negatively affect the economic viability of the project.[51] The situation might well be different if the project happened now due to the lack of private financing available, but the issue is worth reflecting on if the EBRD is to make a useful contribution. Further conversations with the EBRD have pointed to issues of complex and slow grid connection procedures. A further issue is the lukewarm commitment by southeast European countries to renewable energy and energy efficiency in their energy strategies. Almost all countries in the region have ambitions to become net energy exporters, and have energy strategies full of large-scale new-build energy generation capacity rather than small and smart energy efficiency and renewable energy investments.

The international financial institutions can only select projects initiated by others, which fit their policy goals, and a lack of clear government commitment to making renewable energy and energy efficiency into

[50] European Bank for Reconstruction and Development: Strategy For Croatia: 2010 – 2013, approved 27 April 2010

[51] South East Europe Development Watch/CEE Bankwatch Network: Real Energy Security Is Staring Us In The Face: Renewable Energy Case Studies From South East Europe, December 2007, p.23

a force to be reckoned with in their countries may dampen private companies' appetites to develop new projects that might be financed by the European public banks. However, *this cannot explain the current situation of low IFI support for renewable energy in southeast Europe, as investment plans for renewable energy do exist in almost all of the countries,* whether wind farms in Croatia or small hydro plants in Albania.

The question is whether the IFIs are perhaps being too perfectionist in wishing to ensure that the conditions for renewable energy investments are in place before supporting the sector. *After all, is it not the role of public banks to lead investments in new markets that are still considered too risky for the private sector?* In our opinion, IFI investments in renewable pilot projects could considerably assist in opening the way for further investments by making renewable energy project approval and grid connection procedures more logical and proportional. This should not include throwing caution to the wind and allowing all kinds of developments in any location, but should ensure that projects with low environmental and social risk are treated as such.

Recommendations for International Financial Institutions

- We call upon the International Financial Institutions to shift their funding from fossil fuel energy projects into renewable and energy efficiency projects in the region. This should not include new large hydro power plants, which are not considered sustainable due to biodiversity and water quality impacts and vulnerability to dry weather. Moreover, concerning renewable energy projects, IFIs should support projects where the energy is not primarily intended for export, but its production benefits the development of the country and improves the quality of life of its people.
- IFIs should not wait until the conditions are perfect before financing renewable energy projects, but instead use pilot investments to push through change in the countries in the sector.
- Regarding district heating energy efficiency projects, we recommend the IFIs to look into supporting biomass utilization rather than fossil fuels. Considering the constant problems with increasing gas prices and rising costs of heating and hot water in big cities, we believe the sector has potential, even though economically such initiatives may not be considered as viable in all countries at present. We propose that further research is developed in this area, to show best practices and sustainability of these systems.
- Although energy efficiency in the residential sector is a massive initiative, we expect IFIs to have an active role in assisting the Governments from the region in addressing the low efficiency of buildings and providing proper finances in order to help implement energy efficiency measures. Additionally, thermostats and control switches in households should be included as mechanisms.
- A large percentage of the biomass used in this region is accounted for by wood, and in some countries there is illegal logging that is additionally contributing to significant problems (such as deforestation and erosion, destruction of habitats and harming biodiversity). A programme to support the switching of inefficient with efficient burners is one way to address deforestation.

- Support should be provided to private companies in the countries developing renewable energy technologies. Supporting them through credit lines would have a multi-beneficiary aspect - it would create jobs, support local economic development and increase the share of renewable energy production in the overall energy production in the country. This would also indirectly help households make a major step in introducing renewable energy technology.
- Regarding industrial energy efficiency, there is an urgent need to the improve energy efficiency of existing large industry in the region and decrease high energy intensity. However, there should be a main focus on very clear and transparent accounting and public information disclosure in order to make sure that the companies are really using the support to significantly improve their energy efficiency.
- As there are significant capacity constraints within national and local administrations, the IFIs could step up technical co-operation to support the staff within the ministries and agencies in increasing their knowledge and skills. Providing technical support in developing laws, regulations and toolkits as well as ways to implement them could also assist the Governments in achieving their goals.
- Some regional Governments argue that they can't attract investments in certain renewable energy utilization projects because they do not have proper data to provide the investors with. The IFIs could also support more research into potentials and in combination with their existing expertise from different countries; such initiatives would be beneficial to all parties concerned.
- In terms of energy efficiency in the transport sector, the IFIs need to step up support for sustainable transport. Urban investments need to encourage better urban planning and decrease climate impacts by decreasing dependency on cars, by providing alternative public transport, use of the bicycle and walking. Elsewhere, the IFIs should drastically decrease financing for motorway and highway construction and invest more in railways.
- When assessing energy and transport projects, IFIs need to look at various national strategies and EU legislation rather than just sectoral strategies for the energy and transport sectors. Energy and transport sector strategies, where they exist at all, often conflict with the need to reduce greenhouse gas emissions in order to meet EU targets once the SEE countries join the EU.

References

http://siteresources.worldbank.org/ECAEXT/Resources/258598-1268240913359/chapter3.pdf

IEA, Energy in the Western Balkans, The Path to Reform and Reconstruction, 2008

http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/ECAEXT/0,,contentMDK:22497075~pagePK:146736~piPK:146830~theSitePK:258599,00.html

Albanian Ministry of Economy, Trade and Energy, presentation “Investing in energy efficiency and renewable energy in the Energy Community” at the Investment Conference on EE and RES, Energy Community of SEE and EBRD, Vienna, March 2010

Ministry of Economy of Montenegro, presentation on “Renewable sources in Montenegro” at the Investment Conference on EE and RES, Energy Community of SEE and EBRD, Vienna, March 2010

Gabriela Cretu, Energy Community Secretariat, presentation “The Driving Role of the Energy Community for a Sustainable Development of the Western Balkans, The World Bank Regional Conference on Business Environment Reform in SEE “Growth and Competitiveness: Weathering the Crisis and Looking Ahead”, Tirana, 17-19 November 2009

Pöyry Energy Consulting and Nord Pool Consulting, Report “SEE Wholesale Market Opening”, commissioned by the World Bank, April 2010

IPA Energy and Water Economics, Report “Study on Tariff Methodologies and Impact on Prices and Energy Consumption Patterns in the Energy Community” to Energy Community, March 2009

USAID, Stocktaking report for regional assessment of RES. Regional Findings and country Summaries, April 2009

EIB special report "Partnering with the world", May 2010 URL: http://www.eib.org/about/publications/eib-information-1-2010-n137-special-edition.htm

http://www.economy.gov.mk/WBStorage/Files/precisten_tekst_Strategija_za_energetika_na_RM.pdf

International Energy Agency (IEA).
http://www.iea.org/Textbase/stats/electricitydata.asp?COUNTRY_CODE=AL

Draft National Energy Strategy for Albania, 2006, p.12

Regional Analysis of Policy Reforms to promote Energy Efficiency and Renewable Energy Investments, on the basis of personal interview with the Albanian Energy Regulatory Authority.

Regional Analysis of Policy Reforms to promote Energy Efficiency and Renewable Energy Investments

Regional Analysis of Policy Reforms to promote Energy Efficiency and Renewable Energy Investments
Defined as Albania, Bosnia and Herzegovina, Bulgaria, Macedonia, Montenegro, Romania, Serbia and Croatia. The EBRD categorizes Croatia as Central Europe and the Baltic States however we have chosen to include it in southeast Europe.

European Bank for Reconstruction and Development: Annual Report 2009, p. 4

European Investment Bank website: http://www.eib.org/about/index.htm, accessed 01.06.2010

European Investment Bank website http://www.eib.org/projects/loans/sectors/index.htm?start=2000&end=2009, accessed 01.06.2010

Calculated from data from the EIB website at: http://www.eib.org/projects/loans/regions/index.htm, accessed 01 June 2010. Southeast Europe is defined by the EIB as including Turkey and Croatia but not Romania or Bulgaria, however we have here used figures including Croatia, Romania and Bulgaria, but excluding Turkey.

European Bank for Reconstruction and Development: Energy Operations Policy, 11 July 2006

European Bank for Reconstruction and Development: Sustainable Energy Initiative brochure, May 2009

European Bank for Reconstruction and Development: Sustainable Energy Initiative Phase 2 (2009 - 2011) factsheet, May 2009

European Bank for Reconstruction and Development: Annual Report 2009, p. 1

CEE Bankwatch Network: Change the lending, not the climate, 02 December 2009, p.19

CEE Bankwatch Network: Change the lending, not the climate, 02 December 2009 p. 21

Excluding investments categorised by the EBRD as energy efficiency investments in the transport sector.

The basic figures come from the EBRD's own project database at: http://www.ebrd.com/pubs/general/ar09.htm (accessed 28 May 2010). Figures for energy efficiency projects 2006-2009 come from a database provided by the EBRD on request. Figures for energy efficiency projects from 2000-2005 come from the project list at: http://www.ebrd.com/projects/signed/index.htm (accessed 28 May 2010)

European Environment Agency: Towards a resource-efficient transport system, TERM 2009: indicators tracking transport and environment in the European Union, EEA Report No 2/2010

European Investment Bank website: http://www.eib.org/projects/pipeline/2007/20070438.htm?lang=-en, accessed 1 June 2010

European Bank for Reconstruction and Development: Strategy For Croatia: 2010 – 2013, approved 27 April 2010

South East Europe Development Watch/CEE Bankwatch Network: Real Energy Security Is Staring Us In The Face: Renewable Energy Case Studies From South East Europe, December 2007, p.23

Ana Colovic Leskoska *has been working for CEE Bankwatch Network since 2001, as the national coordinator for Macedonia. She also serves as the Executive Committee member in the Network. In Macedonia she is based in Eko-svest in Skopje and works there as the organisation's Director.* ***Fidanka McGrath*** *became CEE Bankwatch's Network's Coordinator for Southeastern Europe in June 2004 and has been working for the NGO Za Zemiata in Sofia, Bulgaria.* ***Pippa Gallop*** *began working for CEE Bankwatch Network in 2005, initially within Croatian partner group Green Action and later as Bankwatch's Research Co-ordinator. From June 2009 she is also interim EBRD Co-ordinator. Prior to joining Bankwatch she was active in a number of environmental and social groups in the UK.*

THE SHALE GAS PHENOMENON: ALTERING THE WESTERN DISCOURSE ON ENERGY GEOPOLITICS

Peter Kiernan

petervkiernan@yahoo.com

Abstract

High oil prices, and the perception that this fuelled growing geopolitical power of anti-Western energy producers such as Russia, Iran and Venezuela in the mid to late 2000s, prompted a discourse among some Western policymakers and analysts that the energy security and global political and economic influence of the West was being eroded. This erosion of influence was also being enhanced by the rise of a rival major energy consumer to the West; China. However the so-called shale gas "revolution," whether it proves to be as such or not, has prompted a distinct shift from undue pessimism about the future of politics of global energy to almost wild optimism. Now, a discourse that is gaining momentum is that the North American shale gas revolution will undermine the geopolitical influence of states like Russia, Iran and others. This discourse is that the large scale entry of unconventional gas supplies in the US and elsewhere will mitigate Russia's quest to exercise undue influence over Europe while making Iran's bid to develop its vast natural gas supplies for export untenable. While undoubtedly the impact of substantial growth in shale gas output in the US has already impacted global gas markets it is still unclear that this will replicated elsewhere in Europe and Asia. Furthermore, energy producers are being increasingly drawn to supply the growth in hydrocarbons demand in emerging markets, while oil is will remain the primary transport fuel for the foreseeable future. It is still too early to tell how "revolutionary" the advent of shale gas will be.

Key words: Shale gas, Europe, Russia, geopolitics

Before the impact of the global economic meltdown of 2008-2009 sent oil and gas prices plummeting there had been a steadily building fear of the energy security consequences of the growing dependence of the American, and to a lesser extent the European, economies on the dependence on imports for oil and gas. The growing perception among policymakers and media pundits, and indeed some scholars in the energy policy field, was that the geopolitical power of resource-rich states that export hydrocarbons to the developed OECD world was growing at the expense of an increasingly “resource-poor” West.

This has been seen as an alarming problem among policymaking elites in Western capitals. Think tank analysts, legislators, and media commentators have argued that energy-exporting states – such as Iran, Russia, Venezuela and to some extent Saudi Arabia and others – not only do not adhere to the political and cultural values of Western powers, but also to varying degrees use their burgeoning revenue from oil and gas exports to undermine the strategic interests of the US and the West in the global geopolitical theatre. Indeed former US president George Bush once said in a State of the Union address that American were importing oil from countries that “don’t like us,” a sentiment that has been echoed by his successor, Democratic President Barack Obama.

The fact that the majority of the 9/11 terrorists were from Saudi Arabia (a state that is a key ally of the US in the Middle East and the largest OPEC oil exporter), the prolonged conflict in (oil-rich)Iraq, fears over (oil-rich) Iran’s nuclear activities, the successive gas pricing disputes between (oil and gas-rich) Russia and Ukraine over 2005-2009 and the Russian-Georgian war of 2008, the rise of Hugo Chavez in Venezuela, and oil prices reaching a record-high of $147 per barrel in the summer of 2008 all contributed to steadily rising fears that the dynamics of global geopolitics was swinging decisively against the industrialized energy-consuming economies of the West and towards resource-rich states that threaten the stability of the international system.

Such has been the traction of this argument in the US that it has brought together an unlikely alliance of environmentalists and neoconservatives that seek to eliminate American dependence on imported oil through the promotion of alternative transport fuels and cutting oil consumption. In 2006 then Secretary of State Condoleezza Rice stated that "We do have to do something about the energy problem. I can tell you that nothing has really taken me aback more, as Secretary of State, than the way that the politics of energy is warping diplomacy around the world. It has given extraordinary power to some states that are using that power in not-very-good ways for the international system, states that would otherwise have very little power"[52] The Bush administration, however, did little if anything to wean Americans away from their love affair with petroleum. Indeed every US president since Nixon has pledged to reduce American dependence on imported oil yet over the last four decades this dependence has steadily increased.

While in Washington consternation grew at the perceived growing invincibility of Iran’s Mahmoud Ahmadinejad and Venezuela’s Hugo Chavez as oil prices continued to rise, in some European capitals

[52] http://www.tompaine.com/articles/2006/04/27/from_gas_crisis_to_cure.php, Deros Lovaas and Gal Luft, April 27, 2006, From Gas Crisis to Cure.

concern rose about Vladimir Putin's Russia and its perceived ability to use its natural gas exports as leverage against European states to enhance Moscow's geopolitical influence. That Gazprom is a tool of Russia's foreign policy objectives is an often used one-liner in articles attempting to explain the nexus between energy and geopolitics.

Prior to the global economic collapse it was therefore widely perceived that an energy crisis was building, not because oil and gas reserves were depleting but because of the nature of the regimes that possessed them. Fuelling this anxiety was the rise of China as a major global energy consumer – spurred by several successive years of spectacular economic growth – and the operations of its state-owned oil companies in acquiring energy assets in the Middle East, Central Asia, Africa and elsewhere in an attempt to secure its own oil and gas supplies. Today China is the second-largest oil market in the world and the second-largest importer of crude oil, yet it was only in 1993 that China became a net oil importer.

Anxiety was rising that the energy-consuming OECD economies were becoming increasingly unable to control the actions of states – such as in the Middle East, Central Asia and Latin America – that provided them with energy supplies or – in the case of China and India – now actively competed with OECD economies for access to the world's resources of hydrocarbons.

While these themes are still viewed as issues of concern, the sense of urgency regarding them has been eased somewhat by the global economic recession of 2008-09 which saw both oil and gas prices plummet. Although oil prices have recovered to the $70-$80 range, the price of natural gas in different regional markets has not and fundamentals in gas markets look to remain relatively weak, at least in the short term. Overall the pre-occupation with the global economic crisis has somewhat pushed the energy security debate off centre stage. Indeed for a short time hopes were raised that Russia, Iran and Venezuela were heading towards bankruptcy and political impotence because of the crash in energy prices.

However, a potentially more far-reaching development in energy markets has altered the discourse about energy security far more than the current soft economic conditions, and that is the recent rise of shale gas output in the United States. In 2005 the chief executive of ExxonMobil at the time stated that natural gas production in North America had peaked and would continue to decline absent major discoveries.[53] Until recently the prediction had been that the US would become increasingly dependent on natural gas imports in the form of liquid natural gas (LNG). The resultant fear was that this would enhance the dependency of the US on gas exporters such as Russia, thus replicating in the natural gas world what had already happened with oil; the use of energy supplies as political leverage by states of doubtful strategic reliability against the industrialised West.

But the recent technological developments that have rapidly expanded the production of shale gas – a form of unconventional gas that is trapped in between shale rock –has been dubbed a "game changer" in

[53] http://www.reuters.com/article/idUSN2163310420050621 Exxon says N. America gas production has peaked, Reuters, June 21, 2005

the global energy market. Provided that the North American shale gas boon is sustainable the US will no longer need to rely on growing amounts of imported LNG to meet its needs, as previously forecasted, and will become largely self-sufficient. This will in turn allow LNG suppliers to instead focus on other markets in Europe and Asia. The technological breakthrough in North America regarding shale gas production has also generated interest elsewhere, not the least in Europe, in the exploration and development of unconventional gas reserves. Add to this the projected growth in Australia's offshore gas output and prospects for unconventional gas development in the Asia Pacific region and the dynamics of gas markets have altered. This has prompted a change in the discourse regarding the issue of global energy security for the world's leading oil and gas consuming economies.

An op-ed in the Wall Street Journal earlier this year explained "How Shale Gas Will Rock the World:" not only will it stifle the potential for the formation of a global natural gas cartel but will also put "some longtime troublemakers [Russia, Iran and Venezuela] in their place and possibly bringing some rivals into the Western fold."[54] The argument is that American self-sufficiency in natural gas will place export revenue pressure on Russia as well as reduce its available energy markets, and stymie potential gas exporters such as Iran. Other gas-hungry markets in Europe and Asia will be able to either access the growing volumes of LNG entering the market or to explore and develop unconventional gas reserves of their own.

As far as natural gas industry advocates in the US are concerned natural gas can transform the US' transport fuel consumption habits. America's Natural Gas Alliance, an industry body, claims that "replacing 3.5 million heavy-duty vehicles with natural gas vehicles by 2035 would save more than 1.2 million barrels of oil per day-more than the United States imported from either Venezuela or Saudi Arabia in 2009."[55]

Yet how realistic is the view that unconventional gas will change the world as we know it? Will it marginalise Middle East oil producers and thus reduce that region's strategic importance to the United States? Will it break the shackles of European dependence on gas supplies from Russia? Will the shale gas "revolution" reverse what once seemed to be the inexorable growing geopolitical power of anti-Western petro-states?

The shale gas issue has provided many commentators and analysts with the rhetorical ammunition to argue that the energy-consuming industrialised West now has an energy trump card to use against the likes of OPEC, Russia, Chavez, Ahmadinejad and others. Furthermore, if growing economic powers such as China and India are able to develop their own reserves of unconventional gas they will not have to rely on these energy suppliers as much either, so according to this school of thought the prognosis now look

[54] *Shale Gas Will Rock the World*, Amy Myers Jaffe, Wall Street Journal, May 10, 2010
[55] http://www.anga.us/learn-the-facts/transportation/energy-security

pretty grim for the world's axis of energy evil in the longer term. This is quite unlike the mainstream discourse on the global geopolitics of energy that was prevalent only a few years ago.

While much needs to unfold before any definitive conclusions can be made about the extent to which the development of shale and other forms of unconventional gas will permanently alter the geopolitical landscape of global energy markets, it is apparent that the recent rapid rise in production of shale gas in the US has contributed to a more bearish outlook for gas market fundamentals. An example of this is that Gazprom and its partners have reportedly postponed development of the large offshore Shtokman gas field in the Barents Sea because of lowered expectations that the US will require growing volumes of LNG.

Yet the extent to which the shale gas supply phenonemon can be repeated in Europe and elsewhere still depends on many factors. Interest has been generated in European states such as Poland about shale gas potential but it may be at least one decade before this form of unconventional gas will begin production. The reserves and output potential of shale gas in Europe is at this early stage not fully known. A recent report by Chatham House on the implications of shale gas stated that:

The US experience [with shale gas] was triggered by many favourable factors connected with geology, tax breaks and the existence of a vibrant service industry. There are serious doubts about whether such favourable conditions can be replicated outside the United States, especially in Western Europe where there is much current interest. In Europe the geology is less favourable, there are no tax breaks and the service industry for onshore drilling is far behind that in the United States. Finally, there is concern that disruptions caused by shale gas developments will not find public acceptance, especially in a context where the gas is the property of the state and thus the benefits accrue to governments and not local landowners.[56]

The report also argued that should the development of shale gas reserves in North America not prove to be the widely expected boon that many are anticipating then the result could be the return of tight market fundamentals. This is because the anticipation of significant growth in unconventional gas supplies has already resulted in a reduction of LNG capacity utilisation: a problematic scenario once global gas demand recovers to pre-economic meltdown growth rates. Therefore if the North American shale gas sector does not end up being as "revolutionary" as some expect the result could be supply constraints in the longer term until the market can correct itself and stronger growth in LNG capacity utilisation returns to meet the shortfall in supply.[57]

The report also cites heightened environmental concerns about the impact of shale gas development in the US and concerns that shale gas wells have fast depletion rates. There is also the argument put forward

[56] The 'Shale Gas Revolution:' Hype and Reality, Paul Stevens, Chatham House, September 2010 (p.vi)
[57] The 'Shale Gas Revolution:' Hype and Reality, Paul Stevens, Chatham House, September 2010 (p.vii)

by shale gas sceptics that prolonged periods of low gas prices will impact the viability of shale gas projects.

It may be still too early to tell how the shale gas phenomenon will play out geopolitically in the coming decade and beyond, yet there some trends that can be identified at this stage. It is likely that the share of shale gas of total US gas supply will continue to increase, although opportunities in Europe for shale gas development may not be seen until the longer term, and they may not be as dramatic as what will be experienced in North America. Nevertheless countries such as Poland, Germany, Hungary and Romania are believed to possess the geological characteristics for shale gas potential.[58]

Yet even if a shale gas "revolution" does not spread to Europe a sustained and dramatic increase in North American shale gas supply will still likely impact the European gas market. European states will have a greater opportunity to diversify sources of supply from various LNG exporters, such as Qatar, and thus ease somewhat their dependence on natural gas imported from Russia by pipeline.

However Russia currently supplies about 29% of gas consumption in the European Union and Russia is unlikely to be eliminated from European gas markets altogether. The Nord Stream pipeline from Russia to Germany is already under construction and Russia is still pushing for the construction of the South Stream pipeline through the Black Sea and south-east Europe. Yet the emergence of Europe as a stronger market for LNG will impact Russia's influence over pricing as European consumers would be less willing to accept long-term contracts based on prices indexed to oil.

It also appears that as much as European states seek to diversify sources of supply for oil and gas Russia is also seeking to diversify its markets. Russia's pipeline operator Transneft has begun oil shipments to China in November 2010 along a branch of the ESPO pipeline that exports crude oil to the Russian Pacific Coast. Talks are also ongoing between Russia and China for the construction of the Altai gas pipeline that would supply the Chinese market with 30 billion cubic metres of gas annually (about the same capacity as the Nabucco pipeline project – from Turkey to south-east and central Europe – which aims to secure natural gas from the Caspian and Middle East regions and is said to be a rival to the South Stream project). Furthermore Russia may have lowered expectations of European gas demand in the future, as evidenced by the recent decision by Russia and Central Asian states to postpone plans for a Caspian gas pipeline that would supply European markets with gas, mainly from Turkmenistan, via Russia. To minimise the impact of a potentially stagnant European energy market Russia will likely seek to lock its oil and gas supplies into one of the fastest-growing energy markets in the world, China.

The shale gas phenomenon has shifted the nature of discourse in the US, and to a lesser extent in Europe, on the issue of energy security from bleak pessimism to almost wild optimism. Should the shale gas momentum in the US be sustained in the longer term the reduced requirement in the American market for

[58] The 'Shale Gas Revolution:' Hype and Reality, Paul Stevens, Chatham House, September 2010 (p.15)

LNG will provide European markets with the potential option of additional sources of supply. In this case Russia's role in European gas markets will be impacted, but the extent to which this occurs depends on how real Europe's own shale gas potential is, as well as the level of its ability to absorb greater volumes of LNG.

Either way this decade shapes up to be an interesting one for those analysing the geopolitics of energy. The issues of global gas supply and demand will receive greater attention with regard to the debate on meeting energy security and climate change objectives. China and India are seeking to diversify from coal usage by expanding the role of natural gas in the energy mix, while the advent of shale gas in the US potentially provides some impetus for increasing the role of gas as a transport fuel. As this decade progresses the defining trends regarding the relationship between the world's energy consuming economies and oil and gas exporting powers will become clearer.

References

http://www.tompaine.com/articles/2006/04/27/from_gas_crisis_to_cure.php, Deros Lovaas and Gal Luft, April 27, 2006, From Gas Crisis to Cure.

http://www.reuters.com/article/idUSN2163310420050621 Exxon says N. America gas production has peaked, Reuters, June 21, 2005

Shale Gas Will Rock the World, Amy Myers Jaffe, Wall Street Journal, May 10, 2010

http://www.anga.us/learn-the-facts/transportation/energy-security

The 'Shale Gas Revolution:' Hype and Reality, Paul Stevens, Chatham House, September 2010

Peter Kiernan *works as an energy editor based in London and writes frequently on the global politics of energy. He has a Master of Arts degree in International Political Economy and Development from Fordham University.*

NEW POSSIBLE NATO ROLE IN THE FIELD OF ENERGY SECURITY

Toni Mileski
toni@fzf.ukim.edu.mk

Abstract

The primary aim of the paper is to present a new possible NATO role in the field of energy security. More precisely, the paper focuses on the approach of polarizing and securing energy supply, NATO's involvement and role in the field of energy security, as well as the difficulty in defining the role of the Alliance in energy security. The main focus in the paper lies on analyzing the more serious NATO involvement and analyzing the beginnings of such thoughts in the Alliance's strategic documents. These aspects will be analyzed through two crucial moments. The first one is a more military and security focus reflecting the Alliance's need for the implementation of practical and logistical planning for the protection of energy supplies, especially oil. The second moment for the Alliance's involvement in discussions of energy security is more related to political pressure and threats to energy security. This argument gained strength in particular after the dispute between Ukraine and the Russian company Gazprom at the beginning of 2006. The Summits in Riga in 2006 and in Bucharest in 2008 and their accompanying documents provide basic guidelines for the future mandate of NATO. This means that NATO needs to reconsider its potential role in the field of energy security. The Alliance is facing two parallel debates concerning the definition of interruption of supplies of energy. Should it be a military cease including an armed attack or it will be perhaps in the context of competition for access to certain resources? Answers to these questions in extreme cases may be the involvement of armed security infrastructure. The second debate is going in the direction of defining the interruption of supplies of energy, including the political reasons which are hard to define and prove. In this case, it is difficult to expect a consensus of all partners when undertaking certain actions. Therefore, the Alliance will have to actively work on its role in the field of energy security in the context of its evolutionary path, which refers to the existence and functioning in the international security arena.

Key words: NATO, energy security, energy supplies, securitization.

Introduction

For some time now, issues related to energy security have been increasingly represented in interstate high-level political meetings as well as at economic forums. The fact that military-political alliances, such as NATO, are ever more incorporating regularity and stability in the supply of energy in their working agendas provides confirmation that from primarily being an economic issue, energy supply has now come to represent an issue for the security corps too.

What does energy security actually represent? Energy security at the global and national level means the availability of energy, in sufficient quantities and affordable prices, the stable delivery and the physical security of gas and oil pipelines.

When considering that global energy resources are limited, the issue of energy security acquires significant salience. This is the result of increasing demand and consumption of energy resources, arising from the growth of the world population and the development of new technologies. Also, the geographical distribution of resources and their consumption is extremely uneven. The EU member states are the largest consumers of natural gas and their main supplier is the Russian Federation, which possesses one third of gas reserves in the world. On the other hand, the USA and the "Asian Tigers" have the largest demand for oil with the countries from the Middle East being the main oil exporters.

The uneven distribution of power between the demand and supply of energy results in leads to dependence of the buyer on the producer. At the same time, however, such dependence is not unidirectional; energy producers also become dependent on the stability of demand and of the markets where they sell their products. In economic terms, the initial assumption is that the market and its conformity with law constitute a regulatory mechanism, and that the main actors behave rationally in that market. However, basic energy resources are limited and non-renewable, and demand for them is constantly rising because modern economies cannot function without them. This makes energy trade an even more important issue for countries. When energy supply is dealt with at the level of state policy, the relation between supplier and buyer is not only determined by economic logic but also by political motive and foreign-political interests. As a result of such relations and the politicization of energy supply, unpredictability occurs and uncertainty and distrust between all participants in the chain of energy dependence increases.

Dealing with energy issues at the political level also signals the beginning of discussions for securitization and militarization of energy issues. Securitization is a process in which an object or value is determined as having priority in being defended. One of the final methods of acting in such cases is the use of military power. However, other methods, in the domain of foreign political means, are also possible, e.g. the introduction of sanctions or the termination of diplomatic relations[59]. Efforts in the securitization of energy supply may be also understood as an extreme version of politicization. Politicization involves a certain problem being denoted as an issue for the survival of a certain country, nation or certain group, in addition to being a public issue. When a military-political union like NATO addresses a certain topic in the context of global security we speak of efforts for its securitization. Today, NATO's profile slowly but surely is evolving, NATO is a relevant factor on the global security stage, and one that can carry out the securitization, convincing member states and others about the significance of a certain issue. At this point, the Alliance is undertaking steps, discussing the need for securitization of energy supply and incorporating energy security in its priority tasks.

The involvement and role of the Alliance

NATO's involvement in energy security issues consists of two crucial parts. The first has a more military-security focus which reflects the dual requirement of the Alliance for carrying out practical and logistic planning of the protection of energy supplies, especially oil, while at the same time maintaining the wider security of its member states and the stability of its operational capability.

This situation requires evaluating military threats to energy installations as well as to energy supply routes. Possibilities for escalation and personal security are relevant factors for possible military confrontations. Certain analysts believe the issue of access to energy resources may become the subject of large military confrontations and represents a serious flaw in the functioning of the modern international system. Pirate and terrorist attacks increase this risk even more. According to one study there have been at least 330 terrorist attacks on oil and gas plants all over the world between 1990 and 2005, including in NATO's and Partner's countries[60].

The second part of NATO's involvement in the discussions on energy security focuses more on political pressure and threats to energy security. This became especially apparent after the dispute between Ukraine and the Russian company "Gazprom" i.e. the political pressure exerted through gas supply disruptions at the beginning of 2006. Russian authorities explained these actions strictly by reference to economic arguments. The rising prices of oil and gas for the countries of the former Soviet Union marked the end of an era of purchasing energy at lower prices. This is why Moscow insisted on keeping the debate on economic terms, stressing that increased prices have economic, not political, meaning[61]. Nevertheless, these events stimulated the discussion of energy security within NATO.

---

[59] Radoman, J. *Securitization of Energy as a Prelude to Energy Security Dilemma.* Western Balkans Observer, Issue: 4/2007, p. 36-37.

[60] Moran, D.,J.A Russsell, „The Militarisation of Energy Security", Strategic Insights, Vol 7, No. 1, February 2008 p. 2. http://www.ccc.nps.navy.mil/si/2008/Feb/moranFeb08.asp

[61] The Russian Ministers of Finance and Economy stressed that the adjustment of Russian energy prices with world process until 2011 represents one of the conditions for Russia's entry into the World Trade Organization. Radoman, J.

These issues resulted in conceptual differences concerning the realization of the main goal of NATO involvement in energy security. The dilemma is as follows: should the Alliance adopt a wider "thematic" approach towards energy security, seeing the interests of the "producer", "transit" and "consumer" countries effectively in the same light, protecting it against threats that undermine the interests of all, like an attack of a main supply route? Or should it adopt a more regional and direct approach which differentiates between the interests of the "producer" and the "consumer", using its significant influence to support the "consumer" country in what is considered a competitive dialogue between the "producer" and "consumer"?

In the context of having to involve the Alliance in energy security, the Riga Summit held in November 2006 was especially important. The Riga Summit Declaration included a short paragraph explicitly announcing, for the first time that energy security is NATO's concern, and tasking the Alliance with examining the specifics of the role. In this manner, the Declaration changed the nature of the discussion; there was no longer a question of whether the Alliance has a role, rather, it confirmed it has. The question now concerns the nature of that role. A second significant moment was the speech by the American Senator Richard Lugar in the margins of the Riga Summit, which indicated threats from terrorism, and argued that energy will probably be the source of armed conflicts in Europe and surrounding regions. Lugar therefore noted that it would be irresponsible for NATO to reduce its commitment in the field of energy security. However, Lugar focused on the potential of resources for political manipulation and the use of "energy weapon"[62]. His speech received attention from almost the entire international community.

The significance of the political aspect continued to increase after the adoption of the Riga Declaration, in particular after the dispute between Russia and Belarus about gas supply in December 2006 and January 2007. Similar events occurred in the following years. On January 31st 2008 Russia cut gas supplies to Ukraine due to unpaid bills and an increase in gas prices. The Russian-Ukrainian price dispute left ten countries from Central and Eastern Europe without gas in the middle of winter. Moldova, Slovakia, Bulgaria, Serbia, Croatia and Macedonia were left without gas for heating and production of electricity, while Turkey Greece, the Czech Republic, Poland, Hungary and Austria faced significant cuts in their gas supply. The political aspect seems to have reached its peak in January 2009. The cut of Russian gas supply through Ukraine caused great discomfort in the European Union because the EU receives 40% of its natural gas needs from Russia, of which 80% goes through Ukraine[63].

Securitization of Energy as a Prelude to Energy Security Dilemma. Western Balkans Security Observer. Issue: 4/2007, p. 40.

[62] For speech text see: Lugar, R. *Energy and NATO.* Keynote speech delivered to the German Marshall Fund Conference, Riga, 27 November 2006. http://lugar.senate.gov/energy/press/speech/riga.cfm

[63] The crises ended on January 19 after the negotiations between the Prime Minister of Russia, Vladimir Putin and the Prime Minister of Ukraine, Julija Timoshenko. Then it was agreed Ukraine in 2009 to pay Russian gas 20% less than the market value, and from 2010 to begin paying the price like the other countries in Europe, or 470 dollars for

The Riga Declaration constitutes a significant starting point analysis of NATO's role in energy security. Article 45 of the Declaration indicates that the security interests of NATO may be affected by cuts to vital resource supplies. The Alliance supports the coordinated international efforts to assess risks to the energy infrastructure and to promote the security of the energy infrastructure[64]. Engagement of individual NATO member states could be observed even before discussions on the role of the Alliance in the field of energy security began. This can be detected as early as the Iran-Iraq war of 1980-88. During this period, Great Britain, France and the Netherlands participated in the operation "Earnest Will" where they secured the routes of tankers in the Persian Gulf[65].

Overall, prior to the Riga Summit, the Alliance only made vague references to problems of energy stating that NATO activities were moving toward the prevention of supply disruptions in vital resources. Defining prevention is the key challenge for the Alliance, illustrating difference between the military threat to vital resources and threats that are politically motivated. NATO's mandate as defined by the Riga Declaration explains the interests of the Alliance and its focus on energy infrastructure security, but not regarding the other dimensions of energy security. The focused and limited agenda defined by the Riga Declaration formed the basis for official talks in 2007 and the beginning of 2008. Former NATO Secretary General Jaap de Hoop Scheffer confirmed that the Alliance considers energy security a "collective" challenge for which a "collective" response must be provided. A response which is strongly linked to cooperation between national governments and international organizations".[66] Furthermore, the role of NATO in such a collective response would focus on those areas to which it could contribute, such as the protection of supply routes, especially in the transport of liquefied natural gas with tankers on open sea, and protection of critical energy infrastructure when there are strong threats.

At the Bucharest Summit in April 2008, this approach was confirmed. The Alliance insisted on contributing and fully cooperating with the activities of the international community, comprising numerous organizations specializing in the field of energy security, although there are still some vague phrases – the Alliance will commit to "projecting stability" and advancing the international and regional cooperation. At the same time, the focus on civil defence and dealing with crisis and energy infrastructure remains clear.[67] This results in a "deepened" role that NATO would be able to realize. In this context, NATO's involvement could be directed towards contributing to the coordinated international effort with the goal of improving energy security in two broad areas: sharing information and planning and response.

1000 cubic meters. Until then Ukraine enjoyed a favoured price for Russian gas in the amount of 179.5 dollars for 1000 cubic meters.
New gas crises March 8 http://www.pressonline.rs/page/stories/sr.html?id=59582&sectionId=40&view= story
[64] Riga Summit Declaration http://www.nato.int/docu/pr/2006/p06-150e.htm
[65] Varwick, J. *NATO's Role in Energy Security*. NATO at a Crossroads. IP Summer 2008. p. 39.
[66] Speech by NATO Secretary General Jaap De Hoop Scheffer at the 44th Munich Security Conference http://www.securityconference.de/konferenzen/rede.php?id=204&menu2009=&menukonferenzen= &sprache=en&
[67] Bucharest Summit Declaration, NATO Press Release (2008/049) 3 April 2008. www.nato.int

Firstly, sharing information is one of the key principles of energy security. NATO may contribute by acting as an important bridge between the energy and security community. This is clearly designated with the Riga Declaration, and confirmed with the Bucharest Declaration, i.e., NATO may contribute to information exchange, acting as a forum for exchange of reports. Certain opinions are moving toward enhancing the link between the security and energy community through the establishment of permanent monitoring and by assessing the mechanisms for acting in cooperation with the International Energy Agency (IEA) and similar organizations, including companies. Also, NATO may contribute to the exchange of data through the practical use of its assets and capacities. That is, assets for maritime surveillance and early warning may be used to provide current information on main maritime transport routes which are not covered sufficiently by national capacities of the countries concerned.

Secondly, the Alliance may contribute to achieving energy security by making its own military capacities and expertise available where needed. This primarily means physical protection, patrolling and escort along the path of critical infrastructure. NATO already has a clearly defined role in the protection of oil and gas capacities in the North Sea in case of armed attacks[68]. NATO (and EU) maritime capacities are also used to protect oil and gas shipments in the area of the Horn of Africa and Western Africa, especially against attacks by pirates and terrorist groups. The possibilities for responding to threats in this manner are demonstrated by the operation „Steadfast Jaguar 06", held on the Cape-Verde Islands in June 2006[69].

Complexity in the role of the Alliance

The previous paragraphs show NATO has received a mandate to reconsider its potential role in the field of energy security at the international level. The Riga Declaration, especially the part dealing with energy security, faces a number of complex elements that slow down the establishment of a practical definition of the role of the Alliance. Officials and analysts from several NATO member states are of the opinion that energy security remains a national-level problem and should be treated as such. According to them, therefore, it is inconceivable to deploy NATO troops to oil platforms or to guard oil and gas pipelines. In this context, a NATO diplomat responding to speculations regarding the deployment of troops as "police of oil pipelines" in regions such as the Caucasus, emphasized that energy security and security of installations and transport routes are a national responsibility. The engagement of the Alliance would primarily consist of giving advice and assistance rather than of active engagement on the ground[70].

Turkish experts and analysts who say that the Turkish state has achieved much more than the Alliance in terms of protection of key energy infrastructure when fighting against the Kurds have similar views .

[68] *Energy security: A common concern* http://www.regjeringen.no/nb/dep/fd/dep/politisk_ledelse/Statssekretar_Espen_Barth_Eide/taler_artikler/2007/Energy-security-A-common-concern.html?id=486901

[69] More detailed information for operation Steadfast Jaguar 06 on: http://www.nato.int /SHAPE/issues/shape_nrf/steadfast_jaguar.htm

[70] „Climate change may spark conflict with Russia, EU told" http://www.guardian.co.uk/world /2008/mar/10/eu.climatechange?gusrc=rss&feed=networkfront

Azerbaijan, positioned on a significant energy route (the Baku-Tbilisi-Ceyhan oil pipeline), noted through its Deputy Prime Minister Abid Sharifov that the Alliance has no experience in protecting oil pipelines and communications passing through non-member countries[71]. Such positions arise from the fact that the oil pipeline is protected by the Azerbaijan government and from companies relying on protection by other measures such as deep entrenchment of oil pipelines and by raising awareness of the importance of security of oil pipelines among the local population.

On the other hand, moving North, more precisely to the North-Atlantic Region and analyzing the discussions of the experts and analysts there, presents different conclusions. The Norwegian Sea with its transport routes for oil and natural gas promotes discussions about the need for maritime security. It is noted that NATO members from both sides of the Atlantic must work together on energy security, as a central part of the security policy of the Alliance, but primarily on security of transport of energy. According to Bjorn Bjarnasonar, energy security represents a new dimension that redefines the northern areas of the Atlantic region on the political and military stage of NATO, or it reiterates the maritime identity of NATO[72].

According to others, a role in energy security would dilute or distort the agenda of NATO to the detriment of existing missions. Energy security is also connected to other issues on the complex NATO Agenda, such as the debate about whether Article 5 should be further expanded to include energy security. In his speech in the margins of the Riga Summit, Senator Lugar proposed the effective energy strategies to include the new relations with the countries from the Caucasus and Central Asia and particularly the relations with Kazakhstan and Azerbaijan, where the possible membership in NATO would have to be put on the table".[73]

The arguments for expanding Article 5 are related to the possible destruction of national economies should energy be used as a "weapon". As such, the Alliance would be obligated to appropriately respond to attempts to use energy as a "weapon" against its member states.

Although cooperation with other international organizations was an important intention noted at Riga, it is proving to be quite problematic. Defining NATO's role in the framework of energy security allows for broader discussion and aggregates different opinions that are often on the same "frequency". This can be illustrated, for example, by the difference between defining threats to energy security at the national and international level. Taking into account different geographical regions, resources and infrastructure capacities, along with their individual energy strategies, the countries in the EU and NATO take different

[71] „NATO not Responding Positively to Azerbaijan's Appeal for Provision of Security of Pipelines: Deputy Premier" http://news-en.trend.az/politics/enforcemen/1064148.html
[72] „Energy Security, the High North of Europe and NATO" http://www.vardberg.is/?p=36
[73] Monaghan, A. *Russia and the Security of Europe's Energy Supplies: Security in Diversity?* CSRC Paper 07/01. Swindon: Defence Academy of the UK: January 2007. http://www.isn.ethz.ch/isn/ Digital-Library/Publications/Detail/?ots591=0C54E3B3-1E9C-BE1E-2C24-A6A8C7060233&lng=en& id=44087

views of the energy situation. Therefore, within each organization there is a problem in reaching clarification of and consensus on the nature of the threat and whom it is aimed at.

The majority of EU and NATO member states still view the energy crises as an economic problem which should primarily be regulated through the market, not with foreign political and security measures. Generally speaking, the US defines energy security in terms of protecting energy supplies, while the EU defines it in terms of management of energy demand. Such different approaches represent additional complications, especially after the different reactions in the EU and NATO to some of the energy problems. All this undermines the prospects for establishing complementary energy relations between NATO and the EU.

An additional problem is the Russian view of the discussions about involving NATO in energy security. The Alliance is making efforts to avoid the debate on energy security being interpreted by Moscow as an anti-Russian signal. In this context, Russian Foreign Minister, Sergey Lavrov's comment at the end of 2007 is particularly interesting. He condemned the politicization of energy security to the detriment of producing nations and stressed that what is represented as purely economic is politicized by attempts to unify consumers against the Russian energy monopoly[74]. Just like NATO is beginning to speak about energy as a security issue, so does Moscow, which formed a new Military Doctrine in which energy security has a place[75].

Conclusion

In the process of redefining NATO as a security guarantor for its members, the need for serious consideration of the security of energy supplies is increasingly emphasized. Threats to energy security are widely established not only in international policy, but also at the national level. In addition the problems are also seriously elaborated in the academic community. However, views that do not accept NATO's role in solving threats to energy security still dominate.

Concerning the foundations of the Alliance, Article 5 can be interpreted as also including energy security. Article 4 of the Washington Agreement stipulates that Parties "will consult together whenever, in the opinion of any of them, the territorial integrity, political independence or security of any of the Parties is threatened".[76] Article 5 is also potentially relevant, taking into account the nature of most threats "the parties agree that an armed attack against one or more of them in Europe or North America shall be considered an attack against them all".[77] Considering that energy installations or no different than other

[74] Monaghan, A. *Energy Security: NATO's Limited, Complementary Role.* Research Division - NATO Defence College, Rome - No. 36 – May 2008.

[75] Russia's Military Doctrine http://www.armscontrol.org/act/2000_05/dc3ma00?print

[76] The North Atlantic Treaty Washington D.C. - 4 April 1949 Article IV of the Washington Treaty, http://www.nato.int/docu/basictxt/treaty.htm

[77] Article V Washington Treaty, http://www.nato.int/docu/basictxt/treaty.htm

goals, and that threats to energy infrastructure by terrorists, pirates, and even states will most likely come in the form of armed attack, we can assume that an armed attack on energy installations can be reason to invoke Article 5. The only exception would be the deliberate shutdown of production of required amounts of energy and their distribution to end users, which would affect national economies, leading to the taking of certain political positions on the producing nation.

To a certain extent, the negative overtones regarding the proposed agenda for the NATO's role in energy security are misunderstood. That is, speculations generally focus on the possible military response by the Alliance in case of threats to energy security, ignoring the other forms of response the Alliance might use. In addition, it is still too early to discuss amending the existing Article 5 of the Washington Agreement and the potential membership of Kazakhstan and Azerbaijan.

In defining its role within energy security, the Alliance faces two parallel debates. Depending on the threats used, either a shutdown caused by armed attacks or competition for access to certain resources, the Alliance has to make efforts to find the most appropriate solution. Its engagement could focus on cooperation with Partners, capacity building, defence reforms or training of Partner nations. In extreme situations military protection of infrastructure from armed attacks could also be included. The second debate focuses on understanding the shutdown of energy supplies in terms of political reasons, which often are very difficult to define and prove. In this case, a consensus of all Partners on possibly undertaking certain measures is highly unlikely. On the other hand, it might motivate member states to consider solutions inside the Alliance, like improving efficiency in the consumption of energy as a factor reducing the dependence on external conditions. Whatever the Alliance will do, in the context of its evolving path of survival and functioning on the international security stage, it has to work more actively on developing its role in energy security.

References

Radoman, J. Securitization of Energy as a Prelude to Energy Security Dilemma. Western Balkans Observer, Issue: 4/2007

Moran, D.,J.A Russsell, „The Militarisation of Energy Security“, Strategic Insights, Vol 7, No. 1, February 2008 http://www.ccc.nps.navy.mil/si/2008/Feb/moranFeb08.asp

For speech text see: Lugar, R. Energy and NATO. Keynote speech delivered to the German Marshall Fund Conference, Riga, 27 November 2006. http://lugar.senate.gov/energy/press/speech/riga.cfm

New gas crises March 8
http://www.pressonline.rs/page/stories/sr.html?id=59582&sectionId=40&view= story

Riga Summit Declaration http://www.nato.int/docu/pr/2006/p06-150e.htm

Varwick, J. NATO's Role in Energy Security. NATO at a Crossroads. IP Summer 2008

Speech by NATO Secretary General Jaap De Hoop Scheffer at the 44th Munich Security Conference http://www.securityconference.de/konferenzen/rede.php?id=204&menu2009=&menukonferenzen= &sprache=en&

Bucharest Summit Declaration, NATO Press Release (2008/049) 3 April 2008. www.nato.int

Energy security: A common concern http://www.regjeringen.no/nb/dep/fd/dep/politisk_ ledelse/Statssekretar_ Espen_Barth_Eide/taler_ artikler/2007/Energy-security-A-common-concern.html?id=486901

More detailed information for operation Steadfast Jaguar 06 on: http://www.nato.int /SHAPE/ issues/shape_nrf/steadfast_jaguar.htm

„Climate change may spark conflict with Russia, EU told", http://www.guardian.co.uk/world /2008/mar/10/eu.climatechange?gusrc=rss&feed=networkfront

„NATO not Responding Positively to Azerbaijan's Appeal for Provision of Security of Pipelines: Deputy Premier", http://news-en.trend.az/politics/enforcemen/1064148.html

„Energy Security, the High North of Europe and NATO" http://www.vardberg.is/?p=36

Monaghan, A. Russia and the Security of Europe's Energy Supplies: Security in Diversity? CSRC Paper 07/01. Swindon: Defence Academy of the UK: January 2007. http://www.isn.ethz.ch/isn/ Digital-Library/Publications/Detail/?ots591=0C54E3B3-1E9C-BE1E-2C24-A6A8C7060233&lng=en& id=44087

Monaghan, A. Energy Security: NATO's Limited, Complementary Role. Research Division - NATO Defence College, Rome - No. 36 – May 2008.

Russia's Military Doctrine http://www.armscontrol.org/act/2000_05/dc3ma00?print

The North Atlantic Treaty Washington D.C. - 4 April 1949 Article IV of the Washington Treaty, http://www.nato.int/docu/basictxt/treaty.htm

Article V Washington Treaty, http://www.nato.int/docu/basictxt/treaty.htm

***PhD Toni Mileski** is the pro-dean of Finances at the Faculty of Philosophy in Skopje, Macedonia. He works at the Institute for defence and peace studies since 1998. He is giving lectures in the following fields: Political geography and geopolitics, Cartography and Topography, Ecology, Energy Security and Management of natural resources. He also took part in several scientific and research projects connected to the security and defence topics.*

SUSTAINABLE BIOENERGY

Maja Lazareska

maja.lazareska@mzsv.gov.mk; majalazareska@gmail.com

Abstract

Securing energy and conservation of the environment are the most important issues for the sustainable development of human beings. Energy plays an important role in all dimensions of sustainable development including social, economic and environmental. Energy has always been important to humanity and until now, people have relied heavily on fossil fuels for their energy requirements and have released large amounts of greenhouse gases such as carbon dioxide to the atmosphere. As it is essential for ~~the~~ development and growth, the foundation of new bioenergy industries could provide clean energy services to millions of people who currently lack them and generate income in poorer areas of the world. This paper contributes to the understanding of sustainable development, sustainable bioenergy and energy security, as well as the co-relation between them.

Key words: bioenergy, renewable energy, sustainable development

Introduction

Sustainable energy is one of the most important requirements for a supply of energy services, which have deep and broad relationships with each of the three pillars of sustainable development – economy, environment and social welfare. As mentioned in UNDP (2002), "*energy produced and used in ways that support human development over the long term, in all its social, economic and environmental dimensions, is what is meant by the term sustainable energy*". Energy is essential to development and without it the world cannot improve the productivity of the rural poor, nor achieve the Millennium Development Goals[78] (MDGs).

Sustainable development has become an international common issue, which arose essentially from concerns related to the over-exploitation of natural and environmental resources (Anand & Sen, 2000). A definition was put forward by Brundtland (WCED, 1987), which is that humanity has "*to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs*". At the Rio Conference in 1992, the international community agreed on the overarching goal of sustainable development and it adopted a plan on how to get there - Agenda 21[79]. The importance of energy systems in supporting many dimensions of sustainable development was a theme that echoed throughout Agenda 21.

Globally, 80% of total primary energy supply depends on fossil fuels — coal, gas, and oil. In the poorest countries, traditional biomass and diesel are often the only alternatives, although some do have access to hydropower. Even in oil rich countries most people remain energy poor. Interest in the utilization of alternative and renewable energy sources is growing rapidly. A number of studies indicate that national renewable energy component of 2% in 2002, grew to 10% in 2010 and is projected to grow to 20% by 2020. This includes wind, biomass, geothermal, solar, and landfill gas.

Therefore, sustainable development provides a framework for integrating economic, social and environmental concerns over time, not through crude trade-offs but through the pursuit of mutually reinforcing benefits (Jonathan, 2003).

[78] Adopted by world leaders in the year 2000 and set to be achieved by 2015, the Millennium Development Goals (MDGs) provide concrete, numerical benchmarks for tackling extreme poverty in its many dimensions. The goals are: Eradicate extreme poverty and hunger; Achieve universal primary education; Promote gender equality and empower women; Reduce child mortality; Improve maternal health; Combat HIV/AIDS, malaria and other diseases; Ensure environmental sustainability; Develop a Global Partnership for Development.

[79] Agenda 21 is a comprehensive plan of action to be taken globally, nationally and locally by organizations of the United Nations System, Governments, and Major Groups in every area in which human impacts on the environment.

Renewable energy

Despite the considerable progress made recently in the field of renewable technologies, Renewable Energy Sources (RES) continue to play a modest role in the European energy system. It is generally acknowledged that one of the most important barriers to the large scale exploitation of RES is related to their cost which is still significantly higher compared to conventional fuels (Hohmeyer, 1992) and it is estimated that most renewable technologies will not be able to compete with conventional ones before the middle of this century.

Renewable energy systems - notably solar, wind, and biomass are poised to play a major role in the energy economy and in improving the environmental quality. A strong national energy policy is now needed. Renewable technologies have become both economically viable and environmentally preferable alternatives to fossil fuels. Renewable energy technologies have made important and dramatic technical, economic, and operational advances during the past decade. Up to now, the RES have been completely discriminated against for economic reasons. However, the trend in recent years favours them in many cases over conventional sources.

The advantages of RES are that they are sustainable (non-depletable), ubiquitous (found everywhere across the world in contrast to fossil fuels and minerals), and essentially clean and environmentally friendly. The use of renewable is not only due to their availability in many parts of the world, but also, more empathetically, as a result of the fossil fuel damage to environment and Earth’s atmosphere. In fact, the worldwide environmental problems resulting from the use of fossil fuels are the most compelling reasons for the present vigorous search for future alternative energy options that are renewable and environmentally friendly.

Development of renewable energy resources can also make significant contributions to a country’s energy security as well as facilitate energy access in rural areas through the use of solar energy or energy from agricultural waste. Bio-energy can have multiple local co-benefits but requires careful management to avoid negative impacts on biodiversity and food security (IPCC, 2007(c)).

Bioenergy

Bioenergy, defined as energy produced from organic matter or biomass, has recently become one of the most dynamic and rapidly changing sectors of the global energy economy. Rising costs of fossil fuels, energy security concerns, and increased awareness of climate change and potentially positive effects for economic development have led to considerable public attention to the usage of bioenergy. Bioenergy includes traditional bioenergy, biomass for the production of electricity, light and heat and first and next generation of liquid biofuels.

Growing commitments to bioenergy in recent years are based on studies showing that the diversification of energy supplies can contribute to both economics and environmental goals, including the United Nations Millennium Development Goals (MDGs) adopted in 2000. The rapid development of modern bioenergy worldwide clearly presents a broad range of opportunities. Experience with associated economic, environmental, and social impacts is limited, and the types of impacts will depend largely on local conditions and on policy frameworks implemented to support bioenergy development.

Agricultural policy including the availability of rural infrastructure, credit, and land tenure, will determine the scale and distribution of economic benefits. The development of new bioenergy industries can provide clean energy services to millions of people who currently lack them, while generating income and creating jobs in poorer areas in the world. But rapid growth in the first generation of liquid biofuels[80] production will raise agricultural commodity prices and could have negative economic and social effects (and environmental impact – land use, land degradation, e.g. maize), particularly on the poor who spend a large share of their income on food. Next generation biofuels such as cellulosic ethanol and biomass-to-liquids technologies allow conversion into biofuels of more abundant and cheaper feedstock than first generation. This could potentially reduce agricultural land requirements per unit of energy produced and improve lifecycle GHG emissions, potentially mitigating the environmental pressures from first generation biofuels. However, next generation biofuels technologies are not yet commercially proven and environmental and social effects are still uncertain (check this, may be out of date – 3rd generation is already being investigated). For example, the use of feedstock and farm residues can compete with the need to maintain organic matter in sustainable agro-ecosystems. Modern bioenergy can also help meet the needs of the 1.6 billion people worldwide who lack access to electricity in their homes, and 2.4 billion who rely on straw, dung and other traditional biomass fuels to meet their energy needs (United Nations-Energy, 2007).
As attention on energy alternatives to fossil fuels heightens, issues of health, environment, and development must be simultaneously planned and developed. Pros and cons of nuclear power, for example, are well recognized by environmental and health scientists. But fewer cost/benefit analyses have been conducted for biofuels over the years (Berndesa et al., 2003; Hill et al., 2006). While reducing our reliance on fossil fuel energy is immediately and obviously necessary, an unregulated biofuels boom could affect world food supplies and prices (United Nations-Energy, 2007).

Biofuels

Biofuels are combustible materials derived directly or indirectly from biomass (plants or organic wastes). Their use in industrial countries is being promoted as a way to increase energy independence and security and a sustainable way to reduce greenhouse gas emissions while contributing to farmers' income (BRDi 2008; FAO 2008b). Many countries and companies are investing heavily in biofuels for transport,

[80] "First-generation" fuels refer to biofuels made from sugar, starch, vegetable oil, or animal fats using conventional technology. "Second-generation" fuels are made from lignocelluloses biomass feedstock using advanced technical processes.

motivated by concerns and opportunities related to global climate change, energy security, and rural development. Although many countries anticipate large increases in production, the current global production of liquid biofuels is dominated by just a handful of countries. Brazil and in the United States combined have accounted for 75% or more of the global ethanol production for decades. China and India are the next largest producers, together accounting for 12% of global ethanol production in 2006. Almost 80% of the world's production of biodiesel occurs in the European Union, with almost 50% of global production in Germany alone. Global production of liquid biofuels has grown exponentially in recent years.

Despite this growth, liquid biofuels are still small contributors to the global energy supply. As of 2006, they supplied 1.8% of the global use of liquid transportation fuels. This is equivalent to 1% of the total liquid fuel use globally (including liquid fuels used other than for transportation), or 0.4% of the total global energy consumption from all sources.

Currently, almost all ethanol is produced from sugarcane (mostly in Brazil) and corn (mostly in the United States). Most biodiesel comes from crops such as rapeseed (canola oil), soybean, and oil palms. As all these crops are also used for food, this clearly sets the stage for competition between food and biofuels for crop production, a competition that is already imposing major strains on regional and global food supplies (OECD/FAO 2007). As of 2007, only 5% of the global production of cereals (wheat, corn, rice, sorghum) was used to produce biofuels, with most used for direct human consumption or for animal feeds (FAO 2008a). However, the rate of increase in cereal use for biofuels is far greater than that for food use. FAO (2008a) estimates that of the 55 million tons increase in demand for cereals globally in 2007, only 25 million tons was attributable to food and feed.

There is a large global interest in finding alternatives to transportation fuels to substitute petroleum-based fuels. IPCC (2007) highlighted the potential for biofuels to meet the growing energy needs as well as contribute to GHG emissions reduction, especially in the transportation sector. Escalating oil prices and the uncertainty about sustained oil supplies have further added to the growing interest on biofuels. Much of the discussion to date has focused on the benefits of ethanol and biodiesel production in the United States and Europe in terms of:

- Mitigating climate change, where biofuels substitute fossil fuels and their related GHG emissions;
- Promotion of rural development by production of a locally generated form of energy for processing and transportation;
- Creation of rural employment and wealth;
- Reduction of deforestation and land degradation, as biofuels also substitute for the energy currently derived from wood;
- Multiple use crops can be reallocated for energy or food needs depending on changing local needs and priorities.

There are however, some constraints with the production of biofuel. The environmental impacts of biofuel production includes local contamination (Martinelli and Filoso 2008) or reduction of water supplies, loss of biodiversity (Watson 2007); regional and transboundary air pollution problems (Martinelli and Filoso 2008) and global changes in net global warming potential through net emissions or sequestration of greenhouse gas emissions (Menichetti and Otto, Bustamante et al. 2009). The viability of biofuel production in developing countries has to include environmental impact assessments and considerations in the planning and implementation stages.

Increased biofuel production will have negative impacts on biodiversity due to habitat loss, enhanced dispersion of invasive species, and agrochemical pollution. The consequences are likely to be very heterogeneous depending on the biodiversity characteristics and impact history of the region and the type of biofuel production. In already heavily impacted areas, a modest expansion of biofuel production could have large, negative effects on biodiversity. The degree of intensification of biofuel production has a direct impact on biodiversity, with larger losses scaling positively with increasing intensification.

Increasing evidence suggests that biomass can be used much more efficiently (and therefore with less environmental impact) through direct combustion/pyrolysis to generate electricity and heat, rather than being converted to liquid fuels such as ethanol. The first steps towards sustainable energy and resource management should aim for significant reductions on the demand side, with greater conservation and improved efficiency.

The recent experiences of high fuel prices and the mismatch between global demand and supply shows optimism about the potential of biofuels. It is also important to emphasize that the success of biofuel export from developing countries to developed countries will depend on the future policies of the United States and European Union, which subsidize domestic, but inefficient, biofuel agro industries resulting in trade barriers. Brazil currently has difficulties competing against European and American biofuels because of these trade barriers. As a consequence, developing countries have to produce biofuel with a very low price, and often at the expense of the environment. Some countries, both developed and developing, have already set targets for substituting or supplementing diesel and gasoline by biofuels, with proportions ranging from 5 to 20% to be met at various times within the period 2010-2030.

Bioenergy contributing to Climate Change mitigation

Climate change has a profound implications for the environment in which social and economic activity take place, and can thus have similarly important effects on prosperity and human development. The Fourth Assessment Report of the IPCC (2007) concluded that with “90 percent certainty”, human activity (primarily burning fossil fuels and cutting tropical forests) is causing global warming. In the wake of this latest international assessment, political will is already shifting in recognition of the need to reduce greenhouse gases and reduce the adverse consequences of climate change.

Since global warming is caused by cumulative emissions and the developed countries have contributed a greater share of these than the developing world, historical accountability ensures that the payment is indeed undertaken by the polluter and not by the victims of pollution[81]. It is expected that global warming will hurt the developing countries relatively more than the developed ones (IPCC, 1996, p. 218). The origins and impacts of climate change (caused by the rich world, but affecting most seriously the poor) make the arguments for strong development assistance even more compelling. Climate change has profound implications on the environment in which social and economic activity takes place, and can thus have similarly important effects on prosperity and human development. They will be hit not only by increased variability (for example, suffering a greater incidence of both drought and flood) but also by a more adverse overall environment as temperatures keep rising (Stern, 2006).

Climate change is driven by greenhouse gas emissions from energy use, agriculture and deforestation. Effective action on mitigation is to require action including all sectors which contribute to the climate change. If they are to play their part in international action, many would argue that equity demands that we find a way of tackling climate change that does not undermine growth and poverty reduction.

The energy sector accounts for about two-thirds of emissions. Energy related emissions are forecast to grow and the existing stock of greenhouse gases is largely the result of past emissions from rich countries. According to Stern (2006) most of the future emissions growth is likely to be in developing countries. Reductions in emissions from this source depend largely on changes in the links from economic activity to energy intensity, and from energy intensity to carbon intensity. Transport sector activities generate worldwide about one quarter of the total emissions of CO2 from fuel consumption (about 30% in the OECD countries). Within transport, road transport is responsible for 75% of CO2 emissions.

The European Union is already committed to a 20% reduction of its CO2 emissions by 2020 but considers that additional effort from the industrialized countries would be needed to achieve a 25% reduction of their emissions by 2050, given their historic responsibilities and economic capabilities. Obviously, the transport sector will have to contribute its share of this effort.

Bioenergy also offers significant potential for greenhouse gas emission reductions. Sound investments in bioenergy could contribute to developing resilience to potential climate impacts. Reforestation, afforestation, better forestry management, and watershed maintenance are as critical to this effort as producing new bioenergy crops. Biofuels are often promoted as a way to reduce global warming. Most recent studies based on lifecycle analysis conclude that when ethanol from sugar cane is used to replace fossil fuels in transportation, it may result in substantial reduction in net greenhouse gas emissions (from 80% to greater than 100% savings are recorded, when low emissions of nitrous oxide are assumed). On the other hand, using ethanol from corn is less favorable: 30% to a maximum of 50% savings or even an increase of greenhouse gas emissions relative to fossil fuels, depending on process-energy sources occurs

[81] Payment would take place via the buying of emission permits from developing countries, for example.

in this case. Biofuel crops, increasingly an important source of energy, are being assessed for their critical role in adaptation to climatic change and mitigation of carbon emissions (Easterling et al., 2007).

Conclusion

The effects of biofuels production are recognized through all social, economic and political systems, since these systems are intimately connected and characterized by high levels of inertia particularly in the developing world. Beyond poverty alleviation and increased food production, bioenergy can help achieve the MDGs in such areas as health, education, and environmental sustainability.

Expanding the production of bioenergy is a priority for many nations seeking to offset climate change from fossil fuel use, enhance rural development, and improve national or local energy security. Bioenergy from agriculture and forestry based products and byproducts can provide significant opportunities for diversification, added value, and further development of the agricultural sector.

Biofuels from crops have been identified as a major possible alternative to fossil transportation fuels, though their use as a transportation fuel is not new. Some biofuel systems may contribute to climate protection by substitution of fossil fuels and an associated reduction of net CO_2 emissions. The use of modern biomass for energy production has the potential to significantly reduce anthropogenic greenhouse gas (GHG) emissions. (What about third generation, algae, biochar etc – just a sentence may be good, also hybrid systems, co-digestion)

References

Anand Sudhir & Sen Amartya. 2000. Human development and economic sustainability. World Development. 28: 2029-2049

Berndesa G, Hoogwijkb M, van den Broek R (2003) The contribution of biomass in the future global energy supply: a review of 17 studies. Biomass and Bioenergy 25:1–28

BRDi (Biomass Research & Development Board). 2008. National Biofuels Action Plan. BRDi, Washington D.C., USA. (http://www1.eere.energy.gov/biomass/ pdfs/nbap.pdf).

Charles Raux & Martin E. H. Lee-Gosselin, Transport, energy and greenhouse gases: perspectives on demand limitation. Guest editorial, Springer Science+Business Media B.V. 2010

D. Diakoulaki, S. Mirasgedis, M. Tziantzi, Environmental externalities and the development of renewable energy sources

Easterling WE, Aggarwal PK, Batima P, Brander KM, Erda L, Howden SM, Kirilenko A, Morton J, Soussana J-F, Schmidhuber J, Tubiello FN (2007) Food, fiber and forest products. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Cambridge University Press, Cambridge, UK, pp 273– 313

FAO (Food and Agriculture Organization of the United Nations). 2008a. Crop Prospects and Food Situation. Number 1, February 2008. (http://www.fao.org/ docrep/010/ah881e/ah881e04.htm)

FAO (Food and Agriculture Organization of the United Nations). 2008b. The State of Food and Agriculture. Biofuels: Prospects, risks and opportunities. Food and Agricultural Organization, United Nations, Rome.

J, Nelson E, Tilman D, Polasky S, Tiffany D (2006) Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels. Proceedings of the National Academy of Sciences of the United States of America 103:11206–11210

Hohmeyer, O., (1988), Social Costs of Energy Consumption, Springer Verlag, Berlin.

IPCC, 1996. Climate Change 1995: The Science of Climate Change — Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. Janssen, M.A., den Elzen, M.G.J., Rotmans

IPCC 2007. Climate change 2007: synthesis report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, Pachauri RK, Reisinger A. Eds. Geneva: Intergovernmental Panel on Climate Change.

Jonathan Porritt. 2003. Sustainable Development. *New Economy*. 10: 28-33

Martinelli, L. A. and S. Filoso. 2008. Expansion of sugarcane ethanol production in Brazil: environmental and social challenges. Ecol Appl 18: 885-898.

Menichetti, E. and M. Otto. 2009. Energy balance and greenhouse gas emissions of biofuels from a lifecycle perspective. In R.W. Howarth and S. Bringezu (eds) Biofuels: Environmental Consequences and Interactions with Changing Land Use. Proceedings of the Scientific Committee on Problems of the Environment (SCOPE) International Biofuels Project Rapid Assessment, 22-25 September 2008, Gummersbach Germany. Cornell University, Ithaca NY, USA. (http://cip.cornell.edu/biofuels/).

M. Grubb et al. (1992). "Sharing the Burden" page 310 Confronting Climate Change - Risks, Implications and Responses, Cambridge University Press.

OECD/FAO (Organization for Economic Co-opertaion & Development/ Food and Agriculture Organization of the United Nations). 2008. Agricultural outlook 2008-2017. OECD Publishing, Paris.

Stern Nicholas, What is the Economics of Climate Change? WORLD ECONOMICS • Vol. 7 • No. 2 • April–June 2006

UNDP. 2002. Energy and the Challenge of Sustainability. *World Energy Assessment*. New York.

United Nations, 1997. Kyoto Protocol to the United Nations Framework Convention on Climate Change. New York, online available at www.unfccc.de.

United Nations-Energy (2007) Sustainable Bioenergy: A Framework for Decision Makers

Watson, H.K. 2007. Potential to expand sugarcane cultivation in southern Africa – an assessment of suitable and available land. In Proceedings of COMPETE Workshop on Improved Energy Crop and Agroforestry Systems for Sustainable Development in Africa on 22nd June 2007 in Le Reduit, Mauritius.(www.compete-bioafrica.net).

WCED -World Commission on Environment and Development (1987) Our Common Future in eds. Nelissen N, Vander Straaten J & Klinkers L (1998) Classic in Environmental Studies. International Books, The Hague

***Maja Lazareska** holds a Bachelor degree in Biology and is currently completing a Master's degree in Environmental Management at South East European University in the Republic of Macedonia. Her research is focused on sustainable rural development and environmental management. Her previous work experience includes rural development and European Union Instrument for Pre Accession Assistance for Rural Development (IPARD). She is currently Head of the Unit for programming, implementation, monitoring and evaluation of the IPA in the Ministry of Agriculture, Forestry and Water Economy of the Republic of Macedonia.*

TOWARDS HIGHER ENERGY EFFICIENCY: GREECE CASE

Ksenia Petrichenko

kse-petrichenko@yandex.ru

Abstract

Once the developmental path has been chosen by a country it is very difficult to change it, even for more efficient one, because of accompanying costs and established behavioral patterns (Altman 2000). The chosen path or solution might be "locked-in or become a permanent or a stable equilibrium" (Altman 2000). These ideas of path dependency can be implemented to energy efficiency development of a country. The improvement of energy efficiency usually associated with reduction of energy use by means of implementation of more advanced technologies. In this regards once a certain technological mix has been accepted in an economy, it is hard for a market to switch to another technology, as it is, usually, involves additional costs (David 1985 and Arthur 1989). It illustrates the key obstacle for energy efficiency improvement.

To overcome this disadvantage the market has to transform towards higher energy efficiency. This process is hindered by certain barriers to energy efficiency. To reduce the barriers policy instruments, aimed at increasing energy efficiency, have to be implemented.

In this paper the status of bypassing path dependency by means of EE policy development in Greece is considered by analyzing energy intensity of tertiary sector, household energy efficiency index and effectiveness of ongoing and planned policy instruments. On this basis the conclusion on whether the market transformation is taking place in Greece's building sector is made.

Key words: energy efficiency, Greece, tertiary sector

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to Prof. Diana Ürge-Vorsatz (Central European University) for supporting me in writing this paper.
I am very grateful to Dr. Andrei Belyi (Higher School of Economics) for sharing his ideas on theoretical framework for the paper.
I would like to thank Dr Sevastianos Mirasgedis (National Observatory of Athens) for information, support and information.

INTRODUCTION

Energy efficiency (EE) is the level of service provided by a unit of energy, but it can also be the level of service provided by a unit of expenditure (Boardman 2004). The improvement of energy efficiency in buildings means the reduction of energy consumption per square meter of floor area and other co-benefits: reduction of greenhouse gases (GHG) emissions, local air quality enhancement, public health improvement, thermal comfort improvement, occupant productivity increase, additional jobs and business opportunities creation, energy costs reduction, reduction of dependency on energy import, etc (Metz *et al.* 2007, Leaman and Bordass 1999, Jochem and Madlener 2003).

Thus, the improvement of energy efficiency has a lot of benefits, which are also acute for the Member States of the European Union nowadays. In this paper the concept of energy efficiency is analyzed by means of path-dependency theory and the concept of market transformation. This approach is applied to the building sector in Greece.

The problem of energy efficiency improvement of the building sector is very acute for Greece. Since the mid-1980s energy consumption in the country has been growing both in residential and tertiary sectors and almost tripled by 2008 (see Figure 1)

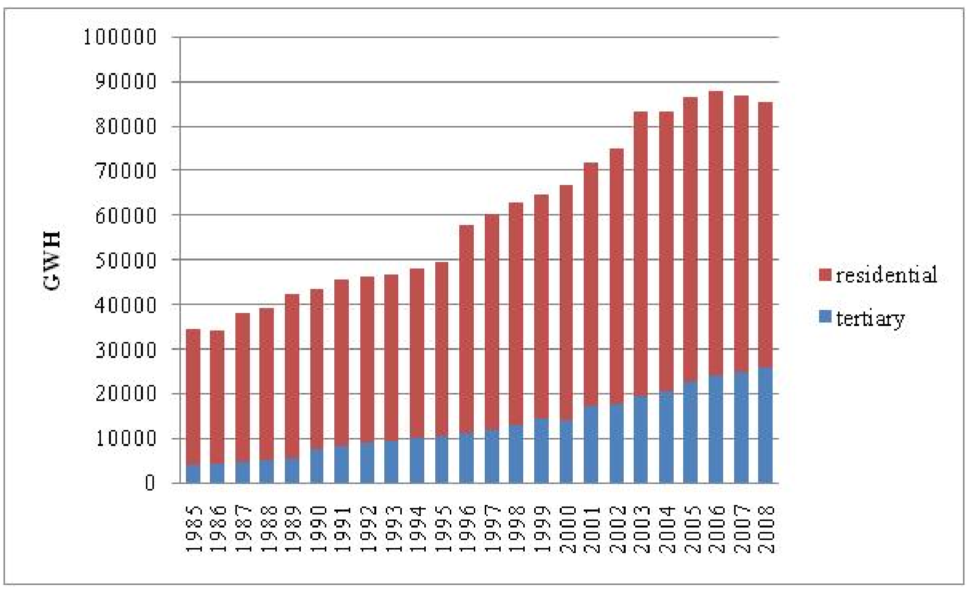


Figure 1. Final energy consumption of the building sector in Greece
Data source: Odyssee (2007)

According to Hellenic Statistical Authority's projections, population of the country is expected to grow by 2050 (EL.STAT 2007), thus, the final energy consumption in the building sector is likely to increase in the future without introducing the measures enhancing energy efficiency. However, there are certain barriers, which aggravate the improvement of energy efficiency in the building sector (see Table 1).

Table 1. Major barriers to energy efficiency in the building sector and possible policy instruments to reduce them

Barrier Categories	Definitions and Examples	Possible policies
Financial barriers	Lack of appropriate financing for the long-term benefits, higher up-front costs for EE improvements, lack of internalization of environmental, health, and other external costs, energy price subsidies	Financial instruments: tax rebates, subsidized loans, subsidies to EE improvements, regulations, removal of energy price subsidies, market-based mechanisms
Cost competitiveness	Lack of the ability of EE technological decisions to compete with traditional ones	Appliances standards, building codes, subsidies, tax rebates to EE decisions
Technological barriers	Technological obstacles related to reseach, development and demostration EE measures	Subsidies, loans for research and development, information instruments, market-based mechanisms
Behavioral barriers	Tendency to ignore small energy saving opportunities, organizational failures, non-payment and electricity theft, tradition, behaviour and lifestyle, corruption	Support, information and voluntary action, voluntary agreements, information and training programs, market-based mechanisms
Administrative barriers	Lack of support at the regional and local levels to stimulate the energy efficiency improvement	Creation of local agencies to promote energy efficiency projects, financial incentives, command and control insruments
Political and structural barriers	Lack of political motivation to support the market initiatives needed for the improvement of EE, slow process of drafting local legislation, gaps between regions at different economic level, insufficient enforcement of standards, lack of detailed guidelines, tools and experts, lack of incentives for EE investments, lack of equipment testing/ certification, inadequate energy service levels	Enhanced implementation of command and control mechanisms, policy incentives to encourage EE building design, ehhanced international cooperation and technology transfer, public leadersip programs
Information barriers	Lacking awareness of consumers, building managers, construction companies, politicians of the opportunities and benefits of EE improvement	Awareness raising compaigns, training of building professionals, command and control instruments

Data sources: Ürge-Vorsatz and Koeppel (2007), Belyi (2009)

In this paper existence of the barriers to energy efficiency is explained by the effect of path-dependency, which makes switching to more efficient developmental path difficult and costly.

THEORETICAL FRAMEWORK

Path-dependency and energy efficiency market transformation

The main idea of the path-dependency theory in terms of technological development is that once the technological path was chosen it is very difficult to change it, even for more efficient one, because of accompanying costs and behavioral patterns (Altman 2000). The chosen path or solution might be "locked in or become a permanent or a stable equilibrium" (Altman 2000). That means that once a certain technological mix has been accepted and became to be used widely in the economy, it is very hard for producers and consumers to switch to another technology, as it is, usually, involves additional costs (David 1985, Arthur 1989).

In equilibrium prevailing technologies in the economy are likely to be suboptimal, which in relation to technology usually means inefficient (David 1985, Arthur 1989). The reason for it is that the technological system chosen first has an advantage of increasing returns which increases over time. It is assumed that productivity and related costs are time-dependent so that newcomers to a market would face a competitive disadvantage compared to the technologies which are already at the market, and this will prevent them from beginning the process of catch-up (Altman 2000). And this situation can take place even if the effectiveness of a new technology is or is becoming higher over time than the existing one. Even if the economic agents know about the higher efficiency of a new technology, it is difficult for them to choose it, because the cost of changing the technology for a new one are higher than the costs of utilization of the inefficient one (usually in the short-run). Thus, once locked-in, the inefficient technological solutions cannot be displaced by market forces alone. The higher efficiency of new technological solution does not generate the economic forces itself to displace the inefficient technological regime. Thus, it becomes too costly for economic agents to adopt a more efficient regime.

Therefore, to reduce existing barriers and provide supply and demand for energy efficient products and technologies, certain actions (co-called interventions) from the outside of the market should be made. A market intervention is "a strategic effort by a utility and other organizations to intervene in the market, causing beneficial, lasting changes in the structure or function of the market, leading to increases in the adoption of energy efficient products, services and/or practices" (Schlegal *et al.* 1997). Such interventions are usually caused by the implementation of different policy instruments, aimed at increasing energy efficiency.

The process of reducing these barriers resulting from a market intervention and evidenced by market effects, which are likely to last after the intervention is withdrawn, creates market transformation. In this regard, a market effect is a change in the structure of a market or the behavior of participants in a market which produces an increase in the adoption of energy-efficient products, services, or practices. (Rosenberg *et al.* 2009). In other words, a market transformation means that the volumes of purchases of a specific product are transformed into purchases of a higher quality (in our case – efficiency) product (Schlegal *et al.* 1997). Therefore, market transformation goes towards reduced energy consumption and higher energy efficiency of economy.

Thus, it can be concluded that the market would autonomously deliver energy efficiency improvements only if producers could benefit from it or if customers are particularly strong. In all other circumstances, energy-efficient technologies are brought to market as a result of policy (Boardman 2004). Therefore, market transformation is mainly caused by policy change. However, the policy change, which is accompanied by the development of certain institutions, can also be explained by the path-dependency theory. In this regard, the set of conditions within a country constitutes a certain path of a country's development, which to a certain extent determines the development and effectiveness of policy measures.

Path-dependency and energy efficiency policy development

Policy change can occur as a result of past experience or availability of new information (Green and Collins 2008). For example, "new information" which stimulated the introduction of energy efficiency policies in European Union was oil prices shock of 1970. At this time energy policy began to focus on overcoming energy shortages and the need for new fuel sources (Blumstein *et al.* 2000). Energy-efficiency has been improved considerably since the 1970s. Next to government policies energy-efficiency improvement resulted from a response to energy price increases and supply uncertainties, as well as independent technology improvements (Klessmann et al. 2007).

Energy-efficiency policies have got a new stimulus when the European Union declared that it wants to accelerate energy-efficiency improvements to 2% per year as part of its strategy to combat climate change and secure energy supply (Klessmann et al. 2007).

During the past decade the concept of market transformation has gained a more concrete meaning as a policy objective to encourage or induce social, technological and economic change in the direction of greater energy efficiency (Blumstein *et al.* 2000).

For 40 years energy efficiency policy instruments in the European Union policy have being changed and developed considerably. Most of these developments and changes have taken place due to the analysis and evaluation of the work of existing instrument for certain period of time, in other words, by policy learning. As Greener (2002) states, policy learning "considers policy legacies to be one of the most significant elements in determining present and future policy". In this relation, such a strategy of policy development can also be explained by the path dependency theory in respect of change: "the trajectory of change up to a certain point constrains the trajectory after that point" (Kay 2005). In other words, the initial policy decisions can determine future policy choices (Green and Collins 2008). Therefore, in relation to current policy choices, past decisions have to be considered as institutions as path dependency presumes that "policy decisions accumulate over time; a process of accretion can occur in a policy area that restricts options for future policy-makers" (Kay 2005). This statement fits the historical institutionalism framework, according to which "not just the strategies but also the goals actors pursue are shaped by institutional context" (Thelen and Steinmo 1992). That also means that "once a set of institutions is in place, actors adapt their strategies in ways that reflect but also reinforce the logic of the system (Thelen 1999).

It makes the analysis of present and planned policy instruments particularly important for understanding the developmental path followed by a country. Policy analysis can provide the ground to conclude whether a country is moving towards energy efficiency improvement, i.e. experiencing the process of market transformation, or it is still following unsustainable path caused by path-dependency.

In this paper such analysis is conducted for the case of Greece.

METHODOLOGY

As it follows from the consideration in the previous sections, the energy efficiency market transformation is driven by energy efficiency policy instruments in a country. Thus, the data on different policy instruments existing and planned in Greece and their estimated efficiency for the reduction of energy use in buildings have been collected.

Due to the lack of factual quantitative data on energy savings provided by the implementation of certain energy efficiency policies the semi- qualitative evaluations were used where they were available (for example, from MURE database).

In MURE[82] database the effectiveness of a policy measure is evaluated in respect of energy savings achieved by this measure (MURE II 2007). There are two types of evaluations: quantitative and semi-qualitative. Quantitative (ex-post or ex-ante) evaluation presumes that the exact amount of energy savings (in %) from the functioning of a measure is known and calculated on the basis of a reliable method. Semi-qualitative evaluations are based on the judgments of experts from a respective country. For all measures, both quantitative and semi-qualitative, there are three level of a measure's effectiveness: low, medium and high. These categories are linked to the aggregated electricity or energy consumption of the building sector. The limits for three effectiveness levels are the following:

- Low effectiveness: < 0.1%
- Medium effectiveness: 0.1-0.5%
- High effectiveness: > 0.5% (Eichhammer and Schlomann 2005).
-

Using MURE's logic the effectiveness of some proposed policy measures was evaluated where the estimations of future energy savings were available in absolute values[83]. The share of these savings in total energy consumption of the Greece's building sector was calculated, using the data from Odyssee database (Odyssee 2007), which were linearly projected till 2016.

[82] "MURE (*Mesures d'Utilisation Rationnelle de l'Energie*) provides information on energy efficiency policies and measures that have been carried out in the Member States of the European Union and enables the simulation and comparison at a national level of the potential impact of such measures. The MURE database is therefore an important tool to show "demonstrable progress" as requested by the Kyoto Protocol" (http://www.isisrome.com/mure/).

[83] Most of such data were taken from Energy Efficiency Action Plan (Ministry of Development 2008).

The policy instruments were grouped into four groups, according to their character and type of enforcement: command-and-control, budgetary, market-based and information mechanisms (Metz 2009). Table 2 presents these four groups of instruments, their advantages and disadvantages.

Table 1 and Table 2 give the information on how different policy instruments can reduce the barriers to energy efficiency market transformation in the building sector. However, they drive the market transformation in different ways and it is hard to evaluate their effect. In this paper two criteria for evaluation of the market transformation are used: energy intensity of tertiary sector and energy efficiency index of household sector. The change in these parameters from 1990 till 2008 is collated with effectiveness of energy efficiency policy measures in terms of estimated energy savings.

Table 2. Advantages and disadvantages of energy efficiency policy instruments

Group of institutions	Examples	Advantages	Disadvantages
Command and control	Regulation, technology-based standards, performance-based standards	"hard" instruments, have direct effect, rely on the power of a centralized authority, are usually effective because they rely on "fear" as motivation catalyst	require significant budget, can cause public resistance, worsen the level of life of low-income consumers
Financial	Energy charges, product charges or levies, user charges, administrative charges, tax rebates, subsidies, grants	provide the additional capital for energy efficiency improvement, reduce costs related to enegy efficiency, support low-income consumers	distort the market, reduce puchasing capacity of low-income people, the implementation can be limited by the lack of political will
Market-based	White Cetrtificate schemes	Create economic incentives for energy efficiency, stimulate R&D activities, incorporate energy efficiency concept into buisness strategies	require strong regulatory body, binding target, standardized procedures for energy savings calculations, a proper market with numerous actors, a concrete penalty in case of non-compliance, guarantee of tradability of WhC, transparent and fair cost-recovery mechanisms and effective enforcement
Information	Information campaigns, labelling, energy audits	can increase the effectiveness of other institutions	have limited effectiveness, do not provide direct incentives to increasing energy efficiency

Data sources: ESCAP (2003), Metz (2009), (Karp and Gaulding 1995), Energy Charter Secretariat (2010)

These criteria have been chosen, because they reflect the trend in market transformation for different subsectors of the building sector: tertiary and household. However, the input data and calculation procedure are different for these indices, consequently, they cannot be compared directly. Thus, only trends in their dynamics over the period 1990-2008 are used for the current analysis. In terms of the path-dependency theory, they reflect a "path" followed by a country in relation to energy efficiency improvement. In more detail each of these criteria is discussed below.

Energy intensity of tertiary sector

Energy intensity is one of the main quantitative indicators of the correlation between the economic development and energy sources utilization. As economic development is usually accompanied by the increase in energy consumption and energy intensity shows the relation between these two variables, thus, the high rate of energy intensity indicates an ineffective use of energy by the economy. On the contrary, the decrease in the energy intensity, generally, means the energy efficiency improvement, which is achieved by the implementation of the policy programs, reducing the overall energy and electricity consumption (Belyi 2009).

In this paper energy intensity is analyzed only for the tertiary sector to consider energy efficiency improvement of commercial and public buildings.

The energy intensity of the tertiary sector is defined as the ratio between the final energy consumption of the sector (measured in energy units: toe, Joule, etc) and the value added measured in constant monetary units (Enerdata 2008).

To follow the trend of energy efficiency by means of energy intensity it is necessary to analyze the data for several periods (years). It is assumed that if there is a significant decrease in energy intensity at the end of the period in relation to the beginning of the period, then there is a tendency to energy efficiency improvement in a country. The change in energy intensity is calculated, according to the Formula 1:

$$\Delta EI = \frac{EI_{end} - EI_{begin}}{EI_{begin}} \times 100\% , \qquad (1)$$

where *EI* – energy intensity, *end* – the end of the analyzed period, *begin* – the beginning of the period.

If the decrease has taken place by the end of the period the result should be negative. For simplification purposes, it is assumed here that the decrease in energy intensity is significant if the result of calculations, according to the Formula 1, is more than or equal to 20%.

Thus, a significant decrease in energy intensity of a country during a continued period of time (at least 10 years) can be a signal that energy efficiency improvement has been taking place in a country during this period.

Energy efficiency index of household sector – ODEX

This criterion shows whether there is a trend of market transformation towards energy efficiency in a country over time, as it assesses energy efficiency trends at the aggregated level. The data and methodology of ODEX are provided by Odyssee project (Enerdata 2008). In this paper the ODEX for households was chosen for the analysis to consider energy efficiency improvement of residential buildings.

In the household sector ODEX aggregates the trends in different end-uses on the basis of their weight in total consumption. The evaluation includes three end-uses (space-heating, water heating and cooking) and five large appliances (refrigerators, freezers, washing machines, dishwashes and TVs). There are certain indicators for each end-use and for big appliances. For space heating energy efficiency trends are calculated from the change in unit consumption per m^2 at normal climate (toe/m^2); for water heating and cooling – from the change in unit consumption per dwelling and for large appliances – from the change in specific electricity consumption (kwh/year/appliance) (Odyssee n.d.).

ODEX is calculated in relation to the year 2000, which is assumed to be the baseline year. Thus, ODEX for 2000 equals 100. If there is a decrease in ODEX in comparison to the previous year, it is a signal of the increase in the aggregated energy efficiency of household sector.

The drawbacks of ODEX are related to its often fluctuations especially in the housing sector, which hinder the understanding of energy efficiency progress. Such fluctuations can be caused by imperfect climatic corrections, behavioral factors, influence of business cycles, imperfection of the statistics, etc (Odyssee n.d.).

In this paper ODEX is analyzed for a certain period of time. The criterion works in a similar way as energy intensity of tertiary sector: if there is a significant decrease in ODEX for the household sector by the end of the period in relation to the beginning it means the significant improvement of energy efficiency in the sector, which, in turn, means market transition to higher energy efficiency. It is assumed that the decrease in ODEX will be considered as significant if it is more than or equal to 20%. The change in ODEX is calculated, according to Formula 2:

$$\Delta ODEX = \frac{ODEX_{end} - ODEX_{begining}}{ODEX_{begining}} \times 100\% \qquad (2)$$

In this paper the change in energy intensity and ODEX is calculated over the period 1990-2008 and then collated to the effectiveness of policy measures. If a significant decrease both in energy intensity of tertiary sector and ODEX of household sector is accompanied by high effectiveness of energy efficiency of policies during the same period of time it means that the process of market transformation towards higher energy efficiency is likely to take place in the analyzed country. This logic is summarized in Table 3.

Table 3. The signals of energy efficiency market transformation

Change in energy intensity	Significant decrease	Not significant change	Significant increase
Change in ODEX	Significant decrease	Not significant change	Significant increase
Effectiveness of policy instruments	High	Medium	Low

RESULTS

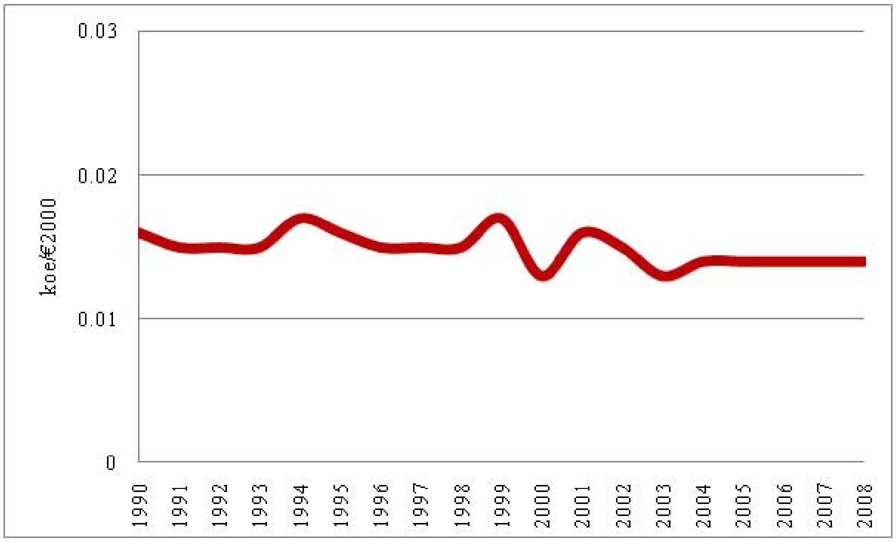
Figure 2 shows the dynamics of energy intensity of tertiary sector in Greece from 1990 till 2008. The chart demonstrates that the magnitude of changes in energy intensity is not considerable. From 2004 to 2008 this parameter remained unchanged. There is an insignificant decrease in energy intensity over this period, which is 12.5% (according to Formula 1). This can be a signal that the energy efficiency of Greece's commercial and public has not improved considerable between 1990 and 2008.

To analyze energy efficiency dynamics in the household sector energy efficiency index for this sector was taken into consideration, which is presented at Figure 3. It shows that there was a rather sharp decline between 1990 and 1992 in ODEX, however, between 1992 and 2008 it almost has not been changing. The calculations according to Formula 2 shows 18.6% decrease in ODEX by 2008 in relation to 1990, which, according to our assumptions, is not significant.

Thus, the improvement of energy efficiency in the residential sector does not seem to be significant.

The analysis of both indicators has not shown a considerable improvement of energy efficiency in the Greece's building sector. This can be explained by the effects of path-dependency and the lack of market transformation process. As it was noted above, the latter is driven by implementation and development of effective energy efficiency policy instruments. Thus, the overview of the energy efficiency policies in Greece and their effectiveness is necessary. The summary of existing and planned policies in Greece is presented in Table 4.

Table 4 shows that between 1990 and 2008 not many policy instruments specifically devoted to the improvement of Hellenic building sector's energy efficiency were in force and their effectiveness in the short run was not high. Thus, these measures did not drive market transformation of Hellenic building sector towards higher energy efficiency considerably, which is also reflected by changeless trends of energy intensity of tertiary sector and energy efficiency index of household sector. Table 4 also shows that a number of measures were proposed in 2008-2010. The efficiency of most of them is estimated to be rather high, however, they either have not been introduced or developed by the time of this research.



Data source: Odyssee (2007)

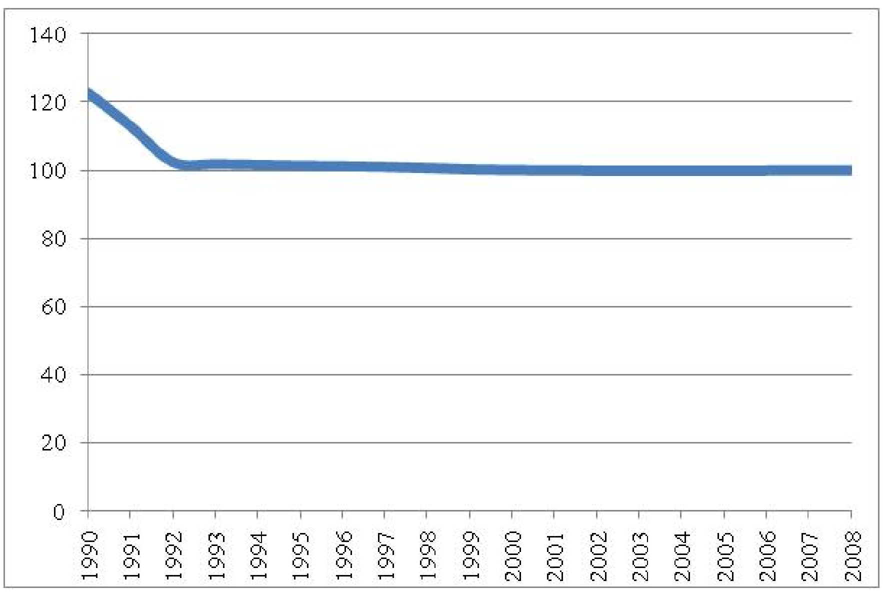


Figure 2. Energy efficiency index for households in Greece
Data source: Odyssee (2007)

If these policy instruments come into force, they will reduce the effect of path-dependency and the barriers to energy efficiency existing in the country, drive the market transformation, increase energy efficiency and, consequently, reduce energy use in the building sector of Greece, which will lead to many co-benefits for the society, some of which have been described at the beginning. However, further development of effective policies might be needed to switch the country to a more energy effective developmental path and bypass the path-dependency.

Table 4. Energy efficiency policy measures in Greece

№	Policy Measure	Type	Starting year	Status	Effectiveness
1	Tax deduction scheme, set by L.2364/95 and L.3522/2006, that considers all small domestic RES systems to be eligible for a 20% tax deduction capped at € 700 per system.	Budgetary	1995	Ongoing	n/a
2	Programmes to provide financial support for investment in energy-saving technologies and research	Budgetary	2000	Proposed	Medium (2010) /High (2016)
3	Installation of electronic and intelligent metering of electricity and natural gas consumers	CAC, information	2006	Proposed	Low (2010) /High (2016)
4	Formation of a unit to collect energy data and forecasts	Information	2008	Proposed	n/a
5	Targeted education campaigns, provision of information and rewarding of "good practices"	Information	2008	Proposed	n/a
6	Further promotion of the integration of natural gas and LPG	Budgetary, Information	2008	Proposed	Medium
7	Energy labelling of appliances and minimum energy efficiency requirements	Information	2008	Proposed	High
8	Implementation of an energy management system (EMS) in the tertiary and public sectors	CAC	2008	Proposed	Medium (2010) /High (2016)
9	Energy upgrading of existing buildings through third-party financing arrangements (TPF), energy performance contracting and public and private joint ventures (PPJV)	CAC, budgetary	2008	Proposed	n/a
10	Promotion of cogeneration of heat and power (CHP) and district heating systems	CAC, budgetary	2008	Proposed	Medium (2010) /High (2016)
11	Integrated energy planning by municipalities	Information	2008	Proposed	n/a

12	Compulsory replacement of all light fittings with low energy efficiency in the public sector and the wider public sector	CAC	2008	Proposed	Medium
13	Allocation of heating costs in collective buildings	CAC	2008	Ongoing	Low
14	Energy improvement of building cell	CAC, budgetary	2008	Proposed	Low
15	Energy Auditing Procedures, Requirements and Guidelines	CAC	2008	Ongoing	Low
16	Obligatory replacement of all lighting systems of low energy output in public sector	CAC	2008	Proposed	High
17	L.3661/2008 'Measures for the building energy consumption reduction'	CAC	2008	Ongoing	n/a
18	JMD (OG 1122/B/2008) "Measures to improve energy efficiency and energy saving in the public and broader public sector"	CAC	2008	Proposed	n/a
19	Financial aid for the upgrading of heating system boilers / burner units in existing buildings	Budgetary	2009	Proposed	Medium (2010) /High (2016)
20	Compulsory installation of central solar thermal systems in new residential buildings and financial incentives for further penetration of small-scale solar thermal systems in residential buildings	CAC, budgetary	2009	Proposed	Medium

Data sources: Ministry of Development (2008), MURE (2007), CRES (2009)

CONCLUSION

Energy efficiency improvement in the building sector can result in considerable energy use reduction as well as other co-benefits. However, its improvement is aggravated by a number of barriers, which can be explained by the effects of path-dependency. Energy efficiency improvement usually requires technological and institutional change, which lead to financial, transaction, time and other costs. Path-dependency, in this regard, means that it is very difficult to change developmental path even to more efficient and beneficial one.

One of the ways to make this switching is to accelerate market transformation with increase of penetration of the products and services with higher energy efficiency. Such transformation is devoted to exclude energy intensive products and services from the market, which will make energy efficient ones more affordable and widely spread. However, to conduct such a transformation in reasonable timeframe additional incentives are required, which can be provided by the implementation of certain energy efficiency policy instruments. Such instruments should be introduced by the government on the national level, taking into account the conditions inside the country.

The case of Greece considered in the paper has shown that the process of market transformation has been started in this country only recently and a lot of efforts should be made in the future to bypass path-dependency. However, a number of energy efficiency measures with high expected effectiveness have already been proposed, which obviously indicates the Greece's development in this direction.

REFERENCES

Altman, M. 2000. A behavioral model of path dependency: the economics of profitable inefficiency and market failure. Journal of Socio-Economics 29: 127–145

Arthur, B. W. 1989. Competing technologies, increasing returns, and lock-in by historical events. *Economic Journal,* 99: 116 –131.

Belyi, A.V. 2009. Environmental economics: aspects of energy regulation (not published). State University – Higher School of Economics.

Blumstein, C., Goldstone, S., Lutzenhiser, L. 2000. A theory-based approach to market transformation. *Energy Policy*, 28: 137-144

Boardman, B. 2004. New directions for household energy efficiency: evidence from the UK. *Energy Policy*, 32: 1921–1933

Ceylan, D. and Gunay, E.N.O .2010. Energy efficiency trends and policies: Cross-country comparison in Europe. The project (09HN201D) supported by Bogazici University Research Fund. International Conference of Economic Modelling (ECOMOD), Istanbul, July 7-10, 2010

CRES. 2009. Energy Efficiency Policies and Measures in Greece. Monitoring of Energy Efficiency in EU 27. Norway and Croatia (ODYSSEE-MURE). Hellenic Republic, Athens.

David, P. A. 1985. Clio and the economics of qwerty. *Annual Economic Review*, 75: 332–337.

Eichhammer, W and Schlomann, B. 2005. Guidelines fort he description of measures in the MURE measure database. Fraunhofer ISI.

Enerdata. 2008. Definition of Energy Efficiency Indicators in ODYSSEE data base

Energy Charter Secretariat. 2010. Market Trading Mechanisms for Delivering Energy Efficiency. Brussels, Belgium.

Environmental Considerations into Economic Policy Making Processes (ESCAP). 2003. Integrating Environmental Consideration into Economic Policy Making Processes. Virtual Conference. URL: http://www.unescap.org/drpad/vc/index.htm. [consulted 20 July 2010]

Hellenic Statistical Authority (EL.STAT). 2007. Population Projections of Greece 2007-2050. Summary Note. URL: http://www.statistics.gr/portal/page/portal/ESYE. [*consulted 17 September 2010]*

Green, M and Collins, S. 2008. Policy, Politics and Path Dependency: Sport Development in Australia and Finland. *Sport Management Review*, 11: 225-251

Greener, I. 2002. Understanding NHS reform: The policy-transfer, social learning, and path dependency perspectives. *Governance, 15*(2): 161-183.

Jochem, E. and Madlener, R. 2003. The forgotten benefits of climate change mitigation: Innovation, technological leapfrogging, employment, and sustainable development. In Workshop on the Benefits of Climate Policy: Improving Information for Policy Makers.

Karp, D.R. and Gaulding, C.L. 1995. Motivational underpinnings of command-and-control, market-based and voluntarist environmental policies. *Human Relations*, 48 (5): 439-465.

Kay, A. 2005. A critique of the use of path dependency in policy studies. *Public Administration*, 83: 553-571.

Klessmann, C., Graus, W., Harmelink, M., Geurts, F. 2007. Making energy efficiency happen: From potential to reality. An assessment of policies and measures in G8 plus 5 countries, with recommendations for decision makers at national and international level. Ecofys International BV, the Netherlands.

Leaman, A. and Bordass, B. 1999. Productivity in buildings: the 'killer' variables. *Building Research & Information*, 27(1): 4-19.

Metz, B. 2009. Controlling Climate Change. European Climate Foundation. Cambridge University Press.

Metz, B., Davidson, O.R. , Bosch, P.R.. Dave, R., Meyer, L.A.. 2007. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Ministry of Development. 2008. Energy Efficiency Action Plan pursuant to Directive 2006/32/EC. TREN/2008/01306-00-00. Hellenic Republic, Athens

MURE II 2007. Database Household. Institute of Studies for the Integration of Systems. Intelligent Energy Europe. URL: http://www.isisrome.com/mure/selection1.asp. [*consulted* 6 September 2010]

Odyssee. 2007. Odyssee Database 2006. URL: www.odyssee-indicators.org/. [*consulted 17 August 2010]*

_______. n.d. Definition of the energy efficiency index (ODEX). SAVE-ODYSSEE Project on EEI - Final Report - Part 2. URL: www.monitoringstelle.at/fileadmin/dam/spritspar/.../Definition_Odex.pdf. *[consulted 2 April 2010].*

Patlitzianas, K.D. 2010. An analysis of energy efficiency investments' environment in Greece – The potential role of JESSICA instrument. *Energy Conversion and Management (2010)*, doi:10.1016/j.enconman.2010.07.011

Rosenberg, M., Hoefgen, L. 2009. Market effects and market transformation: their role in energy efficiency program design and evaluation. CIEE Market Effects Program. California Institute for Energy and Environment, Oakland.

Schlegal, J., Goldberg, M., Raab, J., Prahl, R., Kneipp, M., Violette, D. *et al.* 1997. Evaluating Energy Efficiency Programs in a Restructured Industry Environment. A HandBook for PUC Staff. Washington D.C., National Association of Regulatory Utility Commissioners.

Thelen, K. 1999. Historical Institutionalism in Comparative Politics. *Annual Reviews of Political Science*, 2: 369-404.

Thelen, K. and Steinmo, S. 1992. Historical institutionalism in comparative politics. Historical institutionalism in comparative politics. In *State, society, and economy*. S. Steinmo, K. Thelen and F. Longstreth. New York: Cambridge University Press.

Ürge-Vorsatz, D. and Koeppel, S. 2007. *Assessment of Policy Instruments for Reducing Greenhouse Gas Emissions from Buildings*. Report for the UNEP-Sustainable Buildings and Construction Initiative. Central European University, Budapest.

Ksenia Petrichenko *is doing her PhD Studies at the Central European University (Budapest, Hungary), Environmental Sciences and Policy Department. She is currently a junior researcher at the Centre for Climate Change and Sustainable Energy Policy, Central European University where she is responsible for data collection and analysis. Furthermore she is modelling work for Global Energy Assessment and UNEP report; doing case study research, preparing analytical reports, overviews for Energy Efficiency (EE) Governance project of IEA, etc.*

DEVELOPMENT OF A SMALL DOWNDRAFT BIOMASS GASIFIER FOR DEVELOPING COUNTRIES

Md. Adil Chawdhury, Dr. Khamid Mahkamov
adil99mebuet@yahoo.com.sg; Khamid.mahkamov@durham.ac.uk

Abstract

Biomass gasification has been receiving increasing attention as a potential renewable energy source for the last few decades. This project involved designing, developing and testing a small downdraft biomass gasifier JRB-1 (6-7 kW) at Durham University, UK which could be a feasible solution for the supply of green energy in developing countries. The gasifier was built of stainless steel pipes, sheets and other fittings and tested for wood chips and pellets. The composition, moisture content and consumption of biomass feedstock (3.1 kg/hr for wood chips, 2.9 kg/hr for pellets), temperature inside the reaction zone (950-1150 $^{\circ}\mathrm{C}$*), primary air flow rate (0.0015* $\mathrm{m^3/s}$*) and exit temperature of the producer gas (180-220* $^{\circ}\mathrm{C}$*) was measured. The main constituents of syngas included Nitrogen (50-56%), Carbon monoxide (19-22%), Hydrogen (12-19%), Carbon dioxide (10-12%) and a small amount of Methane (1-2%). These results were used in Engineering Equation Solver (EES) software to obtain the lower calorific value of syngas (4424-5007* $\mathrm{kJ/m^3}$*) and cold gas efficiency (62.5-69.4%) of the gasifier, which were found close to the calculated values. Again the thermal efficiency was calculated as 90.1-92.4%. Being comparatively easy to build, downdraft gasifiers like JRB-1 are likely to be the most appropriate technology for developing countries as a source of decentralized power supply and for development in agricultural sector.*

Keywords: Biomass gasification, syngas, emission, renewable energy

1. Introduction

One of the greatest achievement of man since the beginning of civilization has been the discovery and control of various forms of energy. Energy is a strategic input necessary for socio-economic development. Worldwide, 80% of all energy used by human comes from fossil fuels. Massive exploitation is leading to the exhaustion of theses resources and imposes a real threat to the environment mainly it would seem through global warming. Therefore scientists all over the world are trying to tap the sources of energy that are inexhaustible, cheap, absolutely pollution free and specially suited to remote places.

Of the renewable sources of energy, one of the promising is biomass especially for developing countries. One of the attractive technologies for alternative fuel from biomass is gasification which has been commercially applied for more than a century for the production of both fuels and chemicals. The equipment used in the gasification process is commonly referred to as gasifier. This project intended to design, develop and test a small downdraft biomass gasifier JRB-1 at Durham University, which was fuelled by wood chips and pellets. This was actually a modified version of Fluidyne gasifier suitable for developing countries.

2. Gasification

Gasification is a process of converting carbonaceous materials (biomass/coal) through incomplete combustion at temperatures of more than $1000^{\circ}C$ to combustible gases consisting of Carbon monoxide, Hydrogen, Carbon dioxide and small amounts of Methane etc. This gas mixture is commonly known as a producer gas or syngas while the reactor is termed as gasifier. Biomass gasification is considered as a potential renewable energy source for developing country due to:

- Capable of reducing wood consumption up to 50%
- Environmentally sound technology, reduce greenhouse gas emission
- Reduce dependency on fossil fuels
- Good use of domestic resources and boosts agriculture
- Comparatively easy technology
- Distributed generation (DG) or Island power systems

2.1. Gasification versus combustion

There is a significant difference between gasification and combustion processes.

- Gasification is not an incineration process like combustion; rather it is a conversion technology.
- Combustion processes usually take place with excess of air whereas gasification processes are conducted with limited amounts of air (35% of Stoichiometric conditions or less).
- The combustion processes usually produce CO_2, H_2O, SO_2, NO, NO_2, HCl whereas biomass gasification processes produce CO, H_2, H_2O, CO_2, N_2, NH_3, CH_4, H_2S, HCl, COS, HCN etc.
- Emission of S, NOx and particulate materials are remarkably reduced in the gasification. Moreover furan and dioxin are not formed during gasification processes as combustion.

2.2. Types of gasifier

Gasifiers can be classified according to:

(i) Method of heat introduced in the gasifier
 (a) Direct-Fired Gasifier
 (b) Indirect-Fired Gasifier

(ii) Basic reactor principles
 (a) Fixed-Bed Gasifier
  (x) Updraft or Counter Current Gasifier
  (y) Downdraft or Co-current Gasifier
   (1) Imbert Type (Throated)
   (2) Open Core Type (Throatless)
  (z) Cross-draft Gasifier
 (b) Fluidized-Bed Gasifier
 (c) Entrained Flow Gasifier
 (d) Plasma Gasifier

(iii) Gasifying media: Air/Steam/Oxygen/mixture of these.

(iv) Application of the producer gas
 (a) Heat Gasifier
 (b) Power Gasifier

2.3. Downdraft gasifier

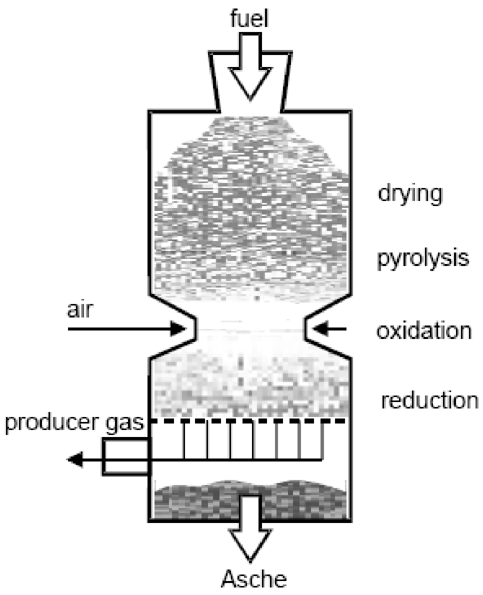


Fig. 1. Downdraft Gasifier

2.3.1. Features

- Aimed to solve the tar entrancement problem found in other types of gasifier to make it suitable for engine applications.
- Primary gasification air is introduced at or above the oxidation zone and producer gas removed from bottom of the gasifier
- Fuel and gas move in the same direction (co-current)
- On their way down acid & tarry distillation products pass through glowing bed of charcoal and converted to permanent gases.
- Depending on the temperature and residence time more or less complete breakdown of tar is achieved

2.3.2. Advantages

- Possibility of producing tar free gas
- Flexible adaptation of gas production to load
- Less environmental objection for condensate.
- Fuel conversion rates could attain over 95%

2.3.3. Disadvantages

- Major drawback is the inability to operate on a number of unprocessed fuels particularly fluffy, low density materials give rise flow problems and excessive pressure drop. Moreover solid fuels must be palletized, briquetted before use.
- Minor drawbacks are somewhat lower efficiency.

Table 1. Commercial Installations of Some Downdraft Gasifiers [8]

Country	Fuel	Capacity	Organization/Project
USA	Hogged wood, stumps	1 MW	CLEW
	Wood chips and corn cobs	40 kW	Stwalley Engg.
Denmark	Wood residues	500 kW	Hollesen Engg.
New Zealand	Wood blocks, chips	30 kW	Fluidyne
France	Wood, agriculture residues	100-600 kW	Martezo
UK	Wood chips, hazel nut shells	30 kW	Newcastle University
	Industrial agriculture waste	300 kW	Shawton Engineering
Switzerland	Woody & agriculture waste	50-2500 kW	DASAG

	Wood, wood waste	0.25-4 MW	HTV Energy
India	Woodchips, rice hulls	100 kg/h	Associated Engineering
South Africa	Wood blocks, chips	30-500 kW	SystBM Johnson Gas
Netherlands	Rice husk	150 kW	KARA Energy System
China	Sawdust	200 kW	Huairou wood equipment
	Crops residues	300 kW	Huantai Integrate Gas System

2.4. Processes and reaction chemistry for the downdraft gasifier

As the feedstock proceeds through the different section of a downdraft gasifier the following physical, chemical and thermal processes may take place simultaneously or sequentially depending on the properties of feedstock and the design of the gasifier.

2.4.1. Drying zone or bunker section

Solid feedstock/biomass is introduced into the downdraft gasifier at the top. During feeding of the biomass, a small amount of air leakage is tolerable. Due to the heat transfer from the lower part of the gasifier, drying of biomass takes place in the bunker section.

$$\text{Moist Feedstock} + \text{Heat} \rightarrow \text{Dry Feedstock} + H_2O \tag{1}$$

Part of this water vapour reduces to hydrogen and the rest ends up as moisture in the gas.

2.4.2. Pyrolysis zone

At temperatures above 250 $^{\circ}C$, pyrolyzing of the biomass feedstock occurs. Wood pyrolysis is a complicated process and details of these reactions are still not well understood. However, we can surmise that large molecules (Cellulose, Hemi-cellulose and Lignin) are broken down into carbon (char) and medium size molecules (Volatiles).

$$\text{Dry Feedstock} + \text{Heat} \rightarrow \text{Char} + \text{Volatiles} \tag{2}$$

Up to 200 $^{\circ}C$, only water is driven off and temperatures in between 200 to 280 $^{\circ}C$, carbon dioxide, acetic acid and water are evolved. The actual pyrolysis reactions occur between 280 and 500 $^{\circ}C$ and produce large quantities of tar, gases and some methyl alcohol.

2.4.3. Oxidation or combustion zone

An oxidation/burning zone is formed in the section where air/oxygen is supplied. During the complete combustion processes, carbon dioxide and steam are formed. These combustion reactions are highly exothermic and result in a rapid temperature increase up to 1100-1500 $^{\circ}C$. The reactions are:

$$C + O_2 = CO_2 \quad (+\ 393\ MJ/kg\ mole) \tag{3}$$

$$2H_2 + O_2 = 2H_2O \quad (+\ 242\ MJ/kg\ mole) \tag{4}$$

Instead of generating heat, another important function of the oxidation zone is to convert and oxidize virtually all condensable products coming from the pyrolysis zone. In order to avoid cold spots in the oxidation zone, air inlet velocity and reactor geometry are carefully chosen.

2.4.4. Reaction or reduction zone

The reaction product of the oxidation zone flows downwards into the reduction zone. Here the sensible heat of the gases and charcoal is converted into the chemical energy of the producer gas. Reactions are:

$$C + CO_2 = 2CO \quad (-\ 164.9\ MJ/kg\ mole) \tag{5}$$

$$C + H_2O = CO + H_2 \quad (-\ 122.6\ MJ/kg\ mole) \tag{6}$$

$$CO + H_2O = CO_2 + H_2 \quad (+\ 42.3\ MJ/kg\ mole) \tag{7}$$

$$C + 2H_2 = CH_4 \quad (+\ 75\ MJ/kg\ mole) \tag{8}$$

$$CO + 3H_2 = CH_4 + H_2O (-205.9 MJ/kg\ mole) \tag{9}$$

Generally the temperature of the reduction zone can reach 800-1000 $^{\circ}C$. The end product of this reduction zone is syngas.

2.5. Efficiency of gasifier

The cold gas efficiency of the gasifier is defined as:

$$\eta_g = \frac{H_g \times Q_g}{H_s \times M_s} \times 100\% \tag{10}$$

If the producer gas is used for direct burning applications, gasification efficiency can be defined as:

$$\eta_{th} = \frac{(H_g \times Q_g) + (Q_g \times \rho_g \times C_p \times \Delta T)}{H_g \times M_g} \times 100\% \tag{11}$$

Cold gas efficiency (η_g) of the gasifier can be varied between 60 and 75% whereas thermal efficiency (η_{th}) can reach up to 95%.

2.6. Properties of producer gas

The performance and suitability for operation of any type of gasifier depends on its producer gas qualities. The following factors affect the producer gas quality:

- Type of gasification system
- Type and composition of the feedstock
- Properties including size and preparation of the feedstock.
- Temperature of the hot zone
- Residence time of the feedstock in the hot zone
- Plant configuration including

(i) Feed system- dry or slurry
(ii) Ash or slag removal system
(iii) Configuration of the grate system
(iv) Gasifier heating system & heat losses
(v) Syngas gas cleaning mechanism
(vi) Producer gas outlet temperature

Table 2. Composition of Producer Gas from Various Fuels [5]

Fuel	Volume Percentage					Calorific value MJ / m^3
	CO	H_2	CH_4	CO_2	N_2	
Charcoal	28-31	5-10	1-2	1-2	55-60	4.60-5.65
Wood	17-22	16-20	2-3	10-15	50-55	5.00-5.86
Wheat straw pellets	14-17	17-19	2-3	11-14	50-55	4.50
Coconut shells	19-24	10-15	2-3	11-15	50-55	7.20
Pressed sugarcane	15-18	15-18	2-3	12-14	50-55	5.3
Corn cobs	18.6	16.5	6.4	3.6	46	6.29
Rice hulls pelleted	16.1	9.6	0.95	3.6	46	3.25
Cotton stalks cubed	15.7	11.7	3.4	3.6	46	4.32

2.7. Fuels for the gasifier

Common biomass feedstocks for the gasifiers are charcoal, wood and wood waste and agriculture residues (coconut shells, coconut husks, straw, maize cobs, rice husks, pressed sugarcane etc.) All these fuels differ in physical, chemical and morphological properties. The most important fuel properties are

(a) Energy content of the fuel

(b) Moisture content

(c) Volatile matter content of the fuel (d) Dust content

(e) Tar content (f) Ash and slagging characteristics

(g) Reactivity & density of the fuel (h) Fuel particle size and distribution

Table 3: Gasification Characteristics of Various Fuels for Downdraft Gasifiers [5]

Fuel	Treatment, Bulk density, Moisture	Tar (g/ m^3)	Ash (%)	Slagging
Alfalfa straw	Cubed, 298 kg/ m^3 , m.c. =7.9%	2.33	6	No slagging
Coconut shell	Crushed, 435 kg/ m^3 , m.c. =11.8%	3	0.8	No slagging
Rice hulls	Pelleted, 679 kg/ m^3 , m.c. =8.6%	4.32	14.9	Severe slagging
Sugarcane	Cut 2-5 cm, 52 kg/ m^3	0.88	6.0	Minor slagging
Wheat straw	Cubed, 395 kg/ m^3 , m.c. =9.6%	---	9.3	Severe slagging
Wood blocks	5 cm cube, 256 kg/ m^3 , m.c.=5.4%	3.24	0.2	No slagging
Wood chips	166 kg/ m^3 , m.c. =10.8%	6.24	6.26	Severe slagging

3. Design and development of the downdraft gasifier

This project involved designing, developing and testing a small biomass gasifier named JRB-1 at Durham University capable of running on wood chips or wood pellets. The first step was to find a feasible design, which could be taken as the basis for the gasifier construction. It was also decided that, at this stage, syngas would be burnt in a simple burner rather than feeding it to an engine. After a few technical considerations, it was decided to develop approximately 6-7 kW capacity downdraft gasifier based on the 'Fluidyne Gasifier' model with modifications.

3.1. Development of model of the gasifier

At the beginning of the project, it was decided that the main body of the gasifier would be divided into 3 pieces of pipe for easy fabrication of the internal parts. These three sections would be top cylinder (fuel chamber), middle cylinder (reaction chamber) and bottom cylinder (ash chamber). For reliability, longer life and future experimentation, the gasifier was decided to be built with stainless steel.

Depending on the available materials and the original Fluidyne model, drawings for different parts and the full gasifier were developed with SolidWorks drawing package

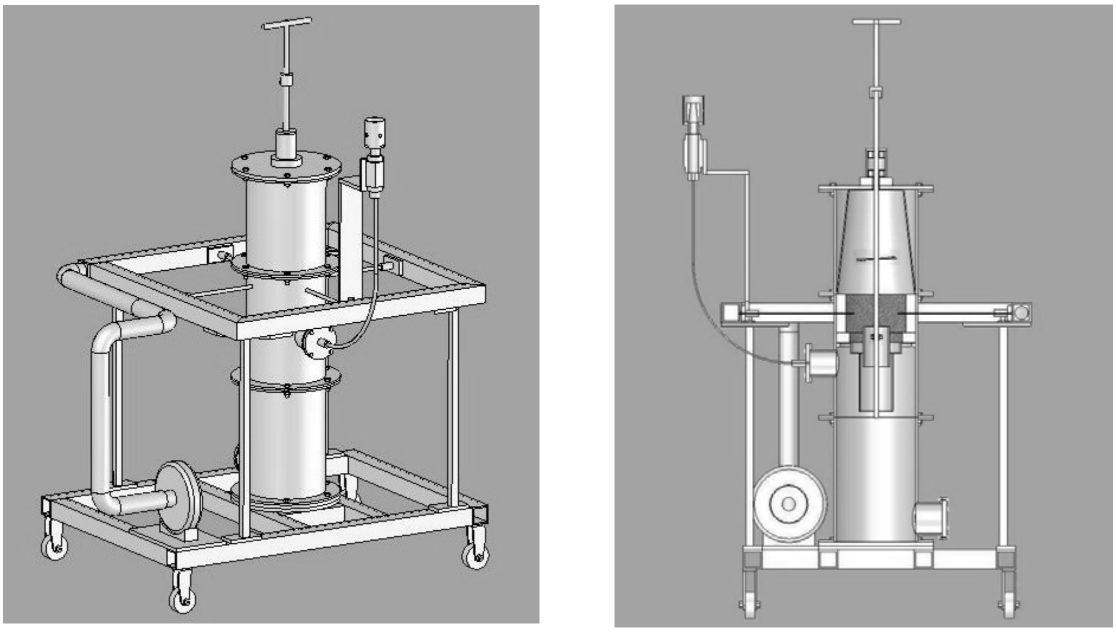


Fig. 2. Schematic and cross-sectional view of the planned JRB-1 gasifier

After developing SolidWorks model of gasifier, materials were collected for fabrication. This included stainless steel tubes/pipes, sheets, flanges; stainless steel straight fittings, copper gaskets, steel and braze metals, Gate valve and high temperature bearings etc.

Non-metal items included high temperature sealing materials/gaskets, thermal resistant cement (Refractory Castable 160 LC cement, service temperature 1600 °C), insulating tape etc.

Electrical equipment included an air supply fan with duct and control system, thermocouples and gas velocity measuring speed-gun.

3.2. Manufacture of different parts and assembly

At the beginning of the construction, all the pipes/tubes and sheet metals were fabricated according to the drawings. The gasifier was sectionalized into the following parts:

3.2.1. Top part or fuel chamber

The top cylinder was made of 6.3 mm thick, 219 mm outer diameter and 272 mm length stainless pipe. It contained bunker and pyrolysis zones. Biomass feedstock dried here due to the convective and radiation heat transfer from the lower parts of the gasifier. A conical tube of 2.5 mm thick stainless steel was placed inside to avoid 'fuel bridging'. The capacity of the fuel chamber was approximately 5 kg of wood chips/pellets.

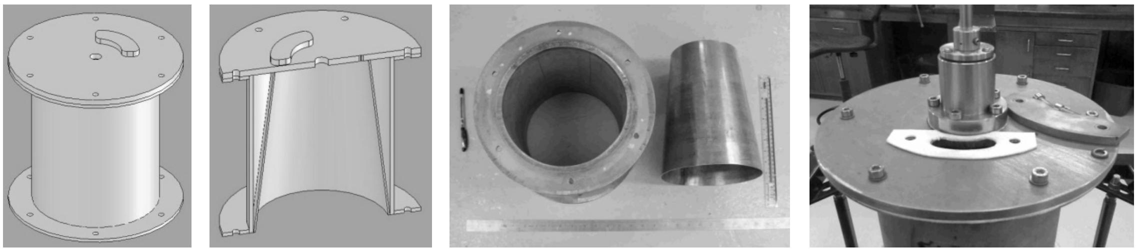


Fig.3. Schematic, cross sectional & manufactured view of top part

3.2.2. Middle part or reaction chamber

The reaction chamber is the heart of the gasifier where the producer gas is produced. It contains the oxidation zone and the throat section of the gasifier. Fuels flow down by gravity. The middle cylinder was made of 6.3 mm thick, 219.1 mm outer diameter and 320 mm long stainless steel pipe. Inside this chamber there was a slab of thermal resistant concrete to provide insulation in hot zone. There were 4 holes in middle of the slab for the air supply nozzles. Two flanges were mounted at the top and bottom be attached to other chambers.

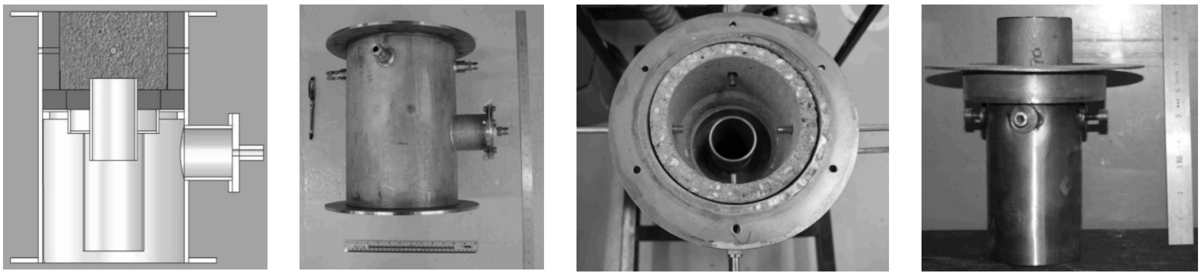


Fig.4. Cross sectional & manufactured view of middle part & throat section

Generally, two methods were applied to obtain an even high temperature distribution. Firstly, reducing the cross sectional area at a certain height ('throat' concept) and spreading the air inlet nozzles over the reduced cross sectional area. The throat section was made of two concentric stainless steel pipes of 70 & 88 mm diameter along with annular plates. The whole assembly seemed like a 'pocket' and gave the facility to change the depth of the throat pipe to modify the distance between the nozzles and the top of the reduction zone in the simplest way. The gas outlet pipe was made of 70mm stainless steel pipe.

3.2.3. Bottom cylinder or ash chamber

The lower cylinder contained the ash zone where the ash resulting from the gasification process of the biomass was stored and occasionally removed. The ash from the reaction chamber could fall down freely through the grate. The bottom chamber was made of 219.1 mm diameter and 325 mm long cylinder.

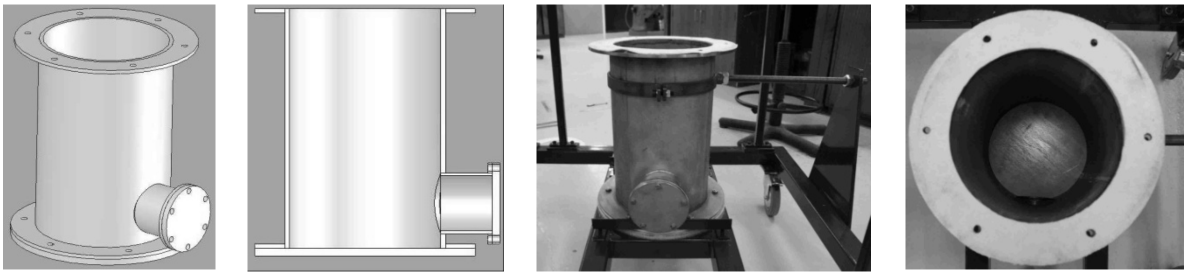


Fig.5. Schematic, cross sectional & manufactured view of bottom part

3.2.4. Stirrer and grate

Because of the fact that fuels often produce bridges, it is often required to use a stirrer. A moveable grate at the bottom is generally considered necessary. This makes it possible to stir the glowing charcoal bed in the reduction zone and thus helps to prevent blockages which can lead to obstruction of gas flow. In our gasifier, stirrer and grate were mounted on a single stainless steel rod (15 mm diameter) inserted from the top of the gasifier. The rod was occasionally rotated with a removable T-shaped handle.

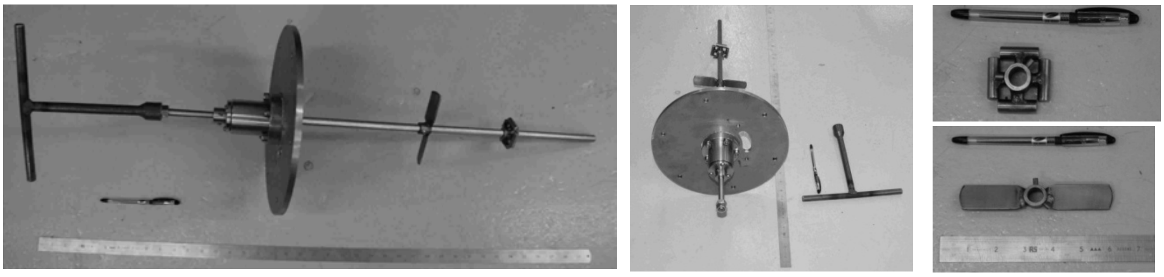


Fig.6. Stirrer and moveable grate connected with top cover plate

3.2.5. Air supply system

Primary air in the oxidation zone was supplied by 4 air inlet nozzles (7 mm inner diameter) placed in the middle of the reaction chamber. These nozzles were connected to the square shape primary air inlet manifold placed around the middle cylinder. The manifold was constructed from 50x50x4 mm square mild steel pipes. Air was supplied to the manifold from a variable speed SAVT metal case centrifugal fan (Model: SAVT-100L, 230V, 85W and 0.60A, nominal speed 2550 rpm, maximum air volume 0.065 m^3/s at 40 $^\circ C$).

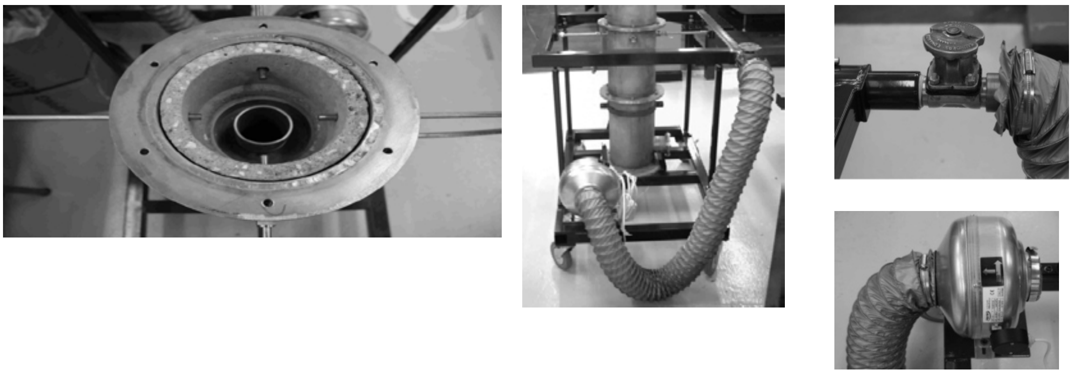


Fig.7. Air inlet nozzles, air supply system, gate valve and centrifugal fan

3.2.6. Other accessories and assembling

A gradually bending stainless steel pipe was connected to gas outlet and the other end was attached to a simple burner. For every flange joint, top and bottom cover plates, and fuel feeding channel a high temperature ceramic paper gasket (2 mm) was used. Again insulation material (Webbing tape, TW G3) was placed on the main body. Finally the gasifier was placed on a trolley so that it could be easily moved to a suitable place for testing. After assembling the final shape of the JRB-1 gasifier became as follows.

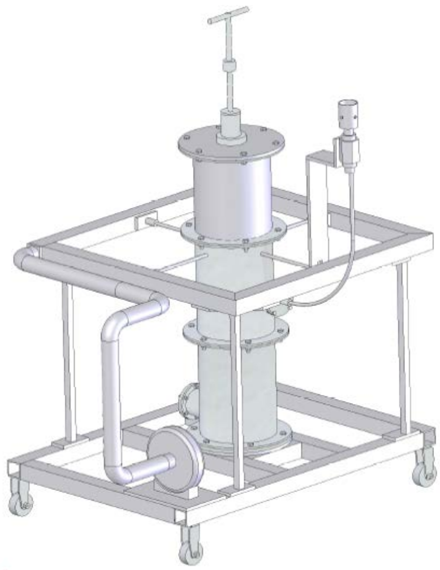


Fig.8. Schematic and final manufactured form of the JRB-1 gasifier

4. Operation and Testing of Gasifier

4.1. Operating procedure

The JRB-1 gasifier was operated and tested in the following steps:

(i) Before starting, all the parts (flanges attachment, fittings) of the gasifier were properly tightened and it was placed on open space.
(ii) The electrical fan for primary air supply was kept switched off.
(iii) The top cover of the gasifier was opened.
(iv) A thin layer of charcoal was placed near the throat (pocket area) of the oxidation zone and some was wetted with fire lighter (liquid) to initiate the combustion.
(v) The charcoal bed was ignited with a torch and fan was switched on to supply sufficient air/oxygen to initiate the combustion.
(vi) The top cover plate was closed and tightened.
(vii) Then the gasifier was loaded with biomass through fuel feeding hole.

(viii) During the second run, gasifier was loaded first and ignition was initiated from the down side through the ash hole. Finally an ignition port was cut to initiate combustion.
(ix) The primary air supply was full at the beginning and then maintained around 35% of the stoichiometric condition to ensure the partial combustion of the biomass using a fan-controller, gate valve and air flow meter.
(x) After 5 minutes, the producer gas in the form of thick white smoke came out through the burner.
(xi) The producer gas was ignited with a firing-torch at the burner.
(xii) A yellowish-red flame was observed and continued to ignite for more than 90 minutes.
(xiii) To stop the gasifier, first the fan was switched-off then the gate valve in the air supply channel was closed to completely stop the primary air supply.
(xiv) The gasifier was ultimately stopped after closing the air supply and left in an open space until it cooled down and all gases came out of the gasifier (more than 6 hours).

During the testing of the gasifier the following measurements were taken:

(a) Primary air velocity & volumetric flow rate of syngas was measured by VELOCICALC Air Velocity instrument. The average air velocity of primary air during the experiment was found in between 6.35 and 8.75 m/s at the gas outlet pipe of ID16 mm. Therefore, volumetric air flow rate was in between 0.00127 and 0.0017 m^3/s. The best result was obtained at 0.0015 m^3/s of air flow rate.
(b) Average solid biomass fuel consumption was measured using digital weight machine. The biomass feedstock was dried in the BINDER electrical oven.
(c) Temperature in the reaction zone and gas outlet zone were measured with the help of a K-type thermocouple and Autoranging multimeter. Throughout our testing, the temperature of the hot zone was found up to 1160 ^{o}C. The producer gas temperature at the generator exit was 180-230 ^{o}C.

4.2. Safety issues during testing

Since the gasifier produced syngas containing toxic and flammable carbon monoxide, methane, hydrogen etc., and the temperature in the oxidation zone was more than 1100 $^{\circ}C$, a number of safety measures were taken to avoid toxic, fire and explosion hazards.

a. Before starting, every joint and fitting was properly tightened to avoid leakage.
b. Tests were carried out in open space and the combustion products were exhausted to the atmosphere.
c. Biomass feedstocks were handled with hand gloves.
d. Safety glass, rigid sole footwear and insulated hand gloves were used during testing.
e. A standard first aid box and fire extinguishing equipment (CO_2 /dry powder) were kept ready for emergencies.
f. After testing, the gasifier was cooled down for a 6 hours period and all the gas was ventilated in open air and the ash was disposed of in the waste bin.

4.3. Fuel tested

The downdraft biomass gasifier was tested for two types of fuels i.e. wood chips and wood pellets. The fuels were processed before loading into the fuel chamber. Both wood chips and pellet were supplied by BTL Woodshed Limited, Bp Auckland; Durham.

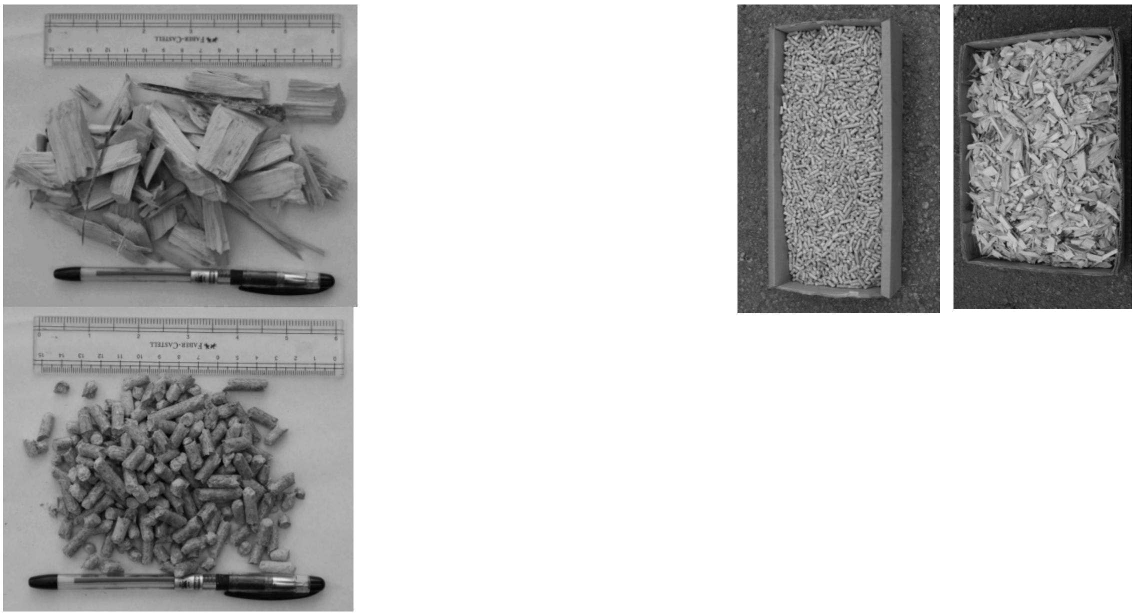


Fig.9. Wood chips and wood pellets tested in the JRB-1 gasifier

The average size of the woodchips was 30-70mm and wood pellets were 15-30mm with 6mm in diameter. Wood chips/pellets were naturally dried for 2 days and electrical oven dried at 105 $^{\circ}C$ for 3-4 hours.

Table 4: Average Properties of the Fuel Used in the JRB-1 Gasifier

Properties	Wood chips	Wood pellets	Reference
Apparent density (kg/m^3)	280-550	600-700	[4], [5]
Ultimate Analysis (dry basis)			
Carbon (weight, %)	46-54	41-48	[4], [5]
Hydrogen (weight, %)	4-6	6-8	[4], [5]
Oxygen (weight, %)	38-43	42-46	[4], [5]
Proximate Analysis (wet basis)			
Moisture content (%)	7.36	8.55	Laboratory Testing
Volatile matter (%)	65-75	80-85	[4], [5]
Fixed carbon (%)	15-20	6-10	[4], [5]
Ash (%)	0.338	0.574	Laboratory Testing

5. Result and Discussion

The gasifier was first fired on 10th July 2009 using wood chips as fuel. Next few days, it was tested for wood pellets and chips and performance in different conditions was observed. Based on these, few modifications were conducted in design. During the first run, unstable flame and tar came out through the burner. The reasons identified were the low temperature in the oxidation zone, short residence time of the tarry vapours due to high gas velocity in the hot zone and wet wood chips. Therefore the gas outlet pipe was replaced with a larger bore (OD=34 mm) stainless steel pipe. Another important modification was made in the burner to reduce gas velocity. Finally the hot parts of the gasifier were insulated with webbing tape (TW G3) to reduce heat loss and an ignition port was made close to the reaction zone. With these modifications it was possible to obtain up to 1160 $^{\circ}C$ temperature in the hot zone and stable flame was observed for 91 minutes.

5.1. Biomass fuels consumption

When the gasifier was run on wood pellets, it consumed around 4400 gm of fuel to give a stable flame for 91 minutes (approximately 2.9 kg/hr). On the other hand, when it was loaded with wood chips, fuel consumption was 3.1 kg/hr.

5.2. Producer gas composition

From the moisture content of the biomass feedstock, the composition of producer gas was calculated using the wood gas composition graphs.

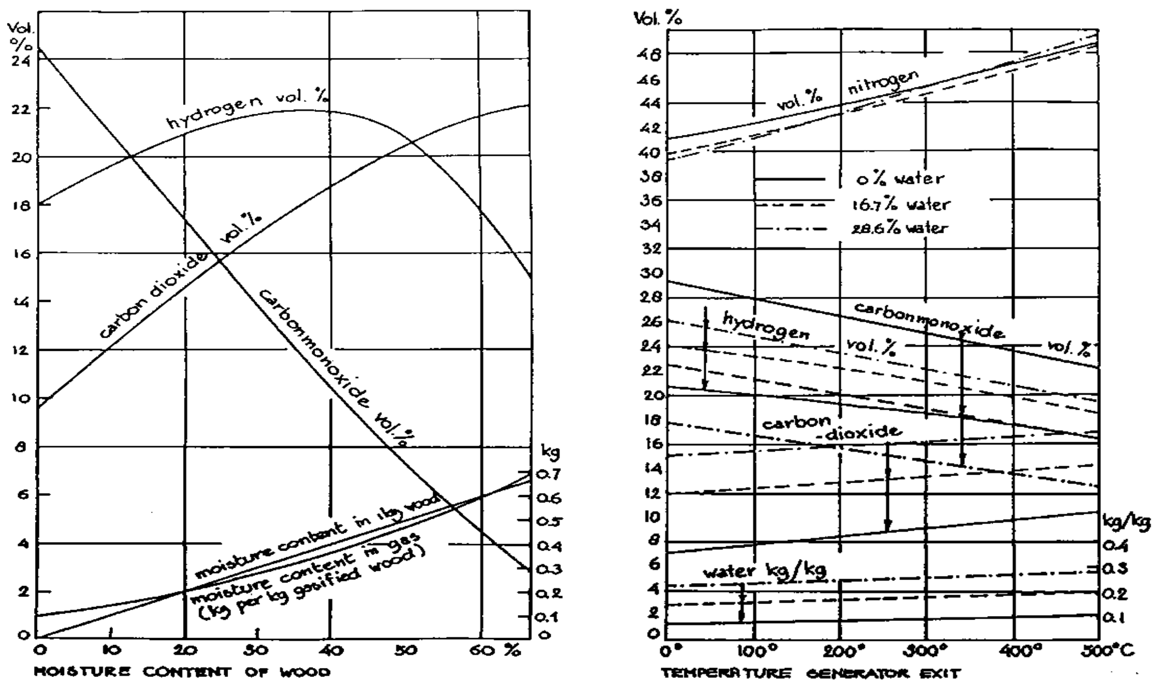


Fig.10. wood gas composition graphs [7]

Table 5: The Composition of Producer Gas (% of Volume)

Fuels	Moisture dry (%)	CO	H_2	CH_4	CO_2	N_2	Moisture in gas (kg/kg of wood)
Wood Chips	7.36	21-22	17-19	1-1.5	10-11	50-55	0.1
Wood Pellets	8.55	19-21	12-19	1-2	11-12	52-56	0.12

Table 7: The Change in Composition of Producer Gas (% of Volume)

Fuels	Temp (^{o}C)	CO	H_2	CH_4	CO_2	N_2	Moisture in gas (kg/kg)
Wood Chips	180-230	23	20	1.5	11	43.7	2
Wood Pellets	220-240	22	20.5	2	11.5	44	2

5.3. Analysis of producer gas using engineering equation solver (EES) software

The producer gas obtained from the different feedstocks was analyzed with a special model of Engineering Equation Solver (EES) software particularly suitable for a stationary model of downdraft gasifier (Felicia Fock and Kirstine Thomsen, 2000, DTU, MEK, Denmark).

5.3.1. Input parameters

Wood chips: Consumption = 3.1 kg/hr, CH_4 =1%, Moisture content=7.36%, Element composition= $CH_{1.586}O_{0.7089}$, Reaction zone temp= 950 ^{o}C , Charcoal=3%, Gas temp=200 ^{o}C .

Wood pellets: Consumption = 2.9 kg/hr, CH_4 =2%, Moisture content=8.55%, Element composition= $CH_{1.615}O_{0.664}$, Reaction zone temp= 1150 ^{o}C , Charcoal=3%, Gas temp=220 ^{o}C .

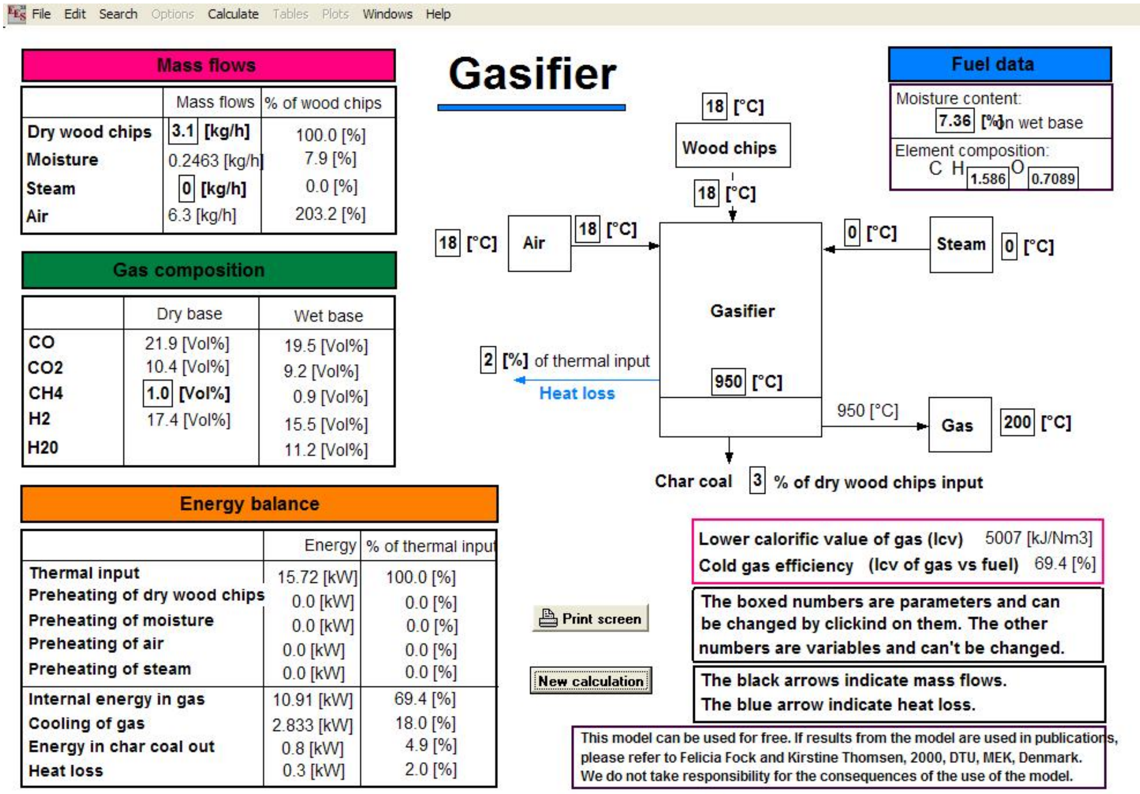


Fig.10. Gasifier performance calculation using EES software

5.3.2. Simulation output

Wood Chips: Lower calorific value of gas (LCV) = 5007 kJ/m^3

Cold gas efficiency (LCV of gas vs. fuel) = 69.4% (At ambient temp=18 ^oC)

Wood Pellets: Lower calorific value of gas (LCV) = 4424 kJ/m^3

Cold gas efficiency (LCV of gas vs. fuel) = 62.5% (At ambient temp=20 ^oC)

5.4. Cold gas efficiency of the gasifier

From equation (10) & (11), the cold gas and thermal efficiency of the gasifier is defined as:

$$\eta_g = \frac{H_g \times Q_g}{H_s \times M_s} \times 100\% \qquad \eta_{th} = \frac{(H_g \times Q_g) + (\rho_g \times C_p \times \Delta T)}{H_g \times M_g} \times 100\%$$

H_g = LHV of syngas; for wood chips 5007 kJ/m^3 and wood pellets 4424 kJ/m^3

Q_g= Volume flow rate of gas; for both wood chips and wood pellets approx. 0.0015 m^3/s

H_s= LHV of gasifier fuel; for wood chips13-15000 kJ/kg and wood pellets14-17000 kJ/kg

M_s= Solid fuel consumption; for wood chips 0.000867 kg/s and wood pellets 0.000805 kg/s

ρ_g = Density of producer gas, 1.3 kg/m^3 (approx.)

C_p= Specific heat of the producer gas, 1.45 kJ/kg°K (approx.)

ΔT= Temp difference between the gas outlet and fuel inlet, 200 ^{o}C or 473 K (approx.)

η_g = Overall cold gas efficiency, for wood chips 66.66 % and wood pellets 58.89 %

η_{th}= Thermal efficiency of the gasifier, for wood chips 90.1% and wood pellets 92.4%

P_g = Thermal power of the syngas, Q_g x H_g =0.0015x4424=6.636 kW (approx. for pellets)

P_{th} = Thermal power consumption (full load), P_g / η_{th} =6.636/0.924=7.18 kW

5.5. Limitations of JRB-1gasifier operation

The small JRB-1 downdraft biomass gasifier was developed for testing purpose. Therefore there were number of technical and operational limitations:

- The gasifier was not built for continuous operation and the fuel chamber capacity was approximately 5 kg of biomass to run 1.5 hours of operation. At each refuelling, the top cover needed to be opened and this caused a lot of air leakage and heat loss.
- The design did not include any special fuel feeding hopper. Instead, a simple small fuel feeding hole was used. It was difficult and time consuming to feed the biomass in the reaction zone.
- In first design, there was no ignition port to initiate the combustion in the oxidation zone. Ignition was initiated either from the top or from the bottom.
- Since the stirrer was attached to the top cover plate, opening, fuel feeding and operation process was always very difficult.

5.6. Feasible application of JRB-1 gasifier in developing countries

Biomass gasification using JRB-1 type gasifier could have many potential applications in developing countries, including:

1. Direct thermal application in agro industries. The main advantages of gasifiers in heating applications are the ability to produce higher temperatures than conventional burning systems, better control over heating systems, enhancement of boiler and total efficiency, lower emissions etc. Therefore it could be used as dryer in tea and cardamom industries; tiles, potteries, ceramic industries; to run furnaces in some foundry industries and in metallurgical industries where high temperatures (up to 1000 $^{\circ}C$) is required, to run boiler in rice processing industries etc.
2. Shaft power applications in the agriculture sector, i.e. farm machinery such as harvesters, tractors, grinding machines etc. Another potential field for gasifiers in the agriculture sector is irrigation.
3. Combined Heat and Power (CHP) application, distributed power generation in remote and rural areas.
4. Stand-alone power systems

5. Chemical production

6. Conclusion

Biomass gasification offers one of the most promising renewable energy systems, particularly for agricultural purpose in developing countries. The main focus is on fast growing trees, woody grass and agricultural residues. A more extensive and attractive system could be a downdraft gasifier capable of generating a syngas with sufficiently low tar content for engine applications. The biggest challenge in gasification systems is considered as being the reliable and economical cooling and cleaning technology. The successful JRB-1 gasifier project at Durham University opens a door to ensure effective use of biomass and to reduce emission in agro industries. On the whole, the primary aims of the project were achieved. Finally we can say, being comparatively easy to build using low coast materials, downdraft gasifiers like JRB-1 could be an attractive technology for thermal and power applications in developing countries.

7. References

Chopra, S. and Jain, A. A Review of Fixed Bed Gasification Systems for Biomass. Agricultural Engineering International: the CIGR e-journal. Invited Overview No. 5. Vol. IX. April, 2007.

Gross, J.R. State of Art of Agriculture Residue Gasifier in the U.S., Proceeding First USAID/GOI Workshop on Alternative Energy Resources and Development, New Delhi, India, November 7-11, 1983

Hgman, C. and Van der Burgt, M. Gasification, Second Edition, Elsivier Inc. 2008Rezaiyan, J. and Cheremisinoff, N.P. Gasification Technology, A Primer for Engineers and Scientist, Taylor & Francis Group, 2005.

Maschio, G. Production of Syngas from Biomass, Dipartimento di Chimica Industriale, Universitd di Messina, CP 29-98166 S. Agata di Messina, Italy, 1993.

Rajvanshi, A.K. Biomass Gasification, Alternative Energy in Agriculture, Vol. 2, , 1986.

Reed, T.B. Das, A. Handbook Biomass Downdraft Gasifier Engine systems, Solar Technical Information Program, U.S. Department of Energy, 1988

Souza-Santos, M.L. Solid Fuels Combustion and Gasification: modeling, simulation, and equipment operation CRC Press, 2004

Md. Adil Chawdhury *has a MSc in New and Renewable Energy from the School of Engineering and Computing Sciences, Durham University in the United Kingdom. He was awarded with the Commonwealth Scholarship'2008, the Research and Development Project Best Poster Competition, Durham University (First Place), the University Deans List & Merit List Scholarships and other Merit Scholarships. His career objectives are to establish himself as a prospective mechanical engineer in the energy sector, particularly in the renewable energy field.*