Inf'OSE

MINES ParisTech

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Special Edition

Include the conference report on:

Sustainable Energy

with: **Ajou University**
Kyoto University
MINES ParisTech School

Editorial

Six months ago, we gathered in Sophia Antipolis from all over the country, coming in with different backgrounds, and eager to learn more about the world of energy. And the knowledge that we were given exceeded our expectations, however high they might have been.

Time has come to put this knowledge into practice. But before we enroll in our respective internships, one last enriching experience was headed our way: A business trip to South Korea.

In this edition, we will relive the fascinating episodes of our adventure together, in a country blessed with wondrous nature and a proud culture of innovation.

Reda BOUIJ

Summary

A short introduction to South Korea

Split in half since 1948 by the sadly famous 38th parallel, South Korea is now one of the most important world economic state. Its develloppement began in the 70's and is one of the quickest ever happened. In few decades, South korea has moved from Third World Nation status to one of the most industrial Asian country. Korean toke good avantage of the economic globalisation by diversified and internatiolized its exchanges with the western countries. More than its unusual economic growth, South Korea has proven by its culture and its personnality that it is one of the world leader country

Few dates of Korean history :

- ***Genesis:*** *people comming from Mandchourie and North China established in Korea, The country was split in 3 different kingdoms.*
- ***Near 735:*** *Country unification under the Silla kingdom.*
- ***1231 - 1294:*** *Mongolian occupation.*
- ***1910 - 15th August 1945:*** *Japanese occupation.*
- ***1945:*** *Korea separeted between North and South by the 38th parallèle*
- ***1950 - 1953:*** *Korea War*
- ***1954 - 1960:*** *Rhee Syngman Gouvernment*
- ***1963 - 1979:*** *Park Chung-Hee Gouvernment*
- ***1980 -1987:*** *Chun Doo-Hwan gouvernment*
- ***25th february 2013:*** *Park Geun-Hye president toke her function*

A strong economy built through six decades of efforts

South Korea is one of the four countries known as the Asian Dragons of the 20th century. Selected following their economic foot print in the world, these countries have known spectacular growth in their economy during the second half of the century. In fact, South Korean GDP, comparable to those of some poor African and Asian countries in the 60's, exceeded in 2007 the GDP of several countries in the European Union such as Portugal. In 2008, South Korea had the 13th most powerful economy in the world. This economy, driven by International Trade, was ranked 11th and 13th internationally in terms of total exports and imports. These rankings are even better if the European internal exchange flows are excluded. In this case, South Korea comes 6th and the 7th, and plays therefore a fundamental role in the world's commerce and economy. In the late 80's, the economy benefited from close relations between the government and the local businesses. An appropriate financing strategy, restrictions on imports and subventions to certain industries from public funds were all the pillars of a very successful stimulus to the economy. These years knew a clear orientation towards imports of commodities at the cost of consumption goods and the government encouraged savings and investments to the detriment of consumption. Korean citizens supported very largely this economic revolution. In fact, an important and effective labor was a key element in bringing South Korea to the scale of developed countries.

An economic development model in continuous reform

The crisis that stoke the Asian countries in the late 90's was a very difficult test that eluded the weaknesses of Korean development model. Strong dependence on foreign loans, an ineffective financial sector and the indebted structure of the economy made it vulnerable. In fact, the economic growth plunged by 6.6 bps in 1998 even if it recovered by 10.8 bps and 9.2 bps in the next two years. In 2001, the world's global economy growth slowed down driving a Korean economy based on exports to 3.3%. However, an emphasis on the construction industry enabled the national economy to regain a dynamic growth of 5.8% in 2002 although the world's economy knew an anemic growth in this same year. In 2007, the national economy continued to show a steady growth of 5%. Historically based on exportation, South Korea stayed during four decades dependant on the North-American market. The recent evolution aimed particularly to decrease this concentration by diversifying the country's commercial partners all over the world. The commerce with China has been developed to make of South Korea the 3rd supplier of the republic that is the destination of 22% of the total Korean exports in 2007. The second biggest client of South Korea was the European Union with 15.1% of exports before the United States, which hogged for a long time a major stake of Korean exports, with only 12.4%. Further diversification has been reached through bilateral free exchange conventions signed with countries such as Chili and Singapore as well as the global

economic partnership with India. Finally, South Korea is a member of the Asia-Pacific Economic Cooperation (APEC).

Electricity

South Korea produced 417 TWh of electricity in 2009: 65% from a fossil source, 34% from nuclear energy and 1% from renewable energies. The nuclear and clean energy sectors witness an important development thanks to colossal investments made particularly in offshore wind farms. Before its restructuring in 2001, KEPCO used to be a state monopole on the electricity market. In this framework, the company controlled the whole value chain including production, transport, distribution and sale. Later, KEPCO was fragmented into six different divisions of which the state still controls five while the only division made entirely independent is the Korea Hydro & Nuclear Power Co. The activities that remained under the control of KEPCO were the supply, the distribution and the transport of electricity. In 2008, the subsidiaries of KEPCO detained 82% of the production assets even if the 2001 restructuring opened the market to the competition. As a result of the restructuring, the entity KPX (Korea Power Exchange) emerged to manage the electricity exchange in the country. Its role resides in the regulation and the price fixing for exchanges in the market. In fact, the company pricing policy makes sure that the interests of modest households and industrials are protected. Besides, every change in prices needs to be approved by the Korean Ministry of Knowledge Economy.

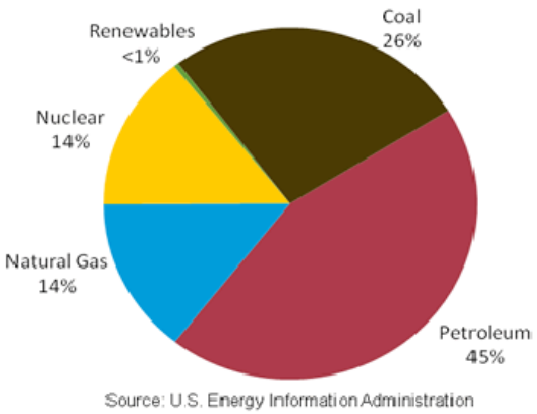
Petroleum

Even though the republic owns several refineries, there are no petroleum sources in the country and it is entirely dependent on the foreign supply. In 2010, the consumption reached 2.2 million barrels per day. The three quarters of these imports are provided by Golf countries with Saudi Arabia as a first supplier with 28% of the total imports. The country uses 50% of this oil in the industrial sector as some activities such as petrochemical industry that is very oil demanding. The Korea National Oil Corporation is the major oil company in the country with a daily production of approximately 300.000 barrels of gas and crude oil in 2012 and with total reserves of 2 billion barrels. These reserves are being operated by production and exploration companies that benefit from government stimulus as fiscal advantages, advantageous credit facilities and diplomatic backup in international negotiations.

Natural Gas

South Korean consumption of natural gas doubled over a decade. This increase was almost entirely covered by imports as the local production only covers 2% of the total consumption. The imports of natural gas are exclusively in the form LNG as the country is linked to no pipeline network. The consumption of natural gas reached 42.5 cubic meters in 2010, 25% more than 2009 and 34% of the total consumption go to electricity production. On the one hand, the chain of gas upstream is managed by Korea Gas Corporation, the world's 1st importer of LNG, which is controlled by the state using a direct participation of 26.9% and an indirect participation of 24.5% via KEPCO. On the other hand, the distribution is operated by 30 private firms, obliged to serve each a specific geographical region, and that buy gas from KIGAS at a price determined by the state in order to sell it to final consumers. Since June 2011, gas companies have the authorization to buy gas from refineries in case of winter peak demand periods.

South Korea's Total Primary Energy Consumption by Type, 2008



Source: U.S. Energy Information Administration

Nuclear energy

South Korea has the world's 6th powerful nuclear structure. The first rector was started in 1978 and since then, the country multiplies investments in order to develop its nuclear capacity. Korea Hydro & Nuclear Power & Co detains four plants for a total of 20 reactors. Furthermore, 14 new reactors are to be added by 2024 in order to attain an objective of 50% of total production from a nuclear source. Driven by its ambition to be a reference in nuclear technology, South Korea signed a contract of 20 billion dollars with the UAE for the construction of four 1400 MW reactors.

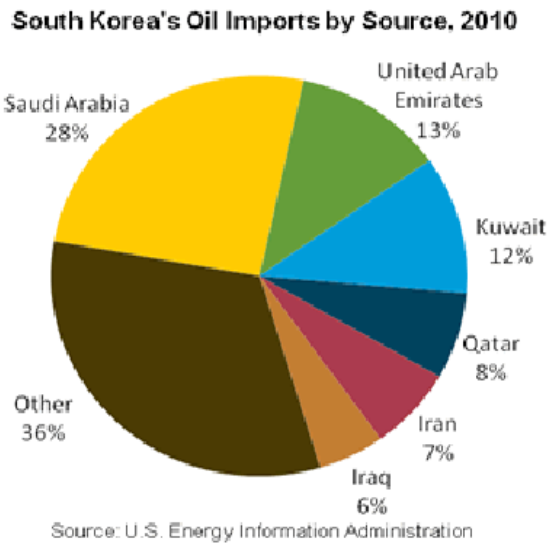
Coal

The reserves of coal in the country are far insufficient to cover the local demand. In fact, South Korean coal reserves are estimated to 139 million tons while the consumption in 2010 reached 126 million tons. Therefore, the country has an approximate yearly production of 3 million tons while the rest of demand is satisfied by imports. As the world's 3rd country in coal importation, South Korea is mainly supplied by Australia and Indonesia. The local consumption increased by 33% between 2005 and 2010 mainly driven by the rise of electrical energy demand.

The sustainable development at the heart of economic strategies

In August 2008, the South Korean president Myung-bak announced an economic boost program essentially

based on renewable energies and baptized "Low Carbone, Green Growth". This program was without doubt the most ambitious by allocating 80% of the 38.1 billion dollar financing funds to the green economy. This included the manufacturing of low carbon emission vehicles, the construction of environment friendly constructions, a green transport network and the protection of environment. The government is aiming to boost the economic wheel and decrease unemployment in a frame of sustainability and environment preservation. This work was essentially motivated by fears related to the energetic dependence of the country as it is not a producer of fossil energy. Hence, the program plans to build 30 nuclear plants by 2030 and includes several works in hydraulic sites. Nonetheless, the opinions on this new program remain much mitigated. In fact, this last element was by the political parties in 2010 and therefore the following budget could not be accepted. The opposition to this project is mainly backed by ecological organizations that believe some parts of the new program would lead to a "grey growth" rather than a "green growth".



The South Korean energy sector dependant on imports, an incentive to develop new energies

Roadmap

Monday 25th march (Seoul)

KSGI – Korean Smart Grid Institute
KepCo - Korea Electric Power Corporation
KPX Korea Power Exchange

Thuesday 26th march (Pusan)

KEMCO – Korea Energy Management Corporation
LG Chemical Electric battery factory

Wednesday 27th march (Pusan)

KHNP - Korea Hydro & Nuclear Power Co., Ltd
Doosan heavy industry

Thursday 28th march (Seoul)

SEDC - Seoul Energy Dream Center Songdo City
Sihwa Usine Maréemotrice

Friday 29th march (Seoul)

Université Ajou Symposium

Chiffres clés

Population	48 754 657 (2011)
Density	488 hab/km^2
GDP	1,356 billion $ (13th world ranking)
IWD	0,897 (15th world ranking)
Electricity consumption (per year)	481,7 TWh (2012)
Coal production (per year)	2,8 million de tons (2010)
Coal consumption (per year)	126 million de tons (2010)
Proven recoverable coal reserves (per year)	139 millions de tons
Oil consumption (per year)	104,8 million de tons
Oil refinery capacity (per day)	2,6 million barils
Hydroelectric installed infrastructure	4.84 MW

Day 1 : KSGI, KEPCO and KPX

Korean Smart Grid Institut

The 25th of mars morning we had the chance to learn about Korean ambitions in Smart Grids thanks to a visit to KSGI.

The Korea Smart Grid Institute (KSGI) was launched in August 2009 as the secretariat of Smart Grid Initiative and projects. This institute, affiliated to the Ministry of Economy and Knowledge, replaced the Power IT Institute created in 2007. The Smart Grid Initiative mainly targets the modernization of electric power systems, the improvement of the quality of life and the stimulation of growth.

In terms of area (99,720 km²) and population (51 million inhabitants), South Korea is quite small. But in terms of energy South Korea is one of the 10 biggest. The energy demand and dependence (97% in 2008) have been increasing in recent years. Korea is also aware of the necessity of enhancing energy efficiency, tackling climate change, and triggering a green energy revolution. To face this growing challenge, President Lee Myung-Bak announced in August 15, 2008, Korea's new national vision "Green Growth, Low Carbon". To implement this vision KSGI was established. KSGI's challenges are to manage comprehensively the government's Smart Grid roadmap, operate a Smart Grid test-bed in a pilot city and extend other policy support for Smart Grid related issues.

Numerous results are expected. A major one is jobs creation. By 2030, 50,000 jobs will be created in the areas of renewable energy, electric vehicle, power grid and energy consumption. The 230 million tons reduction of the greenhouse gases emissions by 2030 is also a top target. Unfortunately this objective is not communicated as a percentage of the current emissions amount. The Smart Grid will also limit energy imports and avoid new power plants constructions.

To achieve those ambitious objectives, a roadmap was unveiled in February 2009. The Smart Grid will play a major role in five areas: power grid, buildings, transport, renewable energy and electric services. In each area, the implementation process is divided in three phases. The first one, the pilot phase, will end by 2013. The second one, the smart grids spread, will last until 2020. Finally, the last one, the implementation of smart grids in a national scale, is scheduled for 2030.

The Smart Grids' philosophy is to promote interactions between consumers and suppliers and to offer high quality electricity. Thus the duration of blackout, now 15 minutes per household, may be reduced to only 9 minutes by 2030. In addition, transmission and distribution losses may decrease from 3.9% to 3%.

Energy consumption in the transport sector will be reduced by two strategies. The first one is the spread of electric vehicles from 500 units in 2012 to 2 million in 2030. The first step will be the deployment of charging infrastructures. Then "Vehicle to Grid" technologies and commercialization of electric vehicles will be developed. The second strategy plans to install smart meters, able to measure and record data from consumers and suppliers.

Renewable energy will be integrated into the national plan through management of intermittency infrastructure and construction of low-energy use buildings. Today renewable energy accounts for only 3.1% in the Korean electric mix and Korea merely targets to meet 11% of renewable energy by 2030.

About the consumer, the goal is, once again, to reduce energy consumption. The smart metering technology will be tested and controlled during the first phase. Then smart meters will be marketed and implemented into zero-energy buildings. Finally, regarding the electricity service, the idea is to enable consumers to really act on their energy consumption and their impact on the grid, especially thanks to dynamic electricity prices. Then a real time trade electricity market could be developed.

The implementation of a large scale Smart Grid pilot in Jeju in December 2009 is the first sign of a strong choice to concretely implement those commitments. For a

budget of $250 million, this pilot is the biggest in the world. During the first two years all the project facilities were built. Now the second state consists in evaluating the network integration and assessing the business model.

This project could be a model for the entire world. But issues will also be very interesting to follow…

Clothilde PASCUAL JAOUANI, and Bénédicte VIGNOBOUL

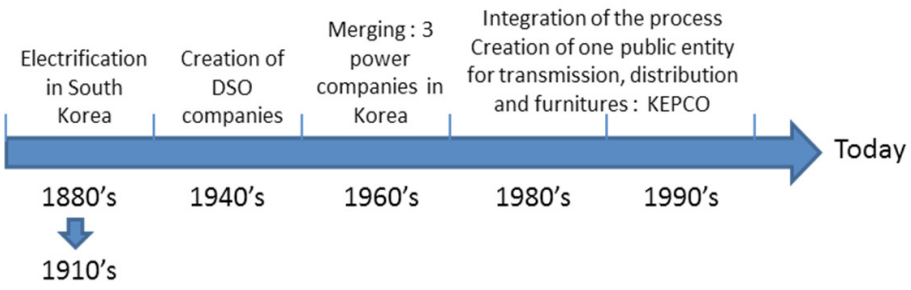
Korean Electric Public Corporation

After KSGI, we visited KEPCO (Korean Electric Public Corporation). We would like to thank them a lot to present us their firm and to receive us greatly, especially M. Kim Jin-Seong, general manager of KEPCO and M. Park Kwon-Sink, vice-president of the firm. We thank everyone that receive us for their kindness, for the time they spend with us and the quality of their presentation.

Electricity in South Korea, as for every developed country in the world, has a great story and many events that explain its recent organization.

As the following scheme shows, Korea electricity story is strongly linked with KEPCO story, needless to say that KEPCO is important for Korea and that its development has significant issues on electricity market and prices.

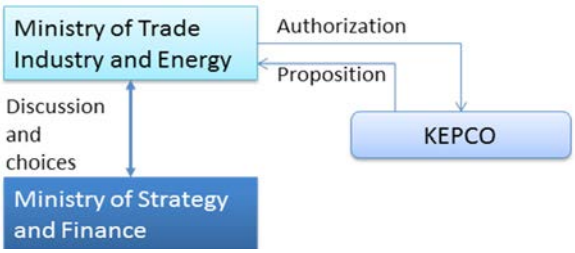
That's why in this article we presented KEPCO, a globalized firm playing an important role in Korea and in Asia. Besides we would like to thank them a lot to present us their firm and to receive us greatly.



History of KEPCO

KEPCO ID

KEPCO is an integrated company of electricity supplies, which had the complete monopoly on the market. KEPCO represents the majority of power generation plants and is the only one operator in transmission and distribution systems.



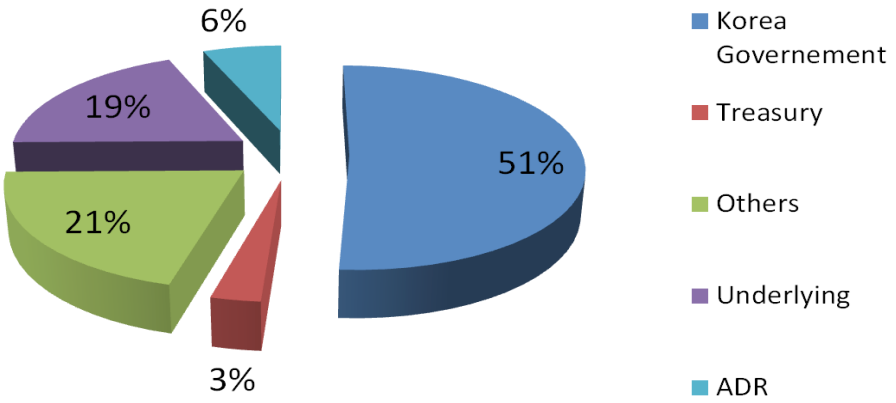
Owning at 51% by the Korean government, the company is partially public and assume public utilities but 25% of shares are owned by foreigners companies.

The governance repartition

According to this governance, KEPCO is monitored by ministries of Energy and Strategy, especially for tariffs choices, as represented here:

Different ministries monitored KEPCO

Nevertheless this is changing: since 2012, the Korean government decided to make a more effi-



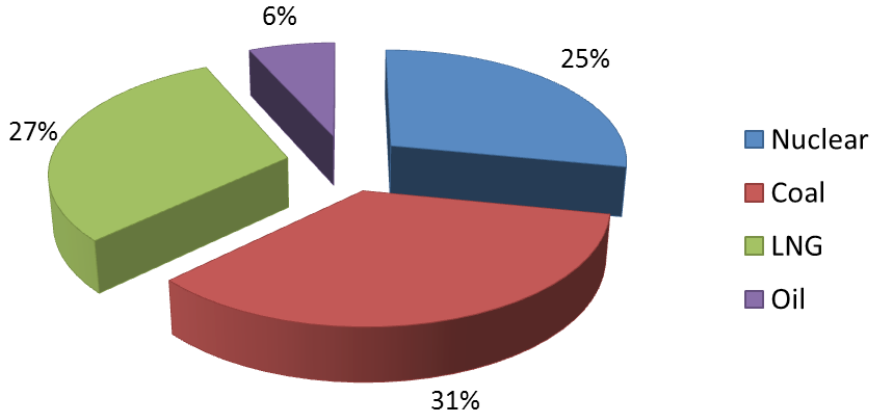
The governance repartition

cient market by compelling competition in the electricity market, in a similar way as it has been done in the European Union.

KEPCO stays however the leader of Korean market. Composed of 6 generation companies (representing 88% of the generation), some affiliates and 7 subsidiaries as for example, KEPCO NF (Nuclear Fuel) and KOWPC, working on Offshore wind power, this firm employs around 20 000 people in the world, working in 27 countries all around it. KEPCO realizes a turnover of 545 billions dollards and develops many projects on technology and innovation in the entire world, especially on nuclear and offshore wind power.

Electricity sources in South Korea: specificities and repartitions

In Korea, many kinds of power plants are used to produce electricity: 508 GWh/year. The following diagram shows this repartition:



The repartition of the plants producing electricity

KEPCO owns the majority of these plants. Besides nuclear plants are really significant: 25 % i.e. 23 plants, which are kept even if Fukushimas' damages in order to keep the security of supplying and low costs of energy and supplies.

Concerning the acceptability of nuclear energy in South Korea in the recent context, M. Park Kwon-Sink explains us that problems of nuclear energy are not recent, there are some no-nuclear groups in Korea, since the beginning of nuclear exploitation but demonstrations have risen up with the tragic accident of Fukushima. Nevertheless the majority of people are aware that electricity is cheap in Korea thanks to the nuclear program, thus people accept to take risks about it. Besides uranium is really well available then problems are really limited to that extent

Coal and Gas are also interesting thanks to the proximity of supplies, however

to reach a decrease of CO_2 emissions by 30 % with such a huge fossil energy utilisation, M. Park Kwon-Sink present us many research that are on the run, especially on "green" coal and carbon capture, making headway in those technologies will allow Korea to reach there objectives.

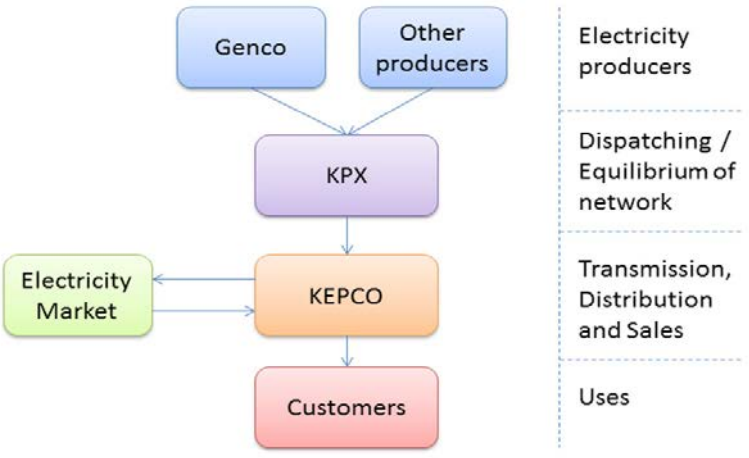
Nevertheless gas became less competitive because Japan imports more and more of it to replace closed nuclear plants.

KEPCO and the electricity market: how it works?

Scheme representing how works the electricity market

GENCO, owned by KEPCO, represents 88 % of the electricity production in the Korean market. All the electricity is sold to KPX which is in charge of the dispatching for transmission and distribution networks and its equilibrium.

Then KPX supplies KEPCO that sell the electricity to customers.



Scheme representing how works the electricity markety

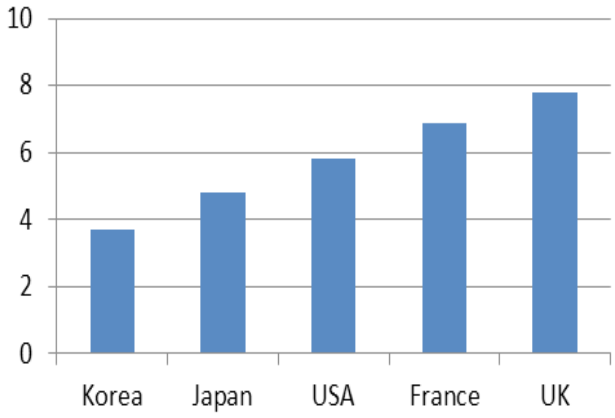
Recent issues and prospective

KEPCO has to tackle several problems linked to its activity:

- They are forced to import resources because in Korea there are no interesting resources on the territory.
- The cost of those resources is really higher than electricity government authorized prices. Thus they had to cope with deficits coming with those differences.

- Concerning renewable energy natural resources are not easily available on Korean territory.

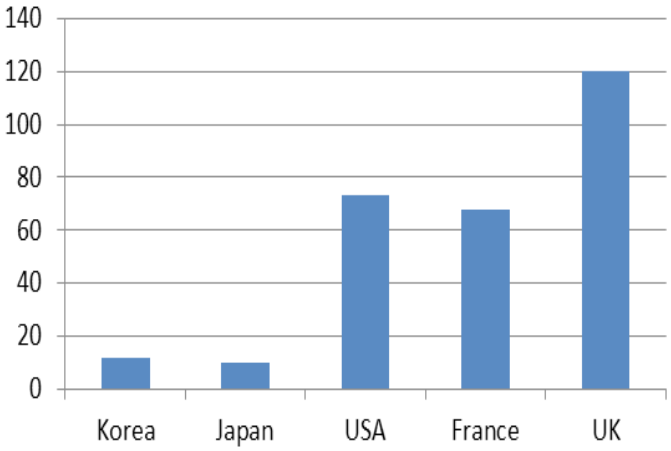
The organization of the electricity market in Korea is almost the same as it was in France before the deletion of the "monitored tariffs" for industrials. Concerning the efficiency of the production, France and Korea are among the most efficient of the world, as shows the loss due to transmission and distribution and also the outage time:



Transmission and distribution losses of electricity network (Data taked from KEPCO Presentation)

According to this point, one question raises up: how will the Smart Grid help KEPCO in its future development?

There are some differences of minds for this subject between KEPCO and government. Until electricity price are regulated, demand response is really low: Smart Grid are not interesting for residential buildings because there are no differences of prices for good users. In the other hand, for one application in management of industrial consumed power, it become much more interesting and offer many possibilities to regulate peaks of electricity demand.



Comparisons of countries performances : Electricity outage time for residential building (Data taked from KEPCO Presentation)

Since the opening to concurrency of electricity market, KEPCO wants to stay a leader in Korea and to grow up in the international market. To make this future real, before 2025, KEPCO would like to develop more and more renewable energy, especially by creating one subsidiary specialized in Offshore for wind energy, the most available renewable resource in South Korea.

Anne KURASIAK and Anne Laure LOUÉDEC

Korean Power eXange

Just after visiting KEPCO we had the opportunity to discover the building of KPX, Korea power exchange. KPX is the electricity stock exchange of south Korea. It has been created following the decision of dividing the historic and fully integrated historical operator: KEPCO. This process first started in the 90's aims at introducing more competitiveness in Korea energy sectors. In 2007 transport, distribution and supplying activities has been separated. Distribution and supply is still the responsibility of Kepco which stay in a situation of mo¬nopoly with 99 % of supplying activity. Competitivness has been introduced in the whole¬sale market.

Mr Se-Cheol Cho who is Public relations and corporate manager has generously welcomed us in KPX building and intro¬duce its activities. KPX has two major goals: ensuring the balance between demand and consumption of the 49 millions of Korean people is continuously meet, and ensuring that power stock exchange is functioning. According to Mr Se-Cheol Cho with a black out time of 10 minutes a year per inhabitant, KPX is one of the most competent operator.

The power stock exchange was made to introduce competitive¬ness between production means and transparency of production activities among Kepco. 96 % of the primary energy is imported in Korea, so there is an urgent need of efficiency. KPX stock exchange deals with futures and day ahead market. Intra-day market or adjustment market are not set up yet. 20 GW are exchanged compare to 80 GW of capacity. KPX establish for each hours in a day the demand and the price of electricity coming from the marginal cost of the last power plant called according to merit order.

We have seen the dispatching center of KPX installed by Alstom and managed by 6 people every day and hours. On the control panel which occupied the entire wall of dispatching centre operators are able to see in real time, all production means over Korea and their availability. Indicators such as failure risks of electricity networks, weather forecast, and power reserves are also available.

After seeing the dispatching center and knowing how electrical network works in South Korea, one question raised up concerning the control of KPX monopoly. In fact, Mr. SE Cheol Cho explained us that Korean government controls directly transmission and distribution networks in order to avoid prices problems and feverish. Besides to assure concurrency on the other working areas of KPX, KPX sells and its concurrence are screened to prevent collusion of the market.

Ghallem ALLAI, Gauthier CADO and Raphaël POULAIN

Some characterisitic on the Korean electric system:

- *Thermic sensibility : 1000 MW/°C*
- *Decreasing of the reserve ratio on the global system: 11,3 % en 2000 -> 5 ,2 % en 2012.*
- *Intern Demand increasing: 73 MW (2010) -> 120 MW (2027)*

Day 2 : KEMCO and LG Chem

Then 26th of mars we started our day by a visit to KEMCO (Korea Energy Management Corporation) then we went LG Chem.

Korea Energy Management Corporation

Established in 1980, KEMCO is a governmental agency specialized in energy efficiency management. His main mission is to carry out national energy tasks in energy efficiency and renewable energy sectors to reduce greenhouse gases which are the main culprits of climate change. KEMCO has been one of the key players in realizing sustainable economic growth which has emerged as a global issue in a great green paradigm shift that calls for green and growth to go together. KEMCO is the leader in creating new value of Smart & Green lift-style by promoting energy saving, low carbon economy while blending energy saving practices in our daily life-style, society and culture in the face of a worldwide green race. Accredited as a CDM (clean development mechanism created by Kyoto protocol) designed operational entity by UNFCCC since 2006, KEMCO validates and verifies internal and external GHG emission reduction projects. Until now 62 CDM projects has been validated by KEMCO including 32 oversea projects. These projects have been developed in East-Asia such as Vietnam, Cambodia, China, Mongolia and Sri Lanka. KEMCO has also developed the certification of international voluntary GHG emission reduction project and provide GHG inventory verification of enterprises.

Mr Park KyungSoon, manager of KEMCO, gave us a presentation on KEMCO's activities. He briefly recalled the historical development of oil price and emphasized on the importance of energy efficiency in the modern world. After the colonization period by Japan, little was left in the country, so the Korean government decided to develop his own industry. The result of a rapid GDP growth in a relatively short period was the creation of a heavy industry that depended largely on oil and gas resources. In 2009, 96.4% of Korea's primary energy was from importation, mainly from Middle-East and Australia. To response Kyoto's protocol engagement, the government created the KEMCO for rational energy utilization, GHG emission reduction and renewable energy promotion.

During the question and answer part, exchanges were vivid. The cold temperature in the company's building was a hot point. Actually, as a supervisor for energy efficiency in Korea, KEMCO has to be an example on energy management, so the company keeps strictly the air conditioning at below 20 degree in winder and above 26 degree in summer.

After the presentation, an exposition on green energy offered a vivid illustration of current technologies' status, including fuel cell power, electricity vehicle, heat and recovery ventilator, photovoltaic storage battery, day-lighting system, hybrid power 4wd, geothermal heating and cooling system, wind pellet boiler, bio energy and "green home".

Reda BOUIJ and Pengbo WANG

LG Chem

Among electronic companies, LG is one of the leaders. Therefore we have been very pleased to get the opportunity to visit the LG Chem site of Ochang, called Ochang plant 1.

LG was founded in 1947 and the Ochang plant in November 1979. This one is divided into two divisions: battery division and optical material division. After being warmly welcomed, a video presenting their activities spanning from smartphones and car batteries to 3D high definition televisions has introduced our visit. However, LG Chem competencies are not limited to these fields. They also demonstrate high expertise in IT films and green technologies. As all international companies, LG Chem is highly involved in environment and social improvement processes by participating and financing eco-friendly projects such as environment clean up and charitable initiatives like library constructions for children.

For the next step of the visit, our guide has presented us a huge range of their products in their display room. The three types of batteries were described as well as their applications for mobile devices: cylindrical type for notebooks, power tools and electrical bikes, prismatic type for smartphones and Li-ion polymer for ultrabooks. Among this variety of batteries, there was also exposed a model of the typical T-shape battery pack of Chevrolet Volt (180 kg, 16 kWh, 160 km of autonomy). We have namely enjoyed experiencing the quality of one of the largest 3D screen in the world. That was a unique chance to assess the diversity of their qualifications.

The last part of the plant's tour was dedicated to explaining the successive stages of the battery cell making process and the various existing processes. Moreover, we have been allowed to see the assembly lines, giving to this complete visit a more concrete dimension. In order to respect the hygienic rules of the building's white rooms, we have been asked to take off our shoes in order to replace them by clogs. Of course we could not help thinking of the Korean tradition that requires visitors to take up the same behavior when entering a house.

Nowadays, LG owns 9 plants in Korea and 15 all over the world. It is a cutting-edge company potentially boasting with a promising future. Nevertheless, by now, the end-of-life products manufactured by LG Chem are sold to the third parties on international market. Thus, in the next steps of its development, a recycling corporate branch could be created in LG Chem's organization chart to fully complete batteries' life cycle and make LG Chem an environmentally integrated company in all its technology sectors.

Show room de LG Chem

Bastien CORSAT and Thibaut FAUCON

Day 3 : nuclear power plant of Kori and DOOSAN

Nucelar poxer plant of Kori

On the morning of Wednesday, we visited the Kori Nuclear Power Site which is located in Busan on the southern coast of Korea peninsula.

The plant is property of the Korea Hydro & Nuclear Power Company which is one of the subsidiaries of KEPCO, the national electric company. The number of nuclear reactors in operation in Korea is twenty-three and they are located in Ulchin (6 units), Wolsang (5 units), Kori (6 units) and Yonggwang (6 units). All the untis are either PWR or PHWR. The installed capacity is 20,716 GW which corresponds to a share of 25,3 % of total capacity. Production amounts to 150 623 GWh (30 % of total electricity generation). Today, South Korea is planning great investment in nuclear power. Five reactors are currently under construction; the previous government wanted to raise the share of nuclear electricity generation to achieve 60 %. Even if the current president has not confirmed this figure, the energy strategy remains in favor

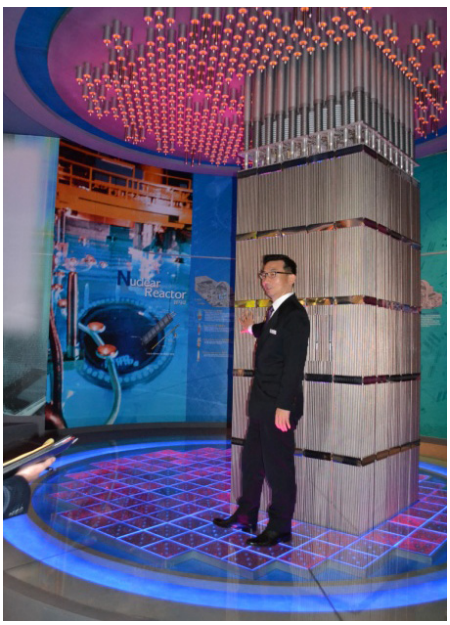
of nuclear power.

The one in Kori was the first nuclear power plant built in South Korea. The first power reactor entered into operation in 1978 followed by three others constructed during 1980s. On the site there are six operating reactors (Kori 1-2-3-4 & Shin-Kori 1-2) and two reactors which are currently under construction(Shin-Kori 3-4). The technology used is a Westinghouse/ ABB PWR. The republic of Korea later developed its own reactor design by Doosan heavy industry (KNSP/OPR 1000) used for the last two reactors which were built on the Kori site (Shin-Kori 1-2). Shin-Kori 1 has been operating since 2011 and Shin-Kori 2 since 2012. The third and fourth units will be completed respectively in December 2013 and December 2014.

The latest model commercialized by Doosan is the APR 1400. The design has been completed in 2002 and is now being implemented in Shin-Kori 3-4. Its features include a core damage frequency of 10-5/year, a design resisting to 0,3 g seismic acceleration and a life span of 60 years. This was the design recently chosen by the United Arab Emirates.

Unit	Capacity(MWe)	Commercial operation	Reactor supplier
Kori 1	587	Apr. '78	WEC
Kori 2	650	Jul. '83	WEC
Kori 3	950	Sept. '85	WEC
Kori 4	950	Apr. '86	WEC
Shin-Kori 1	1000	Fev '11	Doosan
Shin-Kori 2	1000	Jul. '12	Doosan
Shin-Kori 3	1400	Dec '13	Doosan
Shin-Kori 4	1400	Dec '14	Doosan
total	7937		

Simona DE LAURETIS and Loïc GRUSON



DOOSAN Heavy Industries & Construction

Mr Hung Sung-Hu introduced the Doosan Heavy Industry company on the well located Changwon site to the south of the country on the shoreline. We first started by an overview of the numerous activities carried by the company, which range from charity, sport sponsoring, press to vertically-integrated power plant activities such as nuclear plant and steam-coal plant, wind turbine, water treatment desalination passing through road constructionand both metro and train infrastructure. The company established in 1962 with the support of the government, quickly grew to reach the actual configuration, which is a proactive company spread all over the world with 17,000 workers. Doosan is present in UK, Romania, Czech Republic, Vietnam, India, USA and China. The company shows ambitious target on the international stage and is currently one leader in the desalination sector selling 30% of the world market.

The Changwon site is pretty impressive with its huge shops where equipment for power plant are made, along with frigates and desalination materials. Doosan boasts the desalination plant it sold to the United Arab Emirates, whose capacity is 450 tones of potable water a day, equivalent to the consumption of 1.5 million people. Actually the firm is the worldwide leader with 30% of the market. The company has its own harbor to ship its products abroad. Also the company's headquarter is located there as well as football pitches for the employees. The site is likened to a town given its 4 million square meter surface. It is the main site of Doosan company. The heavy activities carried on-site induce a very high electricity consumption, roughly 1 million US dollars per month.

We visited the 'forging and casting' shop where huge pieces of molten steel are processed to make the main part of the turbine. The biggest turbine manufactured by Dossan is a 870 MW one, 41,4 m-long and weighing 215 tones. The machine can reach 3600 rounds per minutes.

Doosan Heavy Industries & Construction

The first manufacturing step is the processing of huge pieces of molten steel to make the main part of the turbine. We observed a massive 13-tones press hammering a 500 t 1100 °C cylinder. The process is conducted 24h/24. The energy consumed by the press is equivalent to the consumption of

200 000 people. Next door is the turbine assembly shop, whereby we observed the turbine axle processing, and the blades assembly. Each titanium alloy blade costs 10 000 US dollars. The overall process to manufacture a turbine is 1.5 year. The average annual turbine output is 9GW.

Benoît LE MAISTRE
and Raphaël POULAIN

Day 4 : Seoul Energy dream center, Shiwa tidal power plant and Songdo town

Soul Energy dream Center

We spent the Thursday 28th of Mars in the heart of Sangam, near to the "Seoul World Cup Stadium", the place where the French national team lost against Senegal during the 2002 FIFA World Cup,we started the day by visiting "Seoul Dream Energy Center" which is not only a symbol of the Sangam metamorphosis, an area that has been a dump for a long time before being converted into a great area, but also a symbol the South Korean sustainable vision.

This three-storey building has a total area of approximately 3500 m² and is a positive energy building, thanks to its innovative architecture and the materials used. The Seoul Dream Energy Center is also a passive building. In fact, it has low energy needs (70 % less than South Korean standards). The low heating and cooling needs are satisfied with geothermal. The roof of the building has a large number of solar panels with a total installed capacity of about 200 kW and the building has a control center that provides an intelligent energy management. The Seoul Dream Energy Center was delivered in December 2012 after four years of work and cost more than 23 billion Wons (approximately 15.5 million Euros).

The visit was followed by an electric bus tour towards the Sangam hydrogen production station. This unit produces hydrogen from landfill gas and supplies bus fleet and public vehicles.

We then moved to the incineration plant «Mapo Resource Recovery Plant» which came into service in 2005. At the beginning of the visit, we enjoy the view of some works of art from waste in the lobby of the station. The incineration plant treats an average of 650 tons of waste per day which came from

Seoul Energy dream Center model

twenty districts of Seoul. Waste is burned at a very high temperature, so the combustion's heat is used to generate electricity and/or to supply the heat networks of more than 20,000 homes in Mapo area. The plant is also equipped with filters to eliminate all the toxic substances generated by the waste combustion.

During these visits, we enjoyed the change of a landfill, into a nice neighborhood, symbol of the commitment of South Korea to develop the sustainable energy for tomorrow's world.

Ghalem ALLAI and Lydie ONGUÉNE

« How to raise a metropole in ten years »

Then we had the privilege to discover the mega urban project of South Korea, the Ifez Project, which mean International Free Economic Zone.

This project plans to gather the three areas of Songdo, Yeongja et Chedngna and stretch on 169,5 km^2.

Inside one of the dozens towers build this last five years, we could observe, on the different models and commercial materials, the breadth of the project. The guide explains us that the place where we stand was still in the ocean less than ten years ago. Indeed, in order to build this neo-city, 610 Ha of reclaimed land were necessary (the equivalent of 600 soccer fields).

Located at equal distances from China and Japan, this new metropolis is directly connected to major Asian cities, thanks to Incheon Airport.

Thought to be the new business centre and neuralgic point of Asian Economy, Korean deciders saw the things in large scale. Three times larger than Manhattan, IFEZ is the most important private estate project of the history. This construction is mainly lead by a private consortium composed by Gale International (61%), the steel manufacturer POSCO (30%)

and the investment's bank Morgan Stanley (9%). This consortium received intense support of the Incheon's municipality in the form of fiscal's facilitates.

The global amount of the project is upper to 40 billion dollars. This metropolis should at terms receive 512000 permanent occupants and opens a direct way to the littoral for Seoul, located at one hour by car.

But Ifez doesn't aims to be just a business district, this zone aims to become a high quality vacation and tourism resort and a world famous research cluster.

Each of the three cities making up the Ifez project will have his specialty domain.

Songdo will be dedicates to business and international exchange.

Ultra modern tourisms estate and infrastructures will take place on Chedngna, with, for instance, the imminent installation of a huge theme Park "Robot Land" and golf's fields.

Yeongjo will be arranged as a residential and functional district with transport facilities to the Airport.

The City will also welcome an international campus. The university could especially benefit of free premises during five years and a financial support upper of 2 million US dollars. The State University de New York, the Utah U, the Gand U (a Belgian one) and Yonsei U (one of the most famous in Korea).

Songdo will moreover welcome research and development centers from big Korean conglomerate. Samsung has already invests almost two billions US $ in his new center at IFEZ.

Ghalem ALLAI and Lydie ONGUÉNE

Sihwa tidal power plant

Following our visit of the neo-metropolis of Songdo, we next went a little more to the peninsula's south. At Sihwa more exactly, where stand the most powerful tidal Hydro power plant of the world.

Just commissioned in August 2011, this power station took the leadership of French tidal plant of La Rance, in Atlantic's coastline, which stood at the top for more than 45 years.

Begun in 2005, the building operations finally last less than 7 years.

The total power of the plant reaches 254 MW and is made up by 10 turbo-alternators, which are totally immerged. These kinds of generators are called "bulbs". The diameter's rotor of the turbines is 7.5 meters high and their speed is around 63,5 RPM (a little more than 1 round per second).

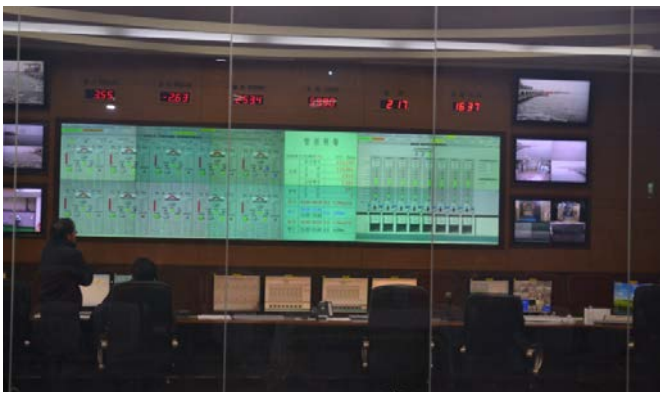
The concept of a tidal power plant is based on the creation of an artificial water holding that creates a difference of high. This potential energy can then be exploited through turbines during the tide.

So, tidal Hydro power plant needs a dam to hold back the water and create the difference in high.

This station shows the particularity to be built on an already existent dam, built in 1994, the Sihwa Dam. So, there only needs an adjustment of the dam, what allows an economy of cost and time and reduce the cost of electricity production to 140 €/MWh.

"Korea is going green, growing green"

Yet, contrary to her French sister which can turbine thanks to the flux and reflux of the tide, the Sihwa power plant was not designed to operate on both ways.



Sihwa power plant uses the downward move of the sea to create the essential difference of high for creating electricity. The plant operated a difference of high of 6 meters, providing a clean energy in a scheduled and predictable way.

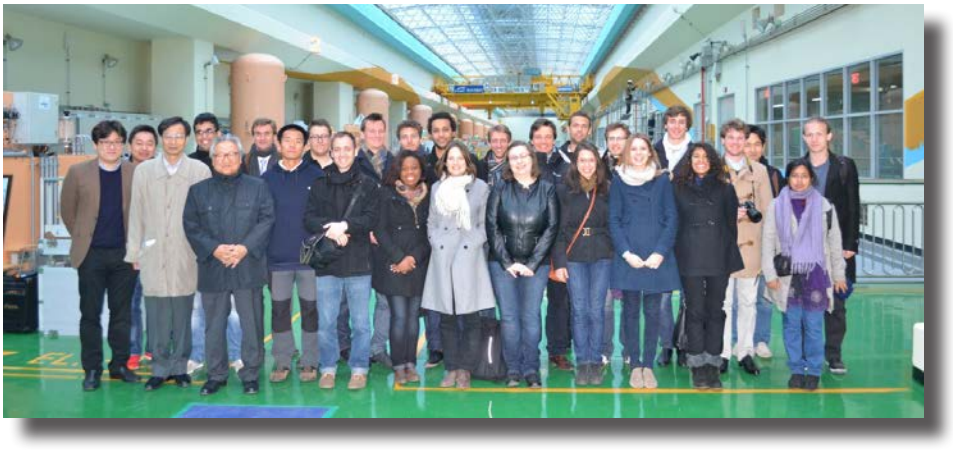
This height delta associated with an important output (482.1 m3/s) able to produce 550 GWh annually, what is a little bit more than the "La Rance power plant" which produces an average of 544 GWh per year.

This project was one of the rare opportunities of Korea to produce renewable energy. Indeed Korea disposes of few potential and few renewable resources on his ground (few spaces, sunshine and few wind).

The construction of this plant was in balance with the political wish and strategy to promote a "green" industry and growth. The climate impact of the plant is very low thanks to the "zero emission" technology of tidal energy.

In this way, the 225 million Euros of the project were mainly financed by the Korean government.

Axel BOUTS and Guillaume JANNIN



Report of the korean symposium: Sustainable Energy

Friday 29th of Mars, we had the chance and the privilege to share our knowledge and experiences with Korean and Japanese students from Anjou University and Kyoto University and learn from theirs.

But before starting the symposium we had the immense honor of meeting the French ambassador.

In the first part of this symposium Professors from Ajou University Kyoto University and Mines Paristech presented their respective schools:

Professor Hyung Taek KIM

Ajou University

New and Renewable Energy Policy measure in Korea: Strategies and perspectives

Professor Hyung Taeck Kim from Ajou University spoke about New and Renewable Energy Policy:

Korea has developed many different renewable energies sources such as Photovoltaic panels, solar, thermal, wind energies, biomass, and hydraulics, but it only represents 2,75% of the total energy mix in 2011. However efforts are continuously done to improve NRE. Since 2000, there has been an increase of production, exports and NRE manufacturers. The annual growth rate of the renewable energy is 10.2% from 2006 to 2011.

In 2011 NRE represents 10 000

Employees and 490 million US $ of exports. Korea has now established the base of an industrial structure with high potential.

Korea has already achieved successful development in fuel cell technologies with POSCO (a Power fuel cell stock plant), bio diesel and tidal energy generation with Shiwah tidal power plants (254 MW). It also has ambitious target. In 2015 Korea would like to be in the world top 5 nation concerning market share of Photovoltaic panels and wind energy with 15% of world market share. Research and development has been boosted over the past years, private and public joint projects have been encouraged to finance NRE developments. Now Korea is extending these green policies to other sectors such as green logistic, green army… and it has also planned a roadmap for offshore wind development.

Concerning detailed policy, Korea feed in tariff has led to development of 1,694 renewable power plants over the country. They would like to expand the Wind Power Capacity to 2.5 GW in 2019.

A subsidy program also encourages energy efficiency for individual homes and political measure has been taken to force 5% of the building investments to be used to finance NRE. Target for 2020 is to reach 12% of NRE in total energy mix. With these previous ambitious targets Korea would like to take the lead in specific renewable technologies and make a big step toward sustainable energy developments.

Gauthier CADO and Anne KURASIAK

Prospective studies for sustainable energy

Associate Professor Gilles Guerassimoff

MINES ParisTech

M. Gilles Guerassimoff present the research of the Centre for Applied Mathematics (CAM) of Mines ParisTech

Depletion of fossil fuels, population growth, finite mineral resources and climate change constraints show us that on a relative short term horizon we can't follow the previous pathways. One of the most important constraints is related to the use of raw materials and energy that directly impact the resources and climate. So it is important to assess these impacts and try to improve the energy systems to make them more sustainable.

To achieve this goal, numerous analyses are often conducted in the field of prospective. Indeed, many laboratories develop models able to represent energy systems with their evolutions on a relative long term horizon. These mathematical models can represent the technico-economical evolution of a given reference energy system (RES) at several scales (from a city to the entire world). These models are powerful decision making tools for policy makers or industrial actors. They can show an optimal pathway for a productive instrument or for an evolution in a given energy end use. It is not at all a matter of prediction but, regarding a potential scenario, what can be a solution that fulfills the constraints that have been included in the model.

After This introduction M. Guerassimoff show us some result on the well-known tool MARKAL-TIMES. This tool is an economic linear programming model generator for local, national or multi-regional systems. It can also been applied to a specific sector. The bottom-up approach of this model generator is an asset for the evaluation of the penetration of new technologies and for the economic evaluation of their penetration.

For example, The CAM have study the industrial sector representation to have an idea of the impact of a technology's choice on a given sector. They also improve the representation of electrical grid to be able to have a representation of the system reliability.

In a another field the CMA study the structure of biomass resources for France to assess the potential of biofuel. And of course, the impacts on climate changes were studied at world level on several scenarios.

Auteurs

Professor Ishihara

Kyoto University

Zero CO_2 emission energy scenario by 2100 - From the GCOE report

Finally Professor Ishihara from Kyoto University spoke about the Zero CO_2 emission energy scenarios by 2100:

The CO_2 gas is responsible for 80% of the global warming emission produced by mankind and its reduction represents one of the greatest challenges of this century. The professor Ishihara from Kyoto University came back on the result on the zero CO_2 emission scenarios from the Global Center of Excellence (GCOE) report. This study, focalized on 4 regions (Japan, Middle East, ASEAN countries and the Word), has two main objectives: prove the feasibility of this extreme constraint and examine the different technologies used to achieve this target. After presenting the models used in this study and the detail to forecast the energy demand the professor show us the result for each region. First outcome, the feasibility of a zero CO_2 energy mix is theoretically possible but with different technologies for each region. For the World model, the main technologies used are the CO_2 capture and storage and the Biomass generation. This last technology has the advantage to be a negative CO_2 emission process thus it can be used to offset the other sector with fatal CO_2 emission like transport or Industry. However making forecast for more than 50 years is really complex that's why all this result should be tempered.

Axels BOUTS and Évariste Chaintreau

A control scheme of the low voltage ride through in wind turbines using a direct power control

In this presentation, Prof. Kyo-Beum Lee from Ajou University talked about a control scheme of the low voltage ride through (LVRT) in wind turbines (WTs). Before the presentation about the scheme, Professor commented on the requirement of the LVRT. The requirement is included in the grid-code regulates WTs to maintain their operation and supply reactive power during grid fault. Therefore, if the systems do not have solutions for the LVRT control, the WTs cannot maintain operation under LVRT condition or the faults can be generated in the system. To solve these problems, Professor brought out a detection method of grid faults and control strategy for flexible power control under LVRT condition. In addition, the control scheme using a direct power control based on a sliding mode control (DPC-SMC) improves a performance of the LVRT control. Finally simulation results verified the validity of the presented control scheme.

Professor Kyo-Bekum Lee

Ajou University

Reda BOUIJ and Guillaume JANNIN

Impact of shale gas on Korea petrochemical industry

M. Eun Duck Park
Ajou University

The shale gas is, without a doubt, one of the most contentious subjects of this century and worries all the oil sensitive countries. Korea imports more than 95% of its fossil energy needs thus Korean market may be affected by those new unconventional gases. M. Eun Duck Park, researcher at the Anjou University's Department of Chemical Engineering, presents the Korean petrochemical position as weaker than the American companies. Indeed, USA has already allowed the exploitation of shale gas in their territories. With this new competitive resource and the investment announced in this branch, shale gas should spread on the international market in the coming years. Korea has no reserve of shale gas thus its answer to this new threat must be innovative. Petrochemical companies has already making partnership each other to invest in shale gas abroad, furthermore the companies believe a lot in the refining research to make new oil product and find cheaper refine process. Moreover shale gas has less refine possibility than conventional oil, so one other possible answer is to diversify the oil product range. However the situation of petroleum companies is tense especially with a new unpredictable resource.

Reda BOUIJ and
Évariste Chaintreau

Finally, the 2012 OSE students Clothilde Pascual Jaouni, Reda Bouij, Simona De Lauretis took the floor and presented European green policies and European Visions of sustainable cities.

European green policies. Vision of sustainable cities

Miss Clothilde Pascual Jouani
MINES ParisTech

On a continent where towns remember old Walled Cities and are world heritage treasures, some issues remain to convert them into sustainable cities. Like in other countries around the world, the main obstacles are urban pollution and sprawl. The 2008 crisis supplemented new difficulties: with income disparities and housing prices growing, it is more arduous to finance improvement projects. The main idea in Europe is to adapt the cities. Hence, the biggest challenges are the renovation of buildings and the development of more efficient mobility systems, while improving life quality.

Given the role cities can play towards developing a greener future, European institutions as well as independent organisations took many initiatives to address environmental and sustainability issues in their urban dimension. In 1994, the city of Aalborg (Denmark) organised on this subject an international conference, adopting the Charter of European Cities & Towns Towards Sustainability, which has to date more than 2700 signatories. Other recent actions include the EU 2020 targets, which address greenhouse gas emissions, renewable energy and energy efficiency, and the 2011 Energy Efficiency Plan

and Energy Directive. Thanks to these initiatives many promising projects have seen the light. The Covenant of Mayors is a movement – launched by the European Commission – which is aimed at supporting emissions reduction projects promoted by local authorities. The signatories commit voluntarily to reduce CO_2 emissions of their city by more than 20 % by 2020, thus exceeding the EU 2020 targets. The reduction is made possible by the endorsement of renewable energy and energy efficiency measures. Another example of collaboration between European local authorities is Grid 4EU, which is the biggest European Smart Grid project. It involves six countries (France, Czech Republic, Germany, Italy, Spain, Sweden) and gives Distribution System Operators all over Europe the opportunity to help each other and learn from each other, in order to develop innovative solutions to major urban challenges, solutions that integrate economic, social and environmental dimensions. The French cornerstone of this collaboration is called NiceGrid, a project aimed at strengthening the French Riviera grid known for its fragility.

M. Reda Bouij

MINES ParisTech

Miss Simona De Lauretis

MINES ParisTech

Reda BOUIJ, Clothilde PASCUAL JOUANI and Simona DE LAURETIS

A second presentation by Master OSE students: Axel Bouts, Loic Gruson et Bénédicte Vignoboul focused on the question of Sustainable mobility in Europe: merging life and transport

Sustainable mobility in Europe: merging life and transport

Sustainable mobility includes sustainable transport, but is a wider concept: it is not enough to go faster from A to B; it must be done in a smarter way and wasting less time.

No single policy will lead to this achievement but a package of well-designed policies bringing the ecological, economic and social dimensions together can. This aim of gathering people around their need of mobility has led to a bunch of major innovations in Europe: new means of transport, smarter urbanization and a brand new integration of the citizen in its daily transportations.

For instance, Information Technologies (IT), taken along with smart transportation, have permitted people to stay aware of

Miss Bénédicte Vignoboul

MINES ParisTech

M. Axel Bouts

MINES ParisTech

M. Loïc Gruson

MINES ParisTech

data concerning their daily journeys (congestions, air and noise pollution, GPS data) and take the best decisions to reduce travel times. But innovations are not only technological; social breakthroughs, like making transports affordable for everybody or giving citizens some power of decision in transport policies, are equally important.

European cities were structured during a time when energy was cheap. Infrastructures dedicated to cars have drawn our cities. Today, this system collapses: congestion, pollution and noise are the daily grind of citizens. One solution is to work on urbanism to become a clever organisation . The idea is to reduce the number and length of trips with a better arrangement of businesses and services, avoiding concentration around the city centre and developing "polycentric" cities. The ideal city is one where people can walk to their jobs, to services and leisure activities. A fundamental aspect of sustainable cities is the well-being of the inhabitants.

Axel BOUTS,
Loïc GRUSON and
Bénédicte VIGNOBOUL

It is on this specialized master OSE student presentation that ended the first part of the symposium

The second part of the symposium allowed a number of Korean, Japanes and French students to present a variety of studies they have done and interesting results they found:

Preparation and characterization of binary metal oxides electrodeposited on carbon sheets for supercapacitors

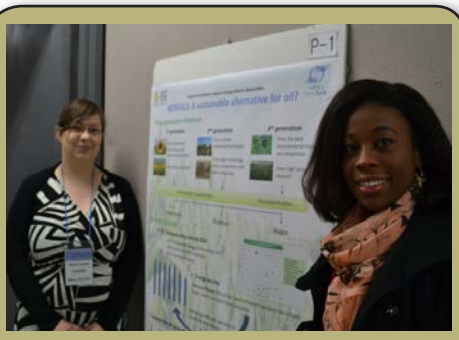
Miss Hae-Min Lee
Ajou University

The application of electrochemical capacitors (ECs) (or supercapacitors) as an energy storage device draw much attention because of their high power density, long cycle life (> 100,000 cycles), rapid charging-discharging rates and so on. ECs are critical components in the next generation all-electric vehicles and cars based on fuel cell. Various materials have been investigated as the electrodes in ECs, including carbon materials, conducting polymers, and transition metal oxides. Metal oxides such as RuO_2, MnO_2, Co_3O_4, and NiO have been employed as electroactive materials for ECs. Ruthenium oxides showed remarkable performance as an electrode active material for ECs. But their high cost has limited commercial applications of ruthenium oxides.

Manganese and its oxides have received much attention as alternatives to ruthenium oxides in ECs applications because of their relatively low cost and toxicity. However, single metal oxides have some limitations such as poor electrical conduction and electrochemical cycling stability, narrow window of voltage operation, and low specific capacitance. To improve the electrochemical performance of manganese oxides for ECs, many efforts have been devoted to incorporate various transition metals into manganese oxides to form binary manganese oxide nanocomposites with controlled micro/nanostructures in order to improve their electrochemical characteristics.

In this work, binary manganese oxides were prepared on carbon sheets by anodic electrodeposition. Electrochemical characteristics were evaluated by cyclic voltammetry, galvanostatic charge-discharge, and electrochemical impedance measurements. The morphology and crystal structure of the film have been investigated by scanning electron microscopy and X-ray diffraction, respectively.

Ronan PINAULT



Miss Lydie Onguéné and Miss Anne-Laure Louédec
MINES ParisTech

Biomass and biofuels: What issues?

The population is growing up: Earth population will be of 9 billion people in 2050. This growth engenders excessive energy consumption. Today, about 75 % of the energy used in the world comes from fossils resources, which are, by definition, finite in our scale of time. As a result, there will be an increase in greenhouse gas emissions and the depletion of natural resources. Biomass could be an answer to this issue. The purpose of our presentation is to explain why and how we could develop the use of biomass to meet our energy needs.

The first part of our exposé will deal with biorefineries which are a good way to reuse waists to generate bioproducts such as cellulose, or bioenergy. In the second part, we will focus on biofuels. They are the more likeable alternative for transport today. In fact, transport is responsible for 14 % of greenhouse gas emissions and represents 25 % of the world's energy consumption. Biofuels are the more likeable alternative for transport today.

Lydie ONGUÉNÉ and Anne Laure LOUÉDEC

Study of multi-scale turbulent transport in fusion plasmas using gyrokinetics simulations

M. Obrejan K.

Kyoto University

In addition to increasing needs for sustainable energy sources, our society depends on access to abundant and reliable energy supply. To satisfy our future energetic needs, a new mix including new renewable sources of energy that safely provide continuous power at large scales and for the long term without harming environment is necessary. With limitless fuel supply essentially hydrogen , no greenhouse gas emissions and no radioactive waste, nuclear fusion, energy of the stars, has the potential to fulfill these expectations. To achieve nuclear fusion reactions, the gas fuelling reaction is heated to extreme temperatures to turn it into plasma state. A plasma is a gas whose atoms are stripped of their electrons, giving the resulting fluid new electromagnetic properties, allowing plasma confining inside the reactor as the metallic wall of the chamber would quickly melt if it contacts directly the hot plasma.

Nowadays fusion plasma physics aims are to understand com¬plex turbulence phenomena and anomalous transport taking place in the plasma. Such processes are consequences of instabilities occurring at multiple space and time scales; for example, fluctuations in fusion plasma are characterized by macro-scale magnetohydrodynamics and micro-scale drift wave turbulence. Researchers have been investigating such instabilities to improve control and plasma confinement by using parallel simulations. Headway of parallel computing theory and supercomputers allow large-scale simulations using thousands of CPUs to cover cross-scale turbulence due to interactions of different modes. Our group purposes model and simulation code to perform multi-scale turbulence simulation with electromagnetic features in fusion plasmas.

Indeed we developed a gyrokinetic Vlasov code, which is essential for the study of turbulent phenomena inside of magnetically confined plasmas. This requires inclusion of additional terms, such as the development of real space gyro-averaging procedure in order to take into account the variation of the temperature profile. Unlike most methods which first simplify the averaging, the real space gyro-averaging method performs the averaging and more complex "double averaging" of the physical variables along the particles' trajectories without requiring further simplifications.

Anne Laure LOUÉDEC

Entirely Solution-Processed ITO-Free Semitransparent Organic Solar Cells: From Bottom- to Top Electrodes

M. Jong Hyuk Yim

Ajou University

Transparent conducting electrodes (TCEs) providing electrical contact to active and/or functional layers for cur¬rent supply or extraction while allowing light transmission are essential components for optoelectronic devices. Most of commercial or research-stage organic and hybrid optoelectro¬nic devices have utilized TCEs made of metal oxides such as indium tin oxide (ITO) or fluorinated tin oxide (FTO). However, metal-oxide TCEs are not compatible with flexible optoelectronic devices on plastic substrates because of their intrinsic weakness, as brittleness and high deposition temperature. For example, sheet resistance of metal oxide films increases substantially with slight deformation, and those films crack easily when bent to small radius of curvature causing device failure.

Moreover, the high processing temperatures to form good quality TCEs, can induce serious damage to underlying organic layers, making metal oxide films inappropriate for a organic devices transparent electrode. On the contrary, there are alternative TCE materials free from ITO's problems. For example, metallic nanowires (NW) are such materials. Properly designed films of these materials can replace ITO electrodes in future optoelectronic devices.

In this presentation, we report successful fabrication of AgNW and highly conductive PEDOT:PSS (PH1000) TCEs via only solution-processing and application of such TCEs for organic solar cells. Our spin-coated transparent conducting AgNW and PH1000 films typically show high figure of merit (FOM) values; FOM increases as film become more transparent and/or less resistive.

FOM of our AgNW film is as high as 360 ± 30, which is higher than values found in literature, whilst that for PH1000 film is one order of magnitude smaller. Control device buffered by ZnO for AgNWs (cathode) and bilayer of AI 4083/GO for PH1000 (anode) shows PCEs of 2.9%. Semitransparent device exhibits relatively low short-circuit current due to reduced absorption, leading to PCEs of up to 2.3% (compa¬rable to ITO-based devices).

Anne Laure LOUÉDEC

Difficulties in implementing a long-term policy in a short-term energy market : the competition between coal and gas in the EU electricity market

M. Raphaël Poulain

MINES ParisTech

Raphael POULAIN étudiant au mastère OSE a présenté devant l'auditoir et sur un poster "Difficulties in implementing a long-term policy in a short-term energy market : the competition between coal and gas in the EU electricity market".

The EU wants to achieve a 20 % and 80 % GES reduction by 2020 and 2050 respectively, in comparison to the 1990 emission level. Nevertheless, because of the lack of both predictability and stability of the energy sector, it is difficult to implement such long term policy. This presentation proposes to highlight those difficulties in Europe by illustrating the case in the electricity sector, particularly with coal and gas technologies, in which some unexpected events changed the course of the strategy dramatically.

Raphaël Poulain

Effect of annealing condition on environmental stability of Al and Ga doped ZnO

Electrical stability of transparent electrode in harsh environment is very important especially for photovoltaic device because it installs outside. Increase of resistivity can decrease the solar cell performance. ZnO is the most promising candidate for transparent electrode to substitute ITO, because it possesses an outstanding opto-electrical property. But electrical stability of doped ZnO is not satisfactory till now. The purpose of this work is to investigate the effect of annealing condition on electrical stability of Al-doped zinc oxide (AZO) and Ga-doped zinc oxide (GZO). AZO and GZO thin films have been deposited on glass substrates by sol-gel method. Annealing treatments were carried out in vacuum atmosphere by two ways:

1. low annealing temperature with short duration (4500 °C for 30 min) and
2. high annealing temperature with long duration (6000 °C for 120 min).

Characteristics of the films were studied by X-ray diffraction, X-ray photoelectron spectroscopy (XPS), optical transmission spectroscopy and four point probes. Effects of annealing condition on electrical stability in normal environment have been investigated. A strong (002) diffraction peak of all AZO and GZO film show a polycrystalline hexagonal wurtzite structure and high preferential c-axis orientation. Transparency of all films was 85-90%. The electrical stability of these films was investigated in normal air environment for 30 days. The tendency to increase the sheet resistance for films which annealed in low temperature and short duration is probably due to oxidation. But samples annealed in high temperature and long duration was highly stable up to investigation time. This happens because may be at the higher temperature, Al and Ga produce oxide layer at the surface and protect further oxidation. The change of crystalline structure and transparency was investigated in these days. After investigating it was found that long time annealing at higher temperature is good for electrical stability with no change in crystalline and optical properties after long time

Miss Samia Tabassum

Kyoto University

Ronan PINAULT

M. Ghalem Allai

MINES ParisTech

Innovating engines for sustainability

With the rarefaction of fossil resources and the strengthening of environmental restrictions, innovative energy solutions are the key to a sustainable future.

By focusing on the transport sector, this speech will show how simple ideas can bring innovation and concrete results. Two innovative engine projects will be presented. The first is named ULCGE after Ultra Low Consumption Gasoline Engine, which has a unique combustion mode. The second is an aircraft engine: its innovative architecture with contra-rotating fans makes it lighter and more efficient.

Ghalem ALLAI

Characterization for fast screening of an optimal ratio of polymer: fullerene mixture for organic bulk heterojunction solar cells by novel coating method

M. Samia Tabassum

Kyoto University

Bulk heterojunction organic solar cells generate electrical power mainly based on the active layer, where consist of a mixture of donor and acceptor materials. In recent, like poly[2,6-(4,4-bis-(2-ethylhexyl)-4H-cyclopenta[2,1-b;3,4-b'] dithiophene)-alt-4,7(2,1,3-benzothiadiazole)] (PCPDTBT) and [6,6]-phenyl-C71-butyric acid methyl ester ([70] PCBM), new donor/acceptor materials with well-matched characteristic have been reported by continued and devoted efforts. However, when new and novel donor/acceptor materials are synthesized, hundreds of pretests are required to determine an optimal mixture ratio for showing best characteristic in bulk heterojunction solar cell. Spin coating method, which is conventional and dominant coating technique, is not desirable to investigate a new material repeatedly because of relatively large solution waste and one-by-one manner. Instead of this standard method, the modified spray or mist coating methods, which can control mixture ratio of donor/acceptor systematically and continuously, can be applied. By taking new methods, the morphological and optical properties of polymer solar cells based on poly(3-hexylthiophene):[6,6]-phenyl C61 butyric acid methyl ester were compared with previous results of spun and sprayed ones. These novel methods allowed each unit cell to coat active layer with relatively quantitative and homogeneous morphology in targeted small area. This study provides a strong and practical screening method to define a critical mixture ratio among the enormous polymer-fullerene combinations.

Anne KURASIAK

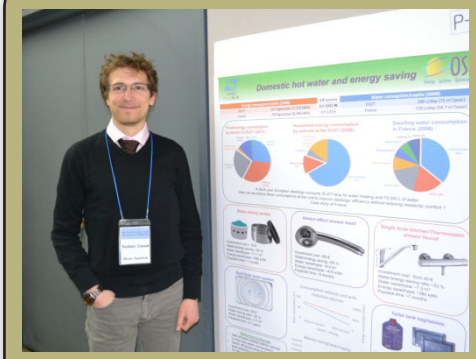
Advanced Master OSE poster presentation

Between the presentations, the students of MINES ParisTech were invited to present posters of their work on sustainable energy

Domestic hot water and energy saving

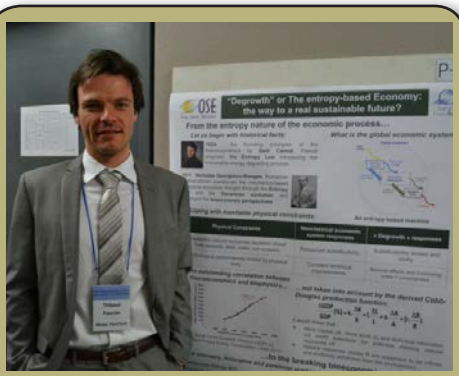
After heating, domestic hot water is the most important item of energy consumption in habitations. In average, each person on Earth consumes 137 liter of water per day. There is a big difference of the consumption between countries, from more than 550L for the USA to less than 10L for Mozambique. With the growth of world population and the rise of the standard of living, the total quantity of water consumed per year and the necessary energy to heat it will increase too. In order to make our habitations more efficient and sustainable, we have to take care of our water consumption. Several solutions already exist to reduce it efficiently and everyone can do it easily. With a little budget and no big work, it is possible to invest in some devices which will allow us to do a significant saving of water and energy at home, and that without reducing our comfort. From the kitchen to the bathroom, including the toilets, these devices bring a solution everywhere there we consume water in our habitations. To give an example with the French case, an investment of around €170 can make you save about €165 on water bill and €280 on the energy one, and that per capita and per year.

Bastien CORSAT



M. Bastien Corsat

MINES ParisTech



M. Thibaut Faucon

MINES ParisTech

Degrowth or the entropy-based Economy : the way to a real sustainable future ?

What if the French engineer and thermodynamics expert, Sadi Carnot, would have been the precursor of the economic system of the future?

Indeed, in 1971, the Romanian and American mathematician and economist, Nicholas Georgescu-Roegen, criticized the mechanistic framework of the occidental economic thought and developed the bioeconomic perspectives based upon the Entropy Law to cope with inevitable physical constraints such as irreversible natural resources (energy, ores, water, soil, etc…) depleting processes for running the economic system.

The poster will endeavor to describe the main cornerstones of the bioeconomic approach to sustainability issues and to present the theoretical framework of a hierarchical system introducing the complementary exosomatic energy and total human time notions and proposed by Kozo Mayumi, a Japanese Georgescu-Roegen's disciple.

Thibaut FAUCON

Applied mathematics for optimization of steel plants

M. Gauthier Cado et M. Guillaume Jannin

MINES ParisTech

Steel industry is one of the most energy consuming industries. During manufacturing process, it also emits lots of different steel gases. These gases represent high potential of energy that are usually burnt directly in flare. This poster aims at presenting the optimization of SOLAC steel plants near Marseille (France). The process of this plant has been analyzed. The purpose is to save as much steel gases as possible to enhance its use in a power plant directly linked to the steel plant. The power plant, considering its needs, will use in an optimal way the different type of steel gases with different calorific value as combustible.

The problem is treated as a linear optimization problem. It has been modeled with the software AMPL. An objectives function that aims at maximizing the use of energy from steel gases has been implemented. Constraints from steel process and plants structure have also been taken into account and integrated. The result of this algorithm presents the optimal way of using the different steel gases into the power plants to meet internal demand of steam, pressurized air and electricity. It also enables to estimate the excess of electricity created and the associated gain. This optimal strategy of gas use has been simulated on several time periods to evaluated benefits in terms of savings of energy and costs. It has been tested and implemented at SOLAC steel Plant.

Gauthier CADO et Guillaume JANNIN

This smart day ended the 2012 promotion business trip in Korea ...

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