Projections for APEC Energy Trade and Investments: Implications for Cooperation

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***Abstract* – The impact of energy policy options on the scale and structure of energy trade and investments in the APEC region is discussing. The APEC Energy Demand and Supply outlook up to 2030 is considered as the business-as-usual scenario, which is complemented by two cases of regional energy policy implementation – power generation industry's GHG emissions curbing in the West Pacific Area, and acceleration of the renewable energy development in China.**

An attempt was made to qualify uncertainties for energy trade and investment decision making, and identify they relationship to the international cooperation efforts in the region.

***Index Terms* – energy demand and supply outlook, energy trade, energy investments, alternative energy policy, uncertainties, international cooperation**

I. APEC ENERGY DEMAND AND SUPPLY OUTLOOK OVERVIEW

A.Major assumptions and findings

The latest "APEC Demand and Supply Outlook, 4th" edition was published in October 2009, and it provides a long-term business-as-usual projections on energy demand and supply in the APEC region up to year 2030. Yet the impact and even assessments of the depth of the current global crisis has been diminished in this report to the "*Governments are moving very rapidly to address the threats of the world economic crisis that began in late 2008*" [1]. However, the obvious fact is that economic activity creates demand for final energy supply. This drives the whole supply chain to primary energy production and/or extraction, international energy trade flows, and thus has significant economic and political implications. Uncertainties in energy demand projection creates even larger scale of uncertainties for investment decision makers in energy-related industries and economic sectors.

Key assumptions for [the only] business-as-usual (BAU) scenario in the 4th edition of the "APEC Demand and Supply Outlook" include projections on GDP and population for each APEC member economy, and projections on international oil prices. Despite the current economic crisis, the assumption was made that the APEC region will continue to have the long-term economic growth at 3.5 percent annual rate of GDP over 25 years to 2030, while population is assumed to increase continuously, but at a diminishing rate – 0.65% up to 2015, and then declining to 0.42% in average to 2030. The oil benchmark prices projections are relying on the IEA's World Energy Outlook for 2030, and the futures market quotations as the basis for the 2015.

The major issues which will affect the long-term pattern of energy demand and supply in the APEC region has been identified: a) impact of the current **double crisis of economic and financial systems** on energy investments and delayed technology advance, b) **security of crude oil supply** and **emerging restructuring in natural gas market**, c) curbing of **anthropogenic climate change**, and d) self-sustained **renewable energy** development.

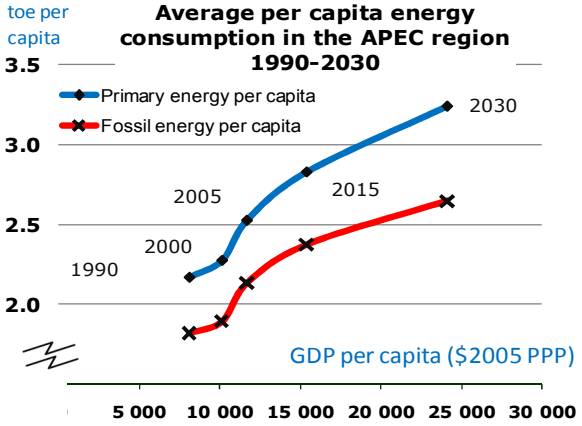

Fig. 1. APEC average GDP per capita, history and projections

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Energy demand per capita in the APEC region in 2030 will grow 1.3 times to its 2005 level, bringing average per capita energy consumption in the APEC region to 3.3 toe in 2030 from 2.5 toe in 2005 (fig.1). An average annual growth rate (AAGR) of GDP per capita *is believed* to stay at 2.9 percent and that for primary energy supply at 1.5 percent. An average GDP per capita GDP in the APEC region will rise twofold from US$2006 PPP 11,656 in 2005 (comparable to that of Russia in 2005) to US$2006 PPP 24,072 by 2030 (comparable to that of New Zealand in 2005).

B.Structural changes for primary energy supply

Nuclear energy will show the highest AAGR at 2.7 percent within primary energy supply, natural gas and renewable energy will follow with 1.7 percent AAGR, while coal and oil will face modest growth at 1.4 percent and 1.0 percent AAGR, respectively. In absolute terms, coal will have the fastest demand growth between 2005 and 2030 (+908 Mtoe), followed by gas (+704 Mtoe) and oil (+651 Mtoe). Use of renewable energy will show high rates of growth in electricity generation (wind and solar), and second-generation biofuels in transport sector. In absolute terms NRE supply will grow at 322 Mtoe, which includes 66 Mtoe of hydro energy.

Primary energy trade flows, such as of crude oil and petroleum products, natural gas and coal, is essential for investment assessments of the energy infrastructure development. While extensive output data on energy demand and supply outlook in the APEC region is available for download from the APERC website, charts fig. 2 – 4 presents intraregional energy flow changes in the APEC region over next decades up to 2030.

C.Energy trade flows

APEC as a whole will remain a modest exporter of coal to the rest of the world, roughly self-sufficient in gas, and a large and growing importer of oil. While in 2005 the APEC region imported about 34% of oil it consume, by 2030 oil import will rise to about 45% of a significantly larger volume of primary crude oil supply. Russia currently is and will remain the only APEC subregion with net export of crude oil and petroleum products, however much of this export is destined outside of APEC.

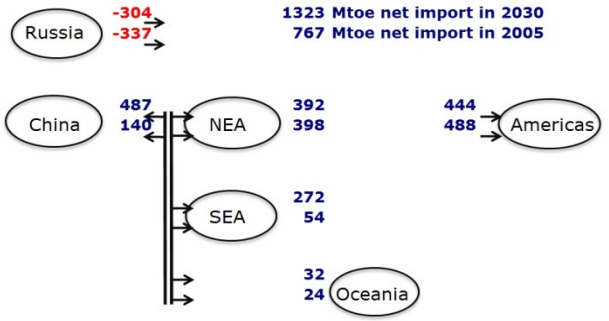

Fig. 2. Net crude oil and petroleum import by APEC subregions, Mtoe

Before 2030 APEC region will swing from being the current net natural gas exporter to net importer, due to domestic gas consumption growth in Southeast Asia and China, despite of some ten-fold natural gas production increase in Oceania. Russia already start gas export to the Asia-Pacific region in 2009, however majority of its gas will flow toward Europe.

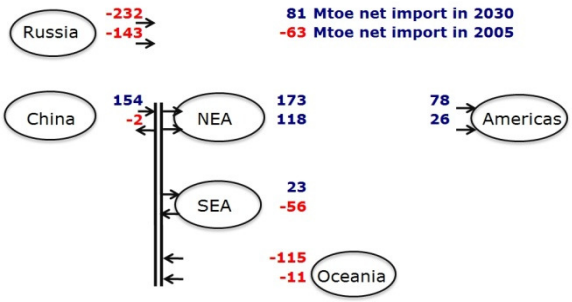

Fig. 3. Net natural gas Import by APEC subregions, Mtoe

Coal will remain and even improve surplus supply positions in the APEC region; however, the ability of China to export coal in the long-term came under great uncertainty, as China is switching to net coal import position.

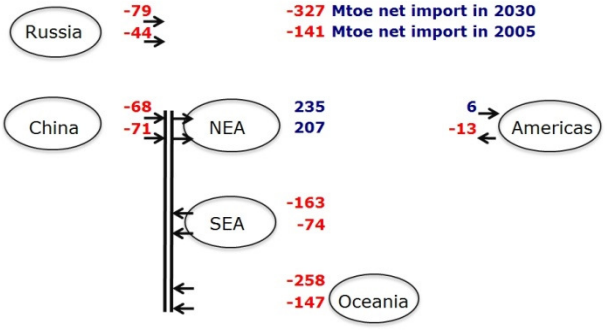

Fig. 4. Net coal Import by APEC subregions, Mtoe

II. ENERGY INVESTMENTS

A.History and methodology

Adequate investment in energy infrastructure is essential to the economic stability and growth of APEC economies, as well as to insure energy security and environmental sustainability. APERC has assessed capital investments in energy infrastructure that is likely to be required under business-as-usual assumptions between 2006 and 2030. Energy investment projections have been provided for each member economy, which is rather unique feature when compared with similar reports, for example presented by IEA and EIA. Previous projections on energy investment made by APERC include three major publications:

- 2002 – Chapter in the "*APEC Energy Demand and Supply Outlook*" to 2020 with discussion on investment issues and challenges [2]
- 2003 – "*Energy Investment Outlook for the APEC region*" report, which comes simultaneously with IEA's "*World Energy Investments Outlook: Insights*" [3]
- 2006 – "*Energy Demand and Supply Outlook for the APEC region*" provide information on investments for coal, oil, gas, and electricity supply for each member economy and regions within APEC [4]

However, due to lack of alternative scenarios for economic growth and energy supply, analysis of possible energy investment shortages or excesses within APEC economies and their relationship with energy security and environmental footprints was been missed for all of above mentioned reports.

Investment estimations for the 2009 Outlook are based on "macro" approach, which is accounting required amount of the infrastructure elements' physical capacity along the energy supply chain and multiplying it by economy-specific capital cost per unit of capacity for each facility type. Capacity estimations took into account average age of facilities' stock, the needs for existing facilities replacement at the end of their normal operating life, and new facilities required for energy infrastructure expansion.

The energy supply chain was considered of four consecutive stages: extraction/production, transformation, transportation, and distribution. Four energy industries were distinguished: coal, oil, gas, and power (electricity and heat). Power generation is part of transformation chain and includes three types of thermal power plants, nuclear and five types of renewable energy facilities. Nuclear fuel chain, biomass utilisation (like biofuels and direct biomass burning), and infrastructure for non-commercial energy supply were not considered. Investments for international energy transportation within the APEC region were shared equally between exporter and importer economies, while investments for energy trading outside the region were attributed exclusively to the APEC member economies.

Compatible costs, with individual economy's amendments where possible, was converted to US dollar 2006 values at exchange rate base from local currencies, then implementing deflation rate of the US dollar. To address various uncertainties along supply chain the range approach (low and high ends) for investment assumptions was implemented, and then cumulative total investments for 2006-2030 time frame was calculated.

B.Investment projections

To meet the projected energy demand growth, APEC economies will spend between 11.1 and 15.0 trillion US dollars of 2006 buying power (US$2006) for energy infrastructure development (table I). The energy transformation sector dominates energy investments with 46 percent share, followed by combined transportation and distribution share with 33 percent. Extraction and/or production of primary energy will require 21 percent of future energy investments in the APEC region.

- China, USA and Russia accounts for 70% of total energy investments
- Transformation and transportation stages of the energy supply chain dominate in total energy investments with 74 percent share (46% and 28%, respectively); power and heat supply infrastructure will require 58% of total energy investments

- Gas trade infrastructure account for 78% of international energy transportation investments
- In order to secure energy supply 0.5 – 0.7 US$2006 trillion will be required to invest outside of APEC region, while crude oil transportation infrastructure will take 75% of these investments.

Table I

TOTAL CUMULATIVE INVESTMENT REQUIREMENTS ALONG THE ENERGY SUPPLY CHAIN IN THE APEC REGION FOR 2006-2030 TIME FRAME, US$2006 BILLION

	2006-2030 low		high
APEC	**11 072**	–	**14 964**
Extraction	2 230	–	2 981
Transformation	5 111	–	6 897
Transportation	3 027	–	4 156
Distribution	704	–	931

Source: [5]

Proportions vary significantly between APEC economies depending on resource availability, geography, and energy infrastructure maturity (table II). Geographic factor influence heavily to energy transportation investments, if long distances separate energy production and consumption.

Table II

TOTAL INVESTMENT REQUIREMENTS BY SUBREGION AND ENERGY SUPPLY STAGE, PERCENT

	Extraction	**Transformation**	**Transportation**	**Distribution**
APEC	**20**	**46**	**28**	**6**
NE Asia	0	66	24	10
SE Asia	27	38	28	7
Oceania	48	19	30	3
Americas	22	46	29	3
China	16	55	21	8
Russia	22	31	39	8

Source: [5]

The case of Russia clearly demonstrates this point. Seemingly, low Russia's share for energy extraction at 22 percent is compensated by 40 percent share of investments in energy transportation, both to domestic consumers and for export.

Table III

INVESTMENT REQUIREMENTS BY ENERGY, US$2006 BILLION

	2006-2030 low		high
APEC	**11 072**	–	**14 964**
Power and heat generation, transmission and distribution	6 439	–	8 703
Crude oil and petroleum products	2 164	–	2 964
Natural gas	1 561	–	2 097
Coal	908	–	1 201

Source: [5]

Within energy industries electricity and heat supply accounts for the largest share of investment requirements in the APEC region for 2006-2030 time period at 58 percent, oil supply will require 20 percent, natural gas 14 percent, and coal 8 percent of total energy investments (tables III-IV).

Table IV

TOTAL INVESTMENT REQUIREMENTS BY SUBREGION AND ENERGY, PERCENT

	Power	**Oil**	**Gas**	**Coal**
APEC	**58**	**20**	**14**	**8**
NE Asia	78	17	5	0
SE Asia	46	26	22	6
Oceania	28	10	41	22
Americas	52	28	15	5
China	69	13	3	15
Russia	54	17	26	3

Source: [5]

The power industry share can exceed 80 percent in economies which lack indigenous energy resources, such as Hong Kong, China and Japan. A notable exception is Singapore, which will need to make substantial investments in refurbish ageing refining industry, and in petroleum products shipping, as well as in diversifying natural gas supply though construction of new LNG receiving terminal.

C.Power and heat supply

Investment requirements for the electricity and heat industry in the APEC region are estimated at US$2006 6.3 – 8.4 trillion (table V). New renewable and thermal power generation facilities will account for 40 percent and 39

percent, respectively, of power generation investments, while nuclear will fill remained 21 percent. Hydro will dominate in renewable energy with 55 percent, followed by wind (23 percent) and solar (7 percent). Coal and gas facilities in thermal power will share 74 percent and 24 percent, with remained 2 percent for diesel generators.

Table V

TOTAL INVESTMENT REQUIREMENTS FOR POWER INDUSTRY, US$2006 BILLION

	2006-2030 low		high
Total Power and Heat	**6 246**	**–**	**8 436**
Power/Heat generation	3 673	–	4 924
Transmission lines	2 016	–	2 787
Distribution of electricity and heat	552	–	726

Source: [5]

Generation of electricity and heat will dominate within industry's investment requirements at 58 percent, while development and refurbishment of high voltage transmission lines will take 33 percent, and remaining 9 percent will be invested in electricity and heat distribution networks (table VI).

Table VI

POWER INDUSTRY INVESTMENT REQUIREMENTS BY REGION, US$2006 PERCENT

	Generation	Transmission	Distribution
APEC	**58**	**33**	**9**
NE Asia	65	23	12
SE Asia	42	45	14
Oceania	47	44	9
Americas	59	36	5
China	64	25	11
Russia	46	47	6

Source: [5]

D.International energy trade

Some US$2006 0.4 – 0.5 trillion needs to be invested for energy trade infrastructure between APEC member economies only, such as transportation of crude oil and petroleum products, coal and natural gas. Three-fourth of this investments shell goes into the LNG business, including liquefaction, transportation, and regasification facilities. To estimate total investment requirements for secure energy supply, facilities outside the APEC region should be accounted.

APEC member economies should invest US$2006 1.3 – 1.8 trillion in 2006-2030 to meet energy import requirements, with 40 percent of them in the Middle East, Africa and Latin America. Oil and gas exploration and production will require US$2006 0.4 – 0.5 trillion, and additional US$2006 0.1 – 0.2 trillion for energy transportation. Infrastructure development and refurbishment to ship coal from APEC region to Europe will need 2 to 3 billion dollars (table VII).

Table VII

TOTAL INVESTMENT REQUIREMENTS FOR INTERNATIONAL TRADE INFRASTRUCTURE DEVELOPMENT IN THE APEC REGION, US$2006 BILLION

	2006-2030 low		high
Within APEC region	384	–	539
Oil	87	–	112
Gas	291	–	418
Coal	6	–	8
Outside APEC region	496	–	672
Oil	372	–	503
Gas	123	–	167
Coal	2	–	3

Source: [5]

Energy investments in **mid- and downstream** of energy supply chain (that is, transformation, transportation and distribution of energy) **as a percent of cumulative GDP** within APEC region for most economies **fall in the range of 0.6 percent (low end of specific investment range) to 1.2 percent (the upper end of this range, or high case) of GDP, regardless energy infrastructure maturity**. The average for APEC region share of mid- and downstream investments to the cumulative GDP over period of 2006-2030 is 0.9 percent (table VIII). It should be noted that the GDP and investment are use different methodologies for measurements – GDP units are US dollars of the 2006 purchasing power parity (US$2006 PPP), while energy investments have been calculated directly in 2006 US dollars (US$2006) through appropriate current exchange rates, when applicable. However, there is opportunity to compare by applying PPP coefficients calculated by WB.

Meanwhile, the key conclusion still stands: only a small share of GDP will be required to

secure energy supply investments. Extreme case of almost 9 percent for Brunei only emphasize economy's overreliance on oil and gas export, and did not pose any risk of underinvestment to domestic energy supply security. In case of Russia, less than 3 percent seems reasonable, considering needs to refurbish and improve economy's enormous heat supply systems, in addition for powering domestic economy and for development of transport infrastructure to support world's top energy export flows.

Table VIII

SHARE OF ENERGY INVESTMENTS (HIGH CASE) IN CUMULATIVE GDP FOR APEC MEMBER ECONOMIES AND SUBREGIONS, IN PERCENT

	mid- and downstream/ cumulative GDP	upstream/ cumulative GDP
Australia	1,10%	1,19%
Brunei	8,58%	8,07%
Canada	1,41%	0,41%
Chile	0,90%	0,01%
China	1,05%	0,21%
Hong Kong, China	0,14%	-
Indonesia	0,80%	0,45%
Japan	0,63%	-
Korea	0,74%	-
Malaysia	0,98%	0,61%
Mexico	0,64%	0,40%
New Zealand	1,23%	0,16%
Papua New Guinea	1,96%	0,85%
Peru	0,69%	0,06%
Philippines	0,87%	0,02%
Russia	2,75%	0,76%
Singapore	0,96%	-
Chinese Taipei	0,79%	-
Thailand	0,71%	0,15%
United States	0,68%	0,17%
Vietnam	1,32%	0,29%
APEC	**0,94%**	**0,23%**
NE Asia	*0,65%*	-
SE Asia	*0,90%*	*0,33%*
Oceania	*1,13%*	*1,06%*
Americas	*0,73%*	*0,21%*

Source: [1]

The key problem APEC member economies are facing – if investment needs to develop energy infrastructure will be met by proper and timely financing?

E.Financing energy investments

Energy-related projects are distinguished by their capital intensity and long construction lead times. They are also vulnerable to construction and operating cost risks, costs of project financing and economy's money lending. **Robust regulatory regime and financial mechanisms** are important preconditions to foster a stable investment climate and favour returns on investment reflective of the high degree of risk often involved. The necessity of such preconditions for adequate investment becomes even greater when economic, financial crisis and energy price vulnerability exaggerate risks for investors – there are many delays or cancels of energy projects around a world in last two years. Given the long lead times required by energy projects, these cutbacks pose a risk that energy supplies could be inadequate as the economic recovers. In this case, a recovery could cause energy prices to spike, dampening the recovery. On the other hand, freezing money for such risky spare capacities will also raise prices for energy consumers. APEC governments will need to tread wisely to assure that an adequate flow of energy investment is maintained, while avoiding unnecessary investments.

The cost of energy extraction/production and energy supply for all APEC members is within reasonable range. Despite the wide scale of energy demand and primary energy extraction/production, energy investments fits rather narrow range of 25 – 63 US$2006 per toe (fig. 5). This is corresponding to 5 – 10 percent of crude oil benchmark price in August of 2010.

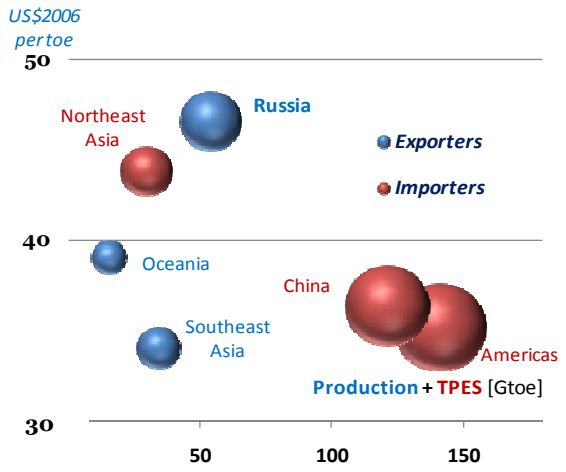

Fig. 5. Specific investments per total energy supply and energy production by APEC subregions

The major theme for international cooperation should be mechanisms to ensure fair access to finite energy resources, appropriate energy pricing and smooth transition to already foreseeable non-fossil based energy supply systems. However, there is lack of sound international projections where the cost/benefit analysis is made to evaluate different mechanisms for such transition, leaving so-called "carbon pricing" as the only option.

APEC region is not self sufficient in oil and its dependence on imported oil will only increase in the future, that is why crude oil supply security is considered as a cornerstone of the energy security cooperation.

Adequate upstream investments became one of the major instruments to address security challenges. International regulatory framework was not efficient enough to prevent impact of price volatility and temporary demand decline on upstream projects delay. Natural gas supply security emerged recently, as APEC region is supposed to become natural gas importer in a near future. However, due to advanced technologies unconventional gas emerge in the market, which increase uncertainties and bring re-evaluation of risk assessment for investors along the whole gas supply chain. Coal supply is of much less concerns due to its abandons in the APEC region and relatively small capital intensity of the industry.

Recent rise in protectionism, concerns on future access to remaining resources of cheap and "clean" energy, financial system restructuring, and current global economic crisis provides solid basis for inception of several fresh initiatives on international energy cooperation in the APEC region. International institutional framework should be amended in a way to facilitate market signals transparency along the energy supply chains and to ensure reliable capital flow from consumers to producers. Energy pricing mechanisms lay in the foundation of such framework, and all involved actors – governments, academia, non-profit organisations, media, not mentioning business should put their efforts to enhance cooperative activity on this issue.

Energy pricing is a cornerstone for synchronisation of domestic and international regulatory frameworks and financial mechanisms to create appropriate energy investment environment. Combating climate change and mitigation of GHG emissions is current mainstream of energy policy. Naturally, it is reduced to the "low carbon energy" issue and pricing carbon emissions. Without disputing the validity of this approach, it should be noted that it misses to address essential problem – market mechanism to incorporate [depleting fossil energy] resource rent into energy price.

Two example cases was made to illustrate the scale of uncertainty and it costs to investors. In each case two issues are addressed simultaneously under alternative policy options – to quantify the uncertainty of future demand for different types of primary energy (the effect of fossil fuels substitution by advanced technologies and renewable energy), and to estimate investments for energy supply infrastructure development.

First case study is estimation of the coordinated policy to curb GHG emissions in West Pacific Area on regional energy trade and cost effectiveness of such policy. Second case study is cost estimation of accelerated pace of renewable energy development in China.

The value of such analysis are to bring quantitative estimations for in-depth analysis of new energy pricing mechanisms, and for new approaches developing to reduce uncertainties of the various energy policy options implementation.

III. INTRODUCTION OF EXTERNALITY COST ON POWER GENERATION IN WEST PACIFIC AREA

Russia and Australia are among top energy exporters (fig. 6), and uncertainties of energy demand development affects greatly not only on energy investments, but economic growth of energy exporters.

The study's objective is to assess the scale of demand side uncertainties the coal and gas industry is facing under Climate Change

mitigation policies (or they absence) in West Pacific Area (West Pacific Area include China, East Asia subregion, Southeast Asia and Oceania – combined to SPA subregion).

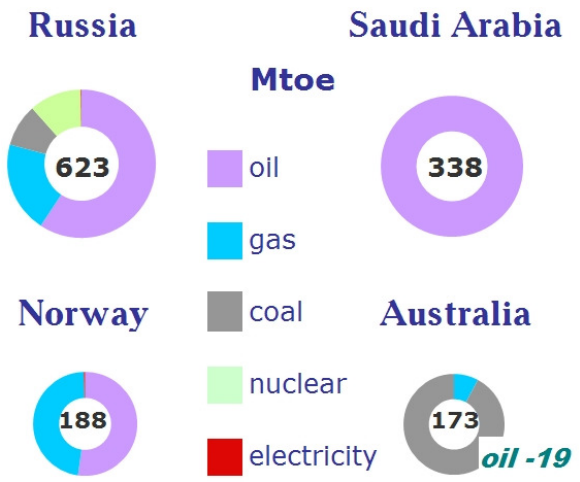

Fig. 6. Four top net energy exporters in 2009, Mtoe

Source: [6]

Multiregional least-cost optimisation model was developed [6], and several simplifying assumptions was made:

- Power generation should be the major actor for GHG emissions mitigation mechanism. Other sectors could make reductions only by 20 percent of respective current emission intensity levels, at their best.
- CCS costs include CO_2 capture at power generation site, but did not include transportation and storage of CO_2.
- There is only one-way interaction of economy and power industry, so that no structural economic changes are considered, and no final energy (electricity) demand changes are expected, as power generation turned to became less carbon-intensive, and more renewable energy is incorporated into the energy supply chain.
- There are no changes for transmission lines losses while generation structure is changing.
- Total investments include cost of additional or avoided facilities for electricity generation, including CCS for coal and gas power plants, extraction and transportation infrastructure.
- Basic power load provide some 80 to 85 percent of the total electricity consumption. This power load could be met by production at coal power plants (which might be equipped with CCS facilities), natural gas (might be equipped with CCS facilities), nuclear, or large scale renewable energy power plants, such as solar PV in desert areas, or hybrid solar and gas generation, or wind (both onshore and offshore), marine, *etc*.

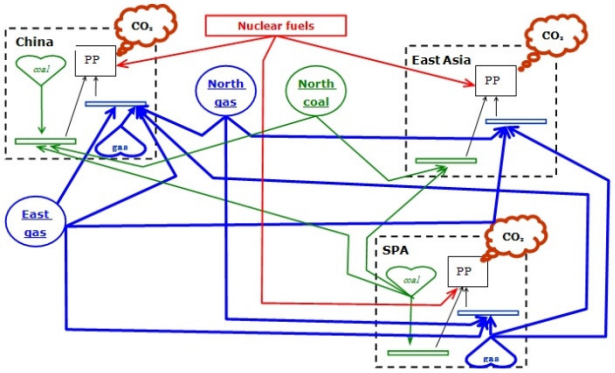

Fig. 7. Structure of the least-cost multiregional optimisation model for GHG emissions mitigation in West Pacific Area

Table IX

GHG REDUCTION TARGETS, MT CO_2

	1	2	3	4	5
China	1086	1808	2412	5314*	4800
East Asia	346	656	844	685	950
SPA	206	417	528	694	1150

*Note: *Reduction of the GDP CO_2 intensity by 50 percent for China actually leads to actual increase of CO_2 target level in comparison to BAU case, if economic structure is not changed*

The power industry's possible emission targets for GHG in West Pacific area in 2030 (table IX) was calculated under following assumptions [in merit of absolute values]:

1. 30 % to 2005 High (slow GHG mitigation progress in economic sectors)
2. 30 % to 2005 Low (fast progress for GHG mitigation in industry, transportation and other economic sectors)
3. Same as 2005 (emissions intensity freezing both for power generation and other sectors)
4. GDP energy intensity 50 % less to 2005 (same shares of CO_2 emission reduction for power generation and other sectors are

applied, which are two times less in 2030 than recorded for 2005)

5. BAU (APERC Energy Demand and Supply Outlook scenario)

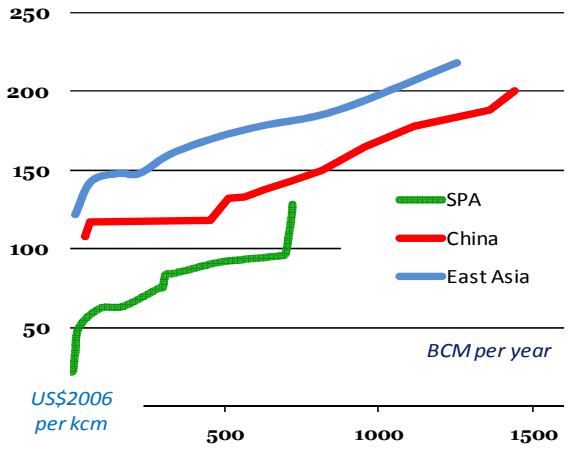

Fig. 8. Natural gas supply cost curves in West Pacific Area in 2030, US$2006 per thousand cubic meter of natural gas

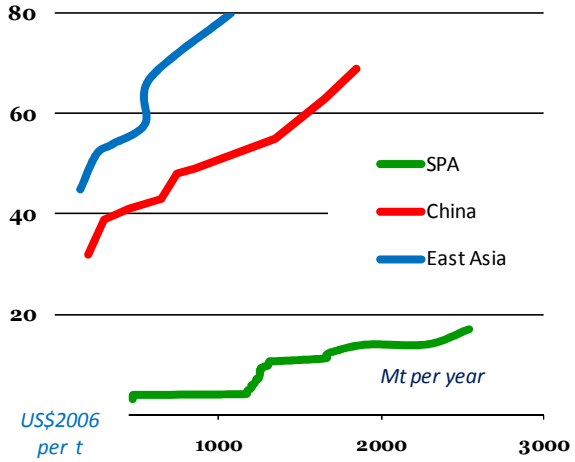

Fig. 9. Coal supply cost curves in West Pacific Area in 2030, US$2006 per tonne

The in-depth analysis of the case study leads to the following major results:

- East Asia is eager to use gas for power generation regardless of GHG mitigation policies. Incremental demand for natural gas in 2030 is 21 to 41 BCM per year.
- China will need additional 100 to 150 BCM of natural gas in 2030.
- South Pacific Area will reduce natural gas consumption because CCS-topped coal generation will take advantage in SPA region due to domestic cheap coal, while SPA gas export to East Asia is very competitive to that from the North Pacific. SPA is the only region where combine cycle gas generation should be topped with CCS technology.

Calculated as difference between the 1st and 5th cases, 870 MT of coal less and 358 BCM of natural gas more should be traded in 2030; more than 1528 US$2006 billion should be invested in advanced power generation and renewable technologies in 2006-2030. Average additional cost for GHG reduction is within range of 25 to 31 US$2006 per ton of CO_2. This indicator is in correlation to the current investment cost of energy supply under baseline scenario, presented above.

IV. ACCELERATED PACE OF NRE DEVELOPMENT IN CHINA

The study's objective is to assess the scale of additional investments and energy markets impact under the alternative electricity supply scenario for China in case of higher pace of renewable energy penetration. The assumptions used for this scenario was based on recently published compilation of leading Chinese researches analysis to address sustainable energy development up to 2050 [9]. Considerable difference in Chinese power generation structure for 2030 was determined when APERC projections (BAU) and alternative electricity supply scenario (AESS) has been compared (table X).

Table X

COMPARISON OF BAU AND ALTERNATIVE ELECTRICITY SUPPLY SCENARIO (AESS) FOR CHINA, POWER GENERATION CAPACITIES IN 2030, GW

	BAU	AESS	Difference AESS-BAU
Conventional	**971.0**	**960.9**	**-10.1**
Coal	513.8	404.5	-109.3
Oil	2.0	1.6	-0.4
Natural Gas	15.2	47.7	32.5
Hydro	320.0	355.0	35.0
Nuclear	120.0	152.0	32.0
Renewable	**111.3**	**194.0**	**82.7**
Geothermal	4.0	6.0	2.0
Solar	3.3	15.0	11.7
Wind	100.0	165.0	65.0
Others	4.0	8.0	4.0

Average thermal efficiency for coal and natural gas-based power plants under AESS are

projected to be higher than for BAU scenario due to higher rates of advanced technologies introduction (table XI).

Table XI

COMPARISON OF POWER PLANTS THERMAL EFFICIENCY FOR BAU AND AESS, PERCENT

	BAU	AESS	Difference AESS-BAU
Coal	33.9	35.3	+1.4
Oil	38.7	38.7	0
Gas	42.2	48.9	+6.7

Total nameplate capacities under AESS scenario is 73 GW higher then under BAU scenario, although there is the same amount of electricity production in 2030. Energy input to thermal power plants under AESS scenario will require 1050 million tonne of coal less and 72 billion cubic meter more of natural gas than under BAU scenario. Total energy investment will be 0.5-0.7 US$2006 trillion higher: apart of power industry enormous investments, Chinese coal industry will lose some 12 percent of investments (58 to 79 US$2006 billion) up to 2030, while for expansion of gas supply chain additional 67 to 98 US$2006 billion will be required (table XII).

Table XII

CHANGES IN ENERGY INVESTMENTS FOR BAU AND AESS, US$2006 BILLION

	low		high
Total investments	**524**	–	**730**
by energy supply chain			
Extraction	-58	–	-79
Transformation	555	–	768
Transportation	33	–	48
Distribution	-6	–	-7
by energy type			
Coal	-64	–	-86
Oil/petroleum	0	–	0
Gas	21	–	31
Electricity/heat	567	–	785

Wind and hydroelectricity will gain the major benefits, swallowing respectively 78 – 117 and 74 – 116 UD$2006 billion additionally up to 2030. Significant shift in electricity generation structure will lead to 11.2 percent reduction of CO_2 emissions in 2030, while cumulative emissions for 2006-2030 period will be reduced only by 8.1 percent.

Estimation range for GHG reduction shows additional cost in 34 to 48 US$2006 per ton of CO_2, which is also in the same order of magnitude with cost of energy supply under BAU and AESS case study on power industry's GHG mitigation within West Pacific Area, described above.

V. IMPLICATIONS ON INTERNATIONAL ENERGY COOPERATION

The Bogor Goals was adopted by APEC Leaders in 1994 in Bogor, Indonesia [10]. That Bogor Goals aim **for free and open trade and investment in the Asia-Pacific by 2010 for industrialised economies and by 2020 for developing economies**. To meet the Bogor Goals, APEC carries out work in three main areas: a) trade and investment liberalisation b) business facilitation c) economic and technical cooperation. However, **approaches** currently used to develop so-called "low carbon energy supply for sustainable economy" **seems not to be of the market-driven nature, but rather by means of almost abandoned central planning economy:** compulsory long-term targets (for renewable energy), non-transparent tax or fees (on carbon emissions, as it refers to uncontrolled "global temperature"), and long-term subsidies and cross-subsidies (complex web of that within energy-related business).

Critical uncertainties, which will affect energy investments and international energy trade in the APEC region, could be reduced to the issues within three topics:

- future energy demand,
- security of oil (and much likely natural gas) supply,
- renewable energy development and climate change deterrent as roadmap to member economy's sustainable development.

The short list of well-known uncertainties within these topics is presented with references to appropriate mechanism (or its absence) in a table XIII.

Table XIII

ISSUES THAT BRINGS UNCERTAINTY FOR INVESTORS [DECISION MAKERS][2]

Topic and related uncertainties to energy trade and investments	**Current mechanism/activity in APEC region to address uncertainty issue (*examples*)**
Energy Demand – *driven by economic activity, dependent on economic structure and energy security regulation, environment and "climate change combating"*	
The current ***global financial system crisis*** poses challenges to the APEC economies. A ***globalisation process*** needs synchronisation within economies to reduce uncertainties on future development. Synergy of double financial system and economic crisis ***impact on energy demand: expectations of lower energy demand***, ***difficulties to obtain proper financing***, ***volatile prices***.	"*UN … unveiled a new panel on global sustainability that is tasked with finding ways to lift people out of poverty while tackling climate change and ensuring that economic development is environmentally friendly*" [3] APEC Leaders and Senior Officials Meetings; processes within G7, G8, G20, BRIC, WTO, WB, *etc*. "*APEC Energy Demand and Supply Outlook*" report provide quantitative analysis based on business-as-usual projections up to 20-25 years.
Uncertainties of the ***pace of energy efficiency and energy conservation*** policy implementation	Expert Group on Energy Efficiency & Conservation under EWG (information sharing and capacity building).
Energy security– "dependence on politically unstable regimes", "resource nationalism", *etc*	
Uncertainties considering ***regulation of energy import/export***, "*long-term cooperation in energy infrastructure, natural gas (including LNG), energy efficiency, clean fossil energy (including carbon capture and geological sequestration), renewable energy and hydrogen and fuel cells*".	Energy security initiative ("*a series of short-term measures to respond to temporary energy supply disruptions, and longer-term measures to address the broader energy challenges*"); IEA, GECF, *etc*.
Uncertainties for natural gas market development by ***advanced technologies to extract unconventional natural gas***. Expansion of resource base, much more even resource distribution within economies, unclear environmental impact, while promising high expectations on extraction growth leading to major gas markets restructuring.	Unconventional Gas Census under EWG ("*to evaluate the potential of unconventional resources and to recommend cooperative actions which could increase natural gas output, boost natural gas trade and use, and moderate natural gas prices to the extent appropriate both for producers and consumers in the APEC region*"), instruction of the EMM9 meeting in Fukui, Japan in June 2010.
Renewable Energy – *dependences on subsidies, regulation, policies*	
Uncertainties for renewable energy development ***due to impact of financial and economic crisis, delayed binding regulation on GHG emissions***. Also induce uncertainties on future demand for fossil fuels and nuclear energy.	Expert Group on New and Renewable Energy Technologies under EWG ("*to facilitate an increase in the use of new and renewable energy technologies*"; information sharing and capacity building).
Climate Change – *policy development and regulation implementation processes has been delaying since 1997 Kyoto Protocol introduction*	
Unclear identification of ***market approaches*** to: a) energy prices transparency and carbon pricing impact on GHG emissions, b) increasing share of already extracted finite resources of oil, gas and coal. ***Lack of economy-scale cost-benefit analysis and uncertainties*** of non-binding, contingent pledges to constrain GHG emissions.	As the latest example – promotion of the APEC's *Low-Carbon Model Town Project*, declared in Fukui, Japan at the EMM9 meeting in June 2010.

[2] *Extensive, in-depth report on international energy cooperation in the APEC region is available* [11]

[3] [12]

A.The major sources of uncertainties

The most important for international energy trade and energy investments, but also the least identifiable, are uncertainties related to the **shift of the long-term economic development paradigm and "mitigation of the climate change"**. Obviously, it creates vague projections for energy demand, both in structural and quantitative ends. Emerging of **unconventional gas supply** might bring fresh actors and transform three main established gas markets. There still exist a risk for sudden **changes in energy import/export regulation** either for exporters (OPEC, *etc*.), or importers (USA, IEA, *etc*.) as a reflections on international or domestic political events. The pace of **renewable energy development** is another big "if", which is emanated after the intertwined challenges posed by above-mentioned issues. Investment estimations for BAU scenario and case studies in chapters 2 – 4 shows that energy investments over next decades in the APEC region are in an order of trillions US$2006, while facing risks posed by various and even increasing uncertainties. The cost of such policy options implementation could amount to almost 10 – 20 percent of total investments.

Political debate on energy supply security is top agenda in the APEC, since Energy Security Initiative was endorsed by the EWG in September 2001, and by APEC Economic Leaders in October 2001. However, **the issue of relationship between finite resources of hydrocarbons and pricing mechanisms on internationally traded oil and gas is not considered currently in any international organisation**. This issue seems to be the centre of political debate after entering into political lexicon, and should bring better qualitative and quantitative understanding to the long-term projections of energy demand and supply, as it will help to commercialise renewable energy and advanced technologies for unconventional resources extraction.

The absence of proper energy price transparency brings the other source of uncertainties to energy trade and investment. **Appropriate energy pricing** will create market mechanisms to consider resource depletion, eliminate government subsidies and cross-subsidies, improve confidence in accessibility to energy resources, and reduce uncertainty for investments on advanced energy technologies and renewable energy.

B.Russia's interest in energy cooperation

Russia has made tremendous progress in expanding energy export to Asia-Pacific RIM in recent years. Operators of Sakhalin PSA start export of high-grade crude and LNG to the top world oil importers – USA, China, Japan, and fast developing Asian economies. Yet under construction East Siberia – Pacific Ocean oil pipeline is already delivering million tonnes of sweet crude to Kozmino export terminal. First stage of huge development plan to build backbone gas trunk lines in east of Russia is implementing in the Russian Far East.

In general, this activity is only a start to create an export-oriented energy extraction, processing, transportation and transformation industry in vast areas of East Siberia and Russian Far East, which will be soon comparable to that currently operational in the European part of Russia. For sure, such development will need international cooperation for smooth adaptation of Asia-Pacific energy markets to "tsunami" of energy flow from Russia, fair business access to opportunities on both ends of the energy supply chain, and robust financial mechanisms to saturate enormous investment needs for coming decades. That is why Russia is so sensitive to the uncertainties on long-term energy demand, and close cooperation with concerned economies around Pacific to establish transparent and stable regime for energy trade and energy investments in the region.

VI. CONCLUSIONS

The assessment of the energy trade and energy investments scale in the APEC region up to 2030 is made – under BAU scenario, and two case studies. The major uncertainties are identified which will influence long-term energy trade projections and increase energy investment risks. The explanation is given for the Russian Federation's driving forces and

objectives to cooperate upon energy issues within Pacific RIM.

VII. BIOGRAPHY

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Graduated from the Irkutsk State Technical University in 1982, he received Candidate of Technical Sciences Degree from the Siberian Energy Institute of the Russian Academy of Sciences in 1993. He has been with ESI SB RAS almost for 30 years, and is concentrating research interests on domestic and international energy policy for the Russian Asia regions. This includes tools to support decision-making, in-depth research of issues on renewable energy, environment, international energy markets and energy cooperation options in the Asia Pacific Region.

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