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Carbon Intensity & Energy Infrastructure

An Overview and Country Case Studies from Latin America, Asia and Africa

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Content

List of Abbreviations

AfDB – African Development Bank
APG – ASEAN Power Grid
APAEC – ASEAN Plan of Action for Energy Cooperation
API - Integration Priority Project Agenda / Proyectos Prioritarios de Integración
ASEAN – Association of Southeast Asian Nations
AUC – African Union Commission
C – Celsius
CBM – Coalbed Methane
CO_2 – Carbon Dioxide
COSIPLAN – South American Infrastructure and Planning Council / Consejo Suramericano de Infraestructura y Planeamiento
DRC – Democratic Republic of Congo
EAPP – East African Power Pool
EPA – Environmental Protection Agency
GDP – Gross Domestic Product
GHG – Greenhouse Gas
Gt – Gigaton
GWh – Gigawatt hour
IEA – International Energy Agency
ICT – Information and Communication Technology
IDDRI – Institute for Sustainable Development and International Affairs
IEA – International Energy Agency
IIRSA – Integration of Regional Infrastructure in South America / Iniciativa para la Integración de la Infraestructura Regional Suramericana
IPCC – Intergovernmental Panel on Climate Change
MEMR – Indonesian Ministry for Energy and Mineral Resources
Mt – Megaton
MW - Megawatt
NEPAD – New Partnership for Africa's Develoment
PAE – Strategic Action Plan / Plan de Acción Estratégico
PIDA – Programme for Infrastructure Development in Africa
PIDA PAP – PIDA Priority Action Plan
PPP – Public-Private Partnership
REC – Regional Economic Communities
SDSN – Sustainable Development Solutions Network
TAGP – Trans-ASEAN Gas Pipeline
TCC – Technical Cooperation Committee
TWh – Terrawatt Hour
UNASUR – Union of South American Nations / Unión de Naciones Suramericanas

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1. Introduction

The world is struggling with ever increasing greenhouse gas (GHG) emissions and, consequently, more extreme impacts of global warming on nature, people and the economy. For the last ten years, we have seen a continuous rise of atmospheric carbon dioxide (CO_2) – the primary GHG emitted through human activities such as the burning of fossil fuels, changes in land use and industrial activities. It is crucial to sharply reduce global CO_2-emissions in order to achieve the globally agreed limit of global warming – 2° Celsius compared to the pre-industrial average – and thus avoid unmanageable climate change impacts. But, as usual, theory and reality drift apart dramatically. Although the 2°C limit was adopted in 2010, GHG and especially CO_2-emissions from the production of energy and the manufacturing of cement have been rising over the past years with emissions in 2013 being the highest in human history (36 Gt CO_2-energy emissions)(see Appendix 1).[1]

The Intergovernmental Panel on Climate Change (IPCC) projects that - in order to stay below the 2°C limit - it is necessary to reduce global CO_2-energy emissions to 11 Gt on average by 2050.[2] Trying to achieve this goal implies a fundamental transformation of the world's energy systems and eventually the phase out of fossil fuels for energy production. Together with effective changes in the transport, agricultural and other sectors, the renunciation of fossil fuel utilization will greatly contribute to decarbonizing the economies all around the world and to achieving the 2°C goal.

Industrialized countries sometimes find it difficult to transition from their reliance on fossil fuel energy infrastructure to the use of renewable energy sources. Developing countries and emerging economies however have the chance to leapfrog the fossil fuel era and eventually benefit from their broadly discussed infrastructure gaps.[3] Efforts in Africa, Latin America and Asia to attract investment for infrastructure financing aim at improving regional and economic integration. Investments in sustainable energy production systems would allow these regions to "skip" the phase of fossil fuel based energy generation that many industrialized countries are struggling to leave behind.

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1 See: http://www.globalcarbonproject.org/carbonbudget/14/hl-full.htm#FFandCement

2 See: SDSN, IDDRI (2014): Pathways to Deep Decarbonization, p. VIII.

3 See for example G20 Development Working Group: 2014 Brisbane Development Update; AfDB: Africa Progress Report 2014, pp.124ff.

This paper looks at different regional infrastructure strategies to analyze whether the need to decarbonize energy production is being taken into account during the respective decision-making and prioritization processes. Our analysis will be supported by case studies from each geographical region that will look at the respective energy generation and decarbonization efforts so far and draw conclusions on how the priority energy projects will affect the country's carbon footprint.

2. Decarbonization

There are several aspects of decarbonization that deserve attention. Firstly, it is important to bear in mind how to define and evaluate decarbonization. This will, secondly, give us an idea of the range of strategies that can be implemented in order to achieve low-carbon energy generation. Thirdly, in the context of those strategies it is important not only to look at the mere data, but also at the long term impacts of energy policy making.

Energy and Carbon Intensity

In their "Pathways to Deep Decarbonization 2014 Report" the Sustainable Development Solutions Network (SDSN) together with the Institute for Sustainable Development and International Affairs (IDDRI) identify the different drivers of CO_2-energy emissions (subsequently referred to simply as CO_2-emissions): population; GDP per capita; energy use per unit of GDP; and CO_2-emission per unit of energy. In the course of their analysis, they assume a growing population as well as a positive economic development and therefore a rise in GDP per capita. Hence the two aspects that can most effectively be addressed by a country's decarbonization efforts are energy/GDP (energy intensity) and CO_2/GDP (carbon intensity of energy in production output).[4]

In the light of these assumptions, different strategies can be applied to positively affect the two main drivers of climate change. In the case of energy intensity, measures affecting the end-use of energy are an important point of leverage: improved energy efficiency (technical improvements to save energy e.g., in households or industrial production processes) as well as energy conservation measures (personal behavioral changes to save energy). Declining carbon intensity requires, on the other hand, changes in the way energy is generated. The production of low-carbon electricity through the replacement of fossil fuel power stations with renewable energy sources is the most urgent measure to take on. On the other hand, a fuel-switching approach would also positively influence a country's carbon intensity. This approach includes the switching of end-use energy supplies (e.g., in buildings, transportation) from highly carbon-intensive fossil fuels (oil, coal) to low-carbon energy carriers (gas, biofuels, etc.) and self-provision with low-carbon electricity (e.g., solar panels on buildings).

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4 See: SDSN, IDDRI (2014): Pathways to Deep Decarbonization, p. 13.

We will look at whether environmental aspects – especially the CO_2-emissions - have been considered during the process of prioritizing energy infrastructure projects in different geographical regions; carbon intensity will be the main focus of this paper.

Beyond GDP and GWh

Analyzing the above mentioned indicators over time provides a picture of a country's decarbonization efforts. However, a closer look is necessary to assess whether strategies to reduce carbon emissions are designed to be sustainable and consider unintended side effects and the impacts of ever proceeding climate change. The scope of renewable energy sources is key in this regard.

In principle, renewable energy sources include: wind, solar, biomass and geothermal, but also hydro and nuclear power. These energy carriers not only fall into the category "renewables" because their fuel sources restore themselves and do not diminish, but many are also considered low-carbon power generation sources because of the substantially lower amounts of CO_2-emissions that are produced compared to the burning of fossil fuels.

However, two things have to be considered. Firstly, the process of energy production is only one moment when CO_2 is emitted. A life cycle assessment (including manufacturing of construction materials, construction of the plant, maintenance works) can give a better picture of which renewable energy sources actually emit the least amount of GHG. Secondly, CO_2-emissions are not the only negative effect on the environment. Evidence shows that the construction of new large scale hydropower plants can have negative impacts on the surrounding environment (e.g., deforestation – which would again bring about a rise in CO_2-emissions; diversion of rivers).

So if we extend our view and consider CO_2-emissions as an important, but still one among many negative environmental impacts, we have to have in mind that within these renewable energy sources there are large differences. Therefore, the U.S. Environmental Protection Agency (EPA) for example talks about "green power" as a subset of renewables defined as "electricity produced from solar, wind, geothermal, biogas, eligible biomass (organic plant and waste material) and low-impact, small hydroelectric sources"[5] and hence ranks those higher than nuclear and large hydropower plants.

[5] EPA: Green Power Market.

3. South America

South American infrastructure development has been largely promoted through the Union of South American Nations (UNASUR). Its Initiative for the Integration of Regional Infrastructure in South America (IIRSA) – established in 2010 – presents the framework within which the region's physical infrastructure in the energy, transport and information and communication technology (ICT) sectors is to be developed. IIRSA, together with its Technical Cooperation Committee (TCC),[6] identified 10 so-called Integration and Development Hubs and their respective infrastructure requirements (see Appendix 2.1). As a second step, the South American Infrastructure and Planning Council (COSIPLAN) was created as a platform to prepare the implementation of the regional infrastructure integration.

COSIPLAN developed a Strategic Action Plan 2012 – 2022 (PAE) and identified 31 priority projects (API) located in the different integration and development hubs. For our analysis we will look not only at the API projects, but at the entire COSIPLAN project portfolio. In 2014, the project portfolio included 579 projects – 89% of those in the transport sector, almost 10% in the energy sector and less than 2% in the communication sector.[7] All projects together account for an estimated investment of US $ 163.3 billion.

Of the 54 energy projects in COSIPLAN's portfolio, the majority are interconnection projects (31 compared to 23 generation projects). Energy projects account for US$ 54.7 billion of investment - about 50% of which are public-private partnerships (PPPs) (see Appendix 2.2).[8]

With regard to the distribution of the energy projects, most projects are located in the Mercosur-Chile Hub (20) and in the Andean Hub (11) (see Appendix 2.3). Hence, in the context of this analysis we will look at the Mercosur-Chile Hub and focus on Argentina, where 10 of the 20 energy projects are located, as a representative country.

Energy Projects in the Mercosur-Chile Hub

Twenty (20) of the 123 projects located in the Mercosur-Chile Hub are energy related projects. Contrary to the distribution observed in the entire COSIPLAN project portfolio, the majority of energy projects in the Mercosur-Chile Hub is focused on energy generation (13 compared to 7 interconnection projects)(Appendix 2.4).

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6 The TCC is comprised of the Inter-American Development Bank (IADB), the Latin American Development Bank (CAF), and the Financial Fund for the Development of the River Plate Basin (FONPLATA).

7 See: UNASUR/COSIPLAN (2014): Cartera de Proyectos 2014, p.10

8 Ibid., p. 45.

Among the power generation projects, the construction and retrofitting of hydroelectric plants prevails with only two out of seven plants being small scale hydroelectric power stations. The construction of thermoelectric plants and nuclear power plants comprises the rest of the projects (two projects in each category).

3.1 Case Study: Argentina

Argentina is implementing half of the energy projects located in the Mercosur-Chile Hub. In order to make assumptions about how these energy projects will contribute to the decarbonization of Argentina's energy sector, we look at the drivers of decarbonization for which data is available (GDP, CO_2-emissions from energy generation) and derive the level of carbon intensity from this information. We also consider trends in decarbonization since 2000. We find that gas and hydropower overwhelmingly dominate the country's electricity generation. The share of all renewable energy sources used in Argentina (hydro, nuclear, biofuels, wind) has been relatively stable, although hydropower use fluctuates and then levels out at approximately 30,000 GWh a year over the entire period (see infographic). The share of fossil fuels on the other hand – especially gas and oil – has been rising steadily since the beginning of the century (see infographic). This rise is also reflected in the slow, but steady increase of Argentina's CO_2-emissions from approximately 130 Mt in the years 2000-2003 to 180 Mt in 2010 with a peak of 190 Mt in 2009 (see infographic). So what does this mean for Argentina in terms of the carbon intensity of its electricity generation?

We see carbon intensity peaking in 2002 and from that moment steadily declining (see infographic). This decline, however, is not a result of reduced CO_2-emissions, but originates from an increase in GDP. The data exemplifies why we need to expand our view on the topic of environmental impacts of energy projects. For as long as a country's GDP is growing more rapidly than its CO_2-emissions, the level of carbon intensity will always be decreasing and can therefore even mask an increase of emissions. Carbon intensity says nothing about the actual change in CO_2-emissions which is why it is important to look at the individual shares of fossil fuels and renewable energy sources in the particular fuel mix.

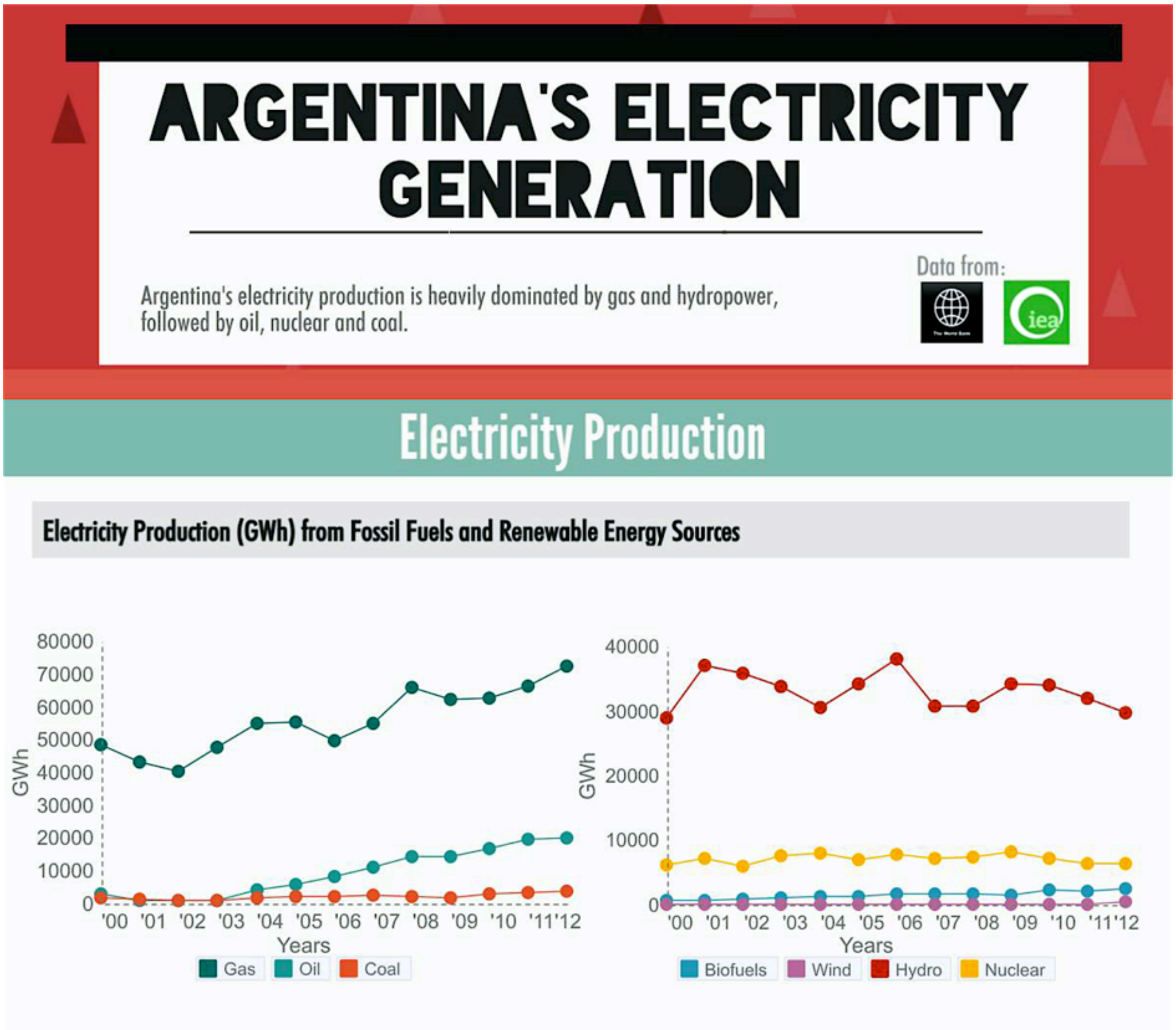
Impacts of COSIPLAN Projects in Argentina

Among the Mercosur-Chile Hub power generation projects located in Argentina are three newly constructed hydropower plants: Corpus Christi, Garabí, and Panambí (see infographic). Furthermore, the Yacyretá and the Salto Grande dams are to be modernized, but the former project has already been completed. Apart from the hydropower projects, there are plans to build a northeastern gas pipeline (also part of the API priority projects), another pipeline connecting Argentina and Brazil,[9] a new

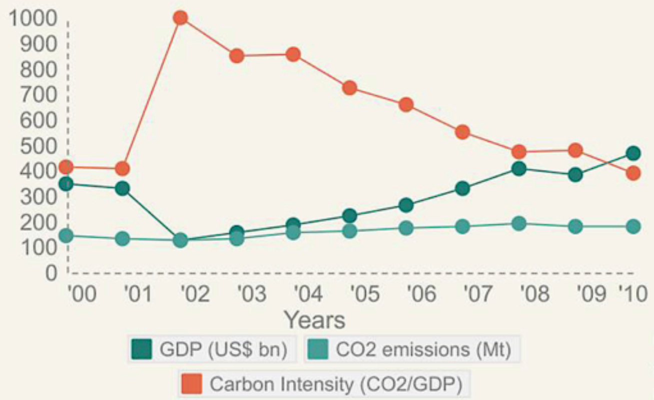
[9] See: UNASUR/COSIPLAN (2014): Cartera de Proyectos 2014, p.215.

nuclear power plant (Atucha II) as well as to repower the Embalse nuclear power plant. Moreover, a transmission line has already been completed (Yacyretá – Buenos Aires).

As the development hubs identified by IIRSA are not coherent with the geographical borders of the countries, we also have to consider energy projects that are not part of the Mercosur-Chile Hub, but which are located in Argentina. Most of the nine projects that therefore also have to be taken into account are transmission lines and interconnection projects (see infographic). By 2014, most of these projects had already been completed. In terms of energy generation, the two already completed thermoelectric plants (Belgrano in Campana and San Martín in Timbúes) both use gas to produce the steam needed for electricity generation.



Carbon Intensity



Carbon intensity of energy generation is defined as the amount of CO_2 energy emissions per unit of GDP.

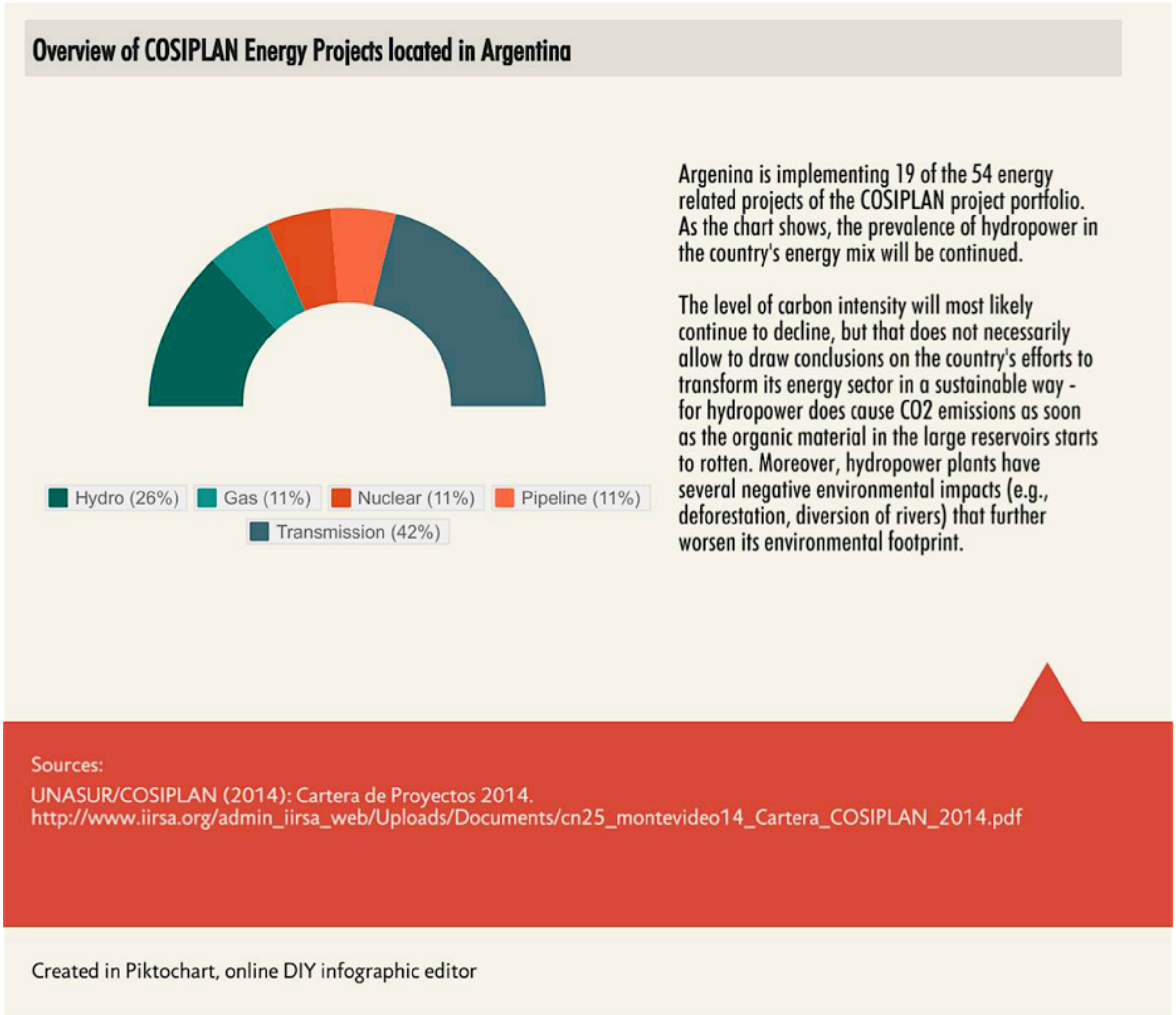
Energy Project located in Argentina (all Integration and Development Hubs)

Mercosur-Chile Hub

Project	Status	Estimated Investment (US$ millions)
Hydropower		
Construction of Corpus Christi Hydroelectric Power Station (AR-PY)	Pre-Execution	4,200
Construction of the Garabí Hydroelectric Power Station (AR-BR)	Pre-Execution	2,728
Construction of the Panambí Hydroelectric Power Station (AR-BR)	Pre-Execution	2,474
Modernization of the Salto Grande Electric Power Plant (AR-UY)	Pre-Execution	0
Yaycretá Hydroelectric Dam: Raise Reservoir Storage Level to 83 (AR-PY)	Completed	1,200
Pipelines		
Northeastern Argentina Gas Pipeline (AR)	Pre-Execution	1,000
Aldea Brasileña – Uruguaiana – Porto Alegre Gas Pipeline (AR-BR)	Execution	510
Nuclear Plants		
Atucha II Nuclear Power Plant (AR)	Execution	740
Repowering of Embalse Nuclear Power Plant (AR)	Execution	1,780
Transmission		
Yacyretá - Buenos Aires Transmission Line (AR)	Completed	600

Other Hubs

Project	Status	Estimated Investment (US$ millions)
Gas		
Belgrano Thermoelectric Plant in Campana (AR) (Paraguay-Paraná Waterway Hub)	Completed	650
San Martín Thermoelectric Power Station in Timbúes (AR) (Paraguay-Paraná Waterway Hub)	Completed	500
Transmission		
Transformer Station in Mercedes (AR) (Paraguay-Paraná Waterway Hub)	Completed	25
High-Voltage Transmission Line between Mercedes and Goya (AR) (Paraguay-Paraná Waterway Hub)	Completed	25
High-Voltage Transmission Line between Mercedes and Paso de los Libres (AR) (Paraguay-Paraná Waterway Hub)	Pre-Execution	15
Electricity Interconnection between the Argentine Northwestern and Northeastern Regions (AR) (Capricorn Hub)	Completed	725
Construction of a 500-KV Electricity interconnection between Comahue and Cuyo Region (AR) (Southern Hub)	Completed	350
Construction of a 500-KV Electricity Interconnection between Choele Choel and Puerto Madryn (Southern Hub)	Completed	70
132-KV Electricity Interconnection between Villa La Angostura - Traful - Costa del Limay (Southern Hub)	Profiling	30



Piktochart
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The majority of these projects (except for the gas pipeline and the thermoelectric plants) promote the use of renewable energies. Hence, with regard to avoiding CO_2-emissions during the actual electricity generation phase, all projects have and will continue to have a positive impact. The rate of carbon intensity will most likely improve irrespective of how the level of GDP evolves. However, if we look beyond the generation phase and consider the plant's life-cycle CO_2-emissions and further potential environmental and social impacts, the results of the analysis change.[10]

10 We leave out emissions caused by the manufacturing of construction parts as every power plant will cause these emissions to some extent.

In the case of hydropower plants, especially those linked to large scale dams (at least 15m high and with a reservoir capacity of at least 3 million cubic meters [11]) there are several aspects that negatively affect their environmental footprint. On the one hand, although considered as clean energy providers, CO_2 may be emitted. A problem of many larger dams is the rotting of the vegetation that is flooded when filling the reservoir. Once the organic matter starts to rot, large amounts of GHGs, particularly CO_2 and methane, are emitted. [12] On the other hand, there are several negative environmental impacts that do not originate from the emission of CO_2. The change of rivers' biological, chemical and physical characteristics can have far-reaching consequences for the flora and fauna close to the hydropower plant. What is more, the dam itself presents an obstacle to natural fish migration. In many cases, rivers have to be diverted or straightened in order to achieve the necessary speed of the stream. Last but not least, it is very questionable whether large scale hydropower plants are a sustainable way of producing energy in the light of increasing depletion of water resources all around the world due to global warming.

With regard to the impact on local communities, hydropower plants' performance is just as problematic. The construction of large dams and their respective enormous reservoirs regularly causes the displacement of the local population. The loss of land comes with the loss of their livelihood activities – in many cases in the agricultural and fishery sectors. Even if compensation payments have been agreed, it is often not enough to start from scratch – economically, socially and psychologically. However, not only people affected by displacement, but also the population down-stream often suffers from the hydrological changes due to the construction of large dams. [13]

With regard to nuclear power plants, CO_2-emissions are not the problem. However, apart from the serious safety and exposure risks that are linked to the plants' radioactivity, long term environmental impacts are diverse: firstly, there is still no safe way to dispose the nuclear waste; secondly, uranium mining comes with highly destructive environmental and social impacts (including GHG emissions); and thirdly, the cooling process needs large quantities of water which are eventually released into the environment likely to cause a warming of the surrounding waters.

If one wants to make an informed decision about sustainable, environmental friendly and relatively carbon neutral ways of energy generation, the Argentinean case shows that carbon intensity on its own is not a sufficient indicator. Indirect and long term environmental impacts have to be taken into account. From the information available, it

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[11] See: Imhof, A., Lanza, G.R. (2010): "Greenwashing Hydropower: The Problems with Big Dams" in: World Watch Magazine Jan/Feb 2010, Vol.23, No.1.

[12] See: International Rivers (2008): Dirty Hydro: Dams and Greenhouse Gas Emissions.

[13] See: International Rivers: Human Impacts of Dams. pp.124ff.

seems that these aspects have not been considered in the Argentinean decision-making process. It is likely that carbon intensity will continue to decrease, but as we have seen this is not necessarily a sign of sustainable energy generation. The projects identified by COSIPLAN show that Argentina will continue to base its electricity production on gas and hydropower. The opportunity to develop the beginnings of its wind energy sector unfortunately has not been seized within the framework of regional infrastructure development.

4. Asia

In the case of Asia, we will take a closer look at the political and economic organization Association of Southeast Asian Nations (ASEAN). ASEAN includes ten member states[14] and is considered one of the fastest growing economic regions. In terms of energy, the International Energy Agency (IEA) expects the region's demand to increase by 76% between 2007 and 2030.[15] ASEAN member states have a wide range of traditional energy resources at their disposal, such as hydropower, oil, gas and coal. However, even in 2008, more than a quarter of people living in the region did not have access to electricity.

The latest ASEAN Energy Outlook projects that the region will "continue to be heavily dependent on fossil fuels, especially oil, in the future".[16] But with oil production further declining or even stagnating in the region in the face of growing demand, oil imports will be the only way to guarantee a stable oil supply. As a result, the growing demand for electricity will also lead to an increased use of other fossil fuels, especially coal. In fact, it appears certain that fossil fuels will remain as the major source of energy in the ASEAN region, with an approximately 85% share in its energy mix in 2030.[17]

Since the beginning of the new century, ASEAN has made an effort to meet the region's energy needs and to ensure supply security and the efficient use of energy resources. The ASEAN Plan of Action for Energy Cooperation 2010-2015 (APAEC) is the third of a series of action plans aimed at creating a regional energy market and enhancing energy trade across the borders of ASEAN member states.

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14 Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Vietnam.

15 See: Infrastructure Investor (2013): "ASEAN. An Intelligence Report", p.22.

16 3rd ASEAN Energy Outlook (2011), p.2.

17 See: ASEAN Plan of Action for Energy Cooperation 2010-2015, p.6

APAEC 2010-2015 Program Areas

The third APAEC for the period 2010 to 2015 defines seven program areas for its focus:

- ASEAN Power Grid
- Trans-ASEAN Gas Pipeline
- Coal and Clean Coal Technology
- Energy Efficiency and Conservation
- Renewable Energy
- Regional Energy Policy and Planning
- Civilian Nuclear Energy

An assessment of these program areas shows that, superficially, environmental aspects have been considered in the decision-making process; energy efficiency and renewable energies are part of the agenda. But if we take a closer look, it becomes clear that there is a heavy bias towards fossil fuel projects and renewable energy sources that have huge negative impacts on the environment (large hydropower, biofuels, nuclear). Furthermore, the ASEAN Power Grid (APG) and the Trans-ASEAN Gas Pipeline (TAGP) have been identified as flagship projects of special importance.

The aim of the APG is to integrate national power grids among ASEAN members in order to enhance electricity trade across borders. The long term goal is to meet rising electricity demand and to improve access to energy. The APG includes 15 interconnection projects requiring an estimated investment of US$ 5.9 billion.[18] According to the latest information publicly available, most of the projects are not yet completed (see Appendix 3.1).

The TAGP on the other hand is supposed to connect the gas pipeline infrastructure of ASEAN members in order to develop a regional gas grid by 2020. The project involves the construction of approximately 8,000 to 10,000 kilometers of pipelines, many of them undersea. In spring 2013, 11 bilateral gas pipelines were in operation (3,020 kilometers)(see Appendix 3.2). With regional gas demand projected to grow around 7-8% per year, the TAGP is an important step towards meeting this demand. However, the growing demand for gas also requires an increase in the gas supply. ASEAN's big hope in this regard is the commercialization of the East Natuna gas field in Indonesia. Other options considered include the import of LNG gas or the use of alternative sources like coalbed methane (CBM).[19]

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[18] See: ASEAN Plan of Action for Energy Cooperation 2010-2015, p.12.

[19] Coalbed methane is a form of natural gas extracted from coal beds by drilling into the coal seam.

Another focus in terms of energy generation in the ASEAN region is coal. Despite coal fired power plants being the largest emitter of CO_2, the APAEC sees the rapid growth of coal utilization for power generation as an opportunity to promote and increase "cleaner coal use" – greenwashing at its best.

The plans promoted in these three areas dramatically dwarf ASEAN's efforts to actually reduce CO_2-emissions (e.g., the aim of reducing energy intensity by at least 8% by 2015 compared to 2005; promote higher end-use energy efficiency for all sectors). Even the targets set for renewable energy development (15% of total power installed capacity by 2015) are seen not as an alternative to fossil fuel combustion, but as "the right candidate to complement fossil fuel".[20] The focus of the renewable energy program area on hydropower and biofuels as well as the identification of nuclear power as an independent program area is therefore only another proof of ASEAN's limited understanding of sustainability.

All these developments are especially appalling in the light of the fact that Southeast Asia - comprised of numerous smaller islands - is one of the major regions affected by climate change. ASEAN's continued bias towards the use of fossil fuels for energy generation means that the region is digging its own grave.

4.1 Case Study: Indonesia

Indonesia is chosen as an example because of its regional significance in terms of gas supply and because of its significant renewable potential. Indonesia is blessed with abundant energy resources. Its renewable energy potential can be traced back mainly to its large geothermal reserves. Although 40% of the world's geothermal reserves are located in Indonesia, the country's energy production is heavily dominated by coal (49% of installed capacity in 2012), gas (23%) and oil (17%). One of the major problems Indonesia is facing with regard to exploiting its geothermal potential is that most of the reserves are located in conserved forests. Therefore, there is a trade-off between development of its geothermal resources and its commitment to a long term deforestation policy.

Especially against this background, it would be important for Indonesia to tap into other renewable sources. The Indonesian Ministry for Energy and Mineral Resources (MEMR) claims that 96% of renewable potential is undeveloped.[21] The most significant source in this regard is hydro and marine power with the latter offering greater potential. With regard to wind power, Indonesia's onshore capacities are limited due to the lack of wind along the equator. But the coastline offers the opportunity for offshore

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20 ASEAN Plan of Action for Energy Cooperation 2010-2015, p.21.

21 See: Wilcox, J. (2012): Indonesia's Energy Transit: Struggle to Realize Renewable Potential

wind power development. However, despite the various renewable energies that could be tapped, it is not a policy priority of the Indonesian government.

On the contrary, Indonesia's East Natuna gas field, located in the South China Sea, is to play a vital role for ASEAN's gas supply. A business consortium consisting of PT Pertamina (Indonesian state oil and gas firm), ExxonMobil (US), Total SA (France) and PTT Exploration and Production (Thailand) seeks to develop the field. With total proven reserves of 46 trillion cubic feet it is the biggest gas field in Asia.[22] Production is supposed to begin in 2020, but the exploitation of the field is very cost-intensive due to its high CO_2 content (71%).

If we look at the data, we can see that electricity production from coal and gas has been increasing constantly. Furthermore, Indonesia passed an energy law in 2007 in order to diversify its energy supply. So far the development of waste, solar and wind capacities is still in its infancy, not comparable with geothermal and hydropower production (see infographic), but this and the decreasing carbon intensity seem to give reason for hope – at first sight. If we take a closer look, however, we will see that from 2000 to 2012, electricity production from fossil fuels has grown by 121% from an already high level compared to for example Argentina (see infographic) – while the use of renewable energies only grew by 51%. Hence, although carbon intensity has been cut in half (mostly due to the growing reliance on geothermal sources) this cannot been considered a reliable indicator in terms of transforming the energy sector in more sustainable and environmental friendly ways.

Moreover, if the East Natuna gas field begins production by the end of this decade, a massive increase of CO_2-emissions can be expected that will easily undo all the progress that has been made in Indonesia's renewable energy sector. For the region, there is not much hope for improvement, either. All ASEAN member states heavily depend on coal, gas and oil for their electricity generation; only the Philippines and Thailand show a bigger share of renewables in their respective energy mixes – hydropower, geothermal power (in the case of the Philippines), and wind and solar (in the case of Thailand).

22 See: Azwar, A.S. (2012): Consortium expects govt approval on East Natuna.

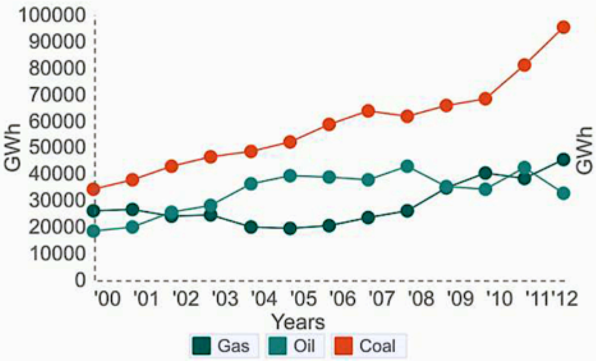
INDONESIA'S ELECTRICITY GENERATION

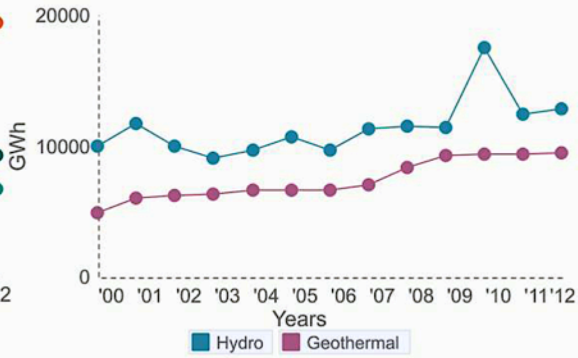
Indonesia's electricity production relies heavily on coal and gas. But its abundant renewable energy resources, especially its geothermal reserves, provide an opportunity for a successful transformation of its energy sector.

Data from:

Electricity Production

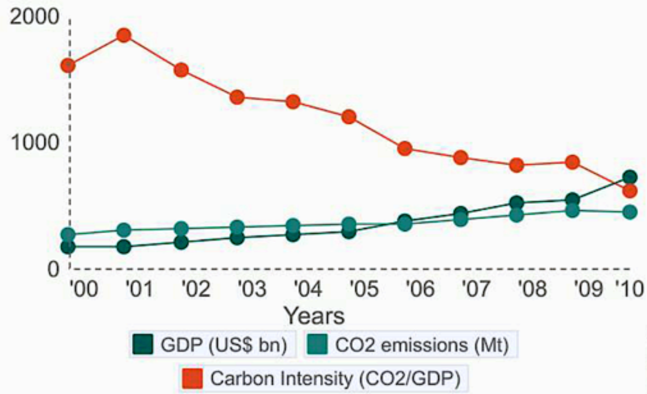
Electricity Production (GWh) from Fossil Fuels and Renewable Energy Sources



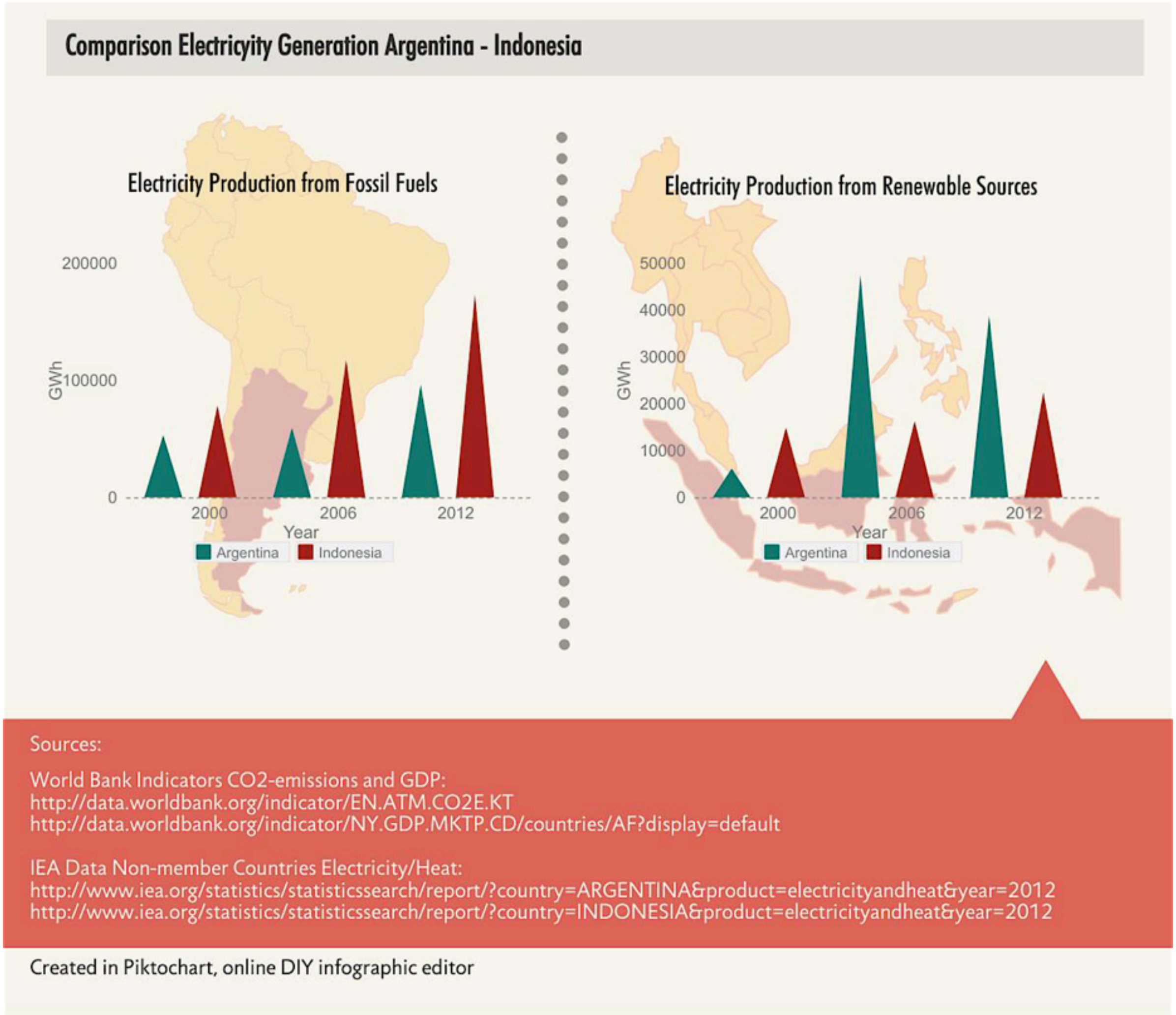


Compared to hydro and geothermal power, energy production from biofuels, waste, wind and solar is still underdeveloped. In the case of biofuels, production remains in the three-digit range only from 2011 on production from waste, wind and solar increased to a double-digit level.

Carbon Intensity



Carbon intensity of energy generation is defined as the amount of CO_2 energy emissions per unit of GDP.



5. Africa

Africa's infrastructure development is driven by the Programme for Infrastructure Development in Africa (PIDA) spearheaded by three entities: the African Union Commission (AUC), the African Development Bank (AfDB) and the New Partnership for Africa's Development Planning and Coordination Agency (NEPAD Agency). PIDA comprises infrastructure projects in the energy, transport and ICT sector as well as in the context of transboundary water resources. In consultation with the respective regional economic communities (RECs), 51 priority action projects have been identified (PIDA PAP) requiring an estimated investment of US$ 68 billion between 2012 and 2020.

Most of the priority projects are related to the transport sector, followed by energy projects. Energy demand in Africa is projected to increase 5.4 fold through 2040. [23] While coal will lose some of its importance for energy production, gas, hydro and nuclear power will be developed (see Appendix 4.1). This is also reflected in the selection of energy priority projects for the continent. The 15 energy related projects include nine hydropower, four transmission and two pipeline projects. If we add the four hydropower projects listed under the water projects, we can see that hydropower is clearly dominating the future energy strategy of the continent (see Appendix 4.2). Hydro is considered as a renewable energy source, but in the context of increasing droughts due to climate change, hydropower plants may not meet expectations for energy generation. Regrettably, other renewable energies such as wind or solar are not considered within the PIDA framework.

Hydropower Projects in Central and West Africa

If we look at where the PIDA hydropower projects are located, we can see that especially the Congo River Basin and the West African River Basins (Volta, Senegal and Niger River Basins) play an important role (see Appendix 4.3). Apart from PIDA's efforts to develop the African energy sector, the REC specific power pools are important institutions in terms of power trade and energy development. From the two areas on which PIDA is focusing, we will have a closer look at the Congo River Basin and therefore at the East African Power Pool (EAPP).

The EAPP is comprised of the national utilities of the following countries: Burundi, Democratic Republic of Congo (DRC), Egypt, Ethiopia, Kenya, Libya, Rwanda, Sudan, Tanzania and Uganda. If we look at aggregated information for 2012 on electricity production for 7 of these 10 countries (Burundi, Rwanda and Uganda are excluded due to a lack of data in the IEA database), we see that 81% of electricity is produced with fossil fuels, namely gas and oil. None of the analyzed countries is dependent on coal.

PIDA strives to promote energy generation through hydropower. The data for renewable shows the beginnings of how the abundant water reserves of the area are being developed. In Ethiopia and the DRC hydropower effectively dwarfs energy generation from fossil fuels: 35GWh from gas and oil vs. 7931GWh from hydropower in the DRC; 40GWh from oil vs. 6615GWh from hydro in Ethiopia. [24] However, both PIDA and the EAPP plan to construct even more new large scale hydropower plants along the Congo River. This is despite having been proved wrong on several occasions, including with respect to the Grand Inga Dam project – the world's largest hydropower scheme. Two hydroelectric facilities have already been built at the Inga Waterfalls; a third dam and

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23 See. PIDA Study Synthesis, p.23.

24 Numbers for 2012; see IEA data for the DRC and Ethiopia.

hydroelectric plant (Inga 3) is a PIDA priority project. The environmental consequences of large dams have already been discussed in the Latin American case; in the case of the Inga project, evidence shows a range of legitimate environmental concerns as well as political challenges. Corruption is a huge problem in the DRC and infrastructure projects are prone to corruption. Furthermore, despite the construction of Inga 1 and 2 in the 1970s and 80s, 94% of the Congolese population still has no access to energy. Transmission lines from the two hydroelectric facilities connect with industrial sites such as mines, bypassing the communities and towns nearby. Today, both facilities only operate at around 50% due to a lack of maintenance.[25] In the light of these experiences, the regional hydropower development strategy clearly has to be challenged.

5.1 Case Study: Ethiopia

Ethiopia has the potential to generate 45,000 MW of electricity from hydropower alone.[26] It comes as no surprise that national development strategies heavily rely on the expansion of hydropower generation. For more than a decade, hydropower has been the main source for electricity generation (see infographic). Only over the last three years has the country slowly started to diversify its energy generation promoting geothermal and wind power. Naturally, the country's carbon intensity is relatively low and its decrease is accelerated by Ethiopia's constant GDP growth.

What these numbers do not show is that Ethiopia is struggling with its water economy. Apart from being used for electricity generation, the 12 major watersheds are an important factor for the local economy. Despite increasing urbanization over the last decade, in 2013, 81% of Ethiopia's population still lived in rural areas.[27] This large rural population comprised of small scale farmers and pastoralists needs water for agricultural purposes. At the same time, their livelihoods are extremely vulnerable due to Ethiopia's significant exposure to severe, climate change related droughts. The last one in 2011 was said to be the worst in 60 years; it was so severe that it caused a food crisis that endangered the lives of millions of people. A further expansion of hydropower will add to the threat that climate change is already posing to the rural population. What is more, they have not been benefitting from the already existing hydropower facilities due to a lack of distribution lines to the rural areas.

However, the national government and the regional power pool, EAPP, have great plans to increase installed capacity from hydropower in the coming years. Apart from the Great Millennium Renaissance Dam that is currently being constructed under the PIDA

25 See: International Rivers: Inga 1 and 2 Dams; Grand Inga Dam, DR Congo.

26 See: Ministry of Finance and Economic Development (2010): Growth and Transformation Plan (GTP) 2010/11 – 2014/15, p.36.

27 See: World Bank Data for Ethiopia: Rural polulation (% of total population).

framework, four other large scale hydropower projects with a capacity of more than 1500 MW each are planned in Ethiopia alone (see infographic); 8 additional dams are to be constructed in the DRC, Rwanda, Tanzania and Uganda.[28] But evidence shows that benefits rarely "trickle down" to the rural population.

Despite electricity generation being entirely dominated by hydropower (98% in 2012), only a quarter of Ethiopians has access to electricity.[29] Yet the country is blessed with an abundance of other renewable sources, e.g., geothermal, solar and wind. The Ethiopian Ministry for Water and Energy itself identified the country's solar energy reserves at 2.199 million TWh per year and a wind capacity of 1,350 GW.[30] Furthermore, 16 sites have been judged to be commercially viable for geothermal power generation.[31] These are optimal conditions to balance the dominance of hydropower. Recently, wind, geothermal and solar projects have been identified as candidates for investment, which provides hope that an actual diversification of the energy sector is underway. It is now crucial that potential sources provide energy in ways that benefit the majority of the Ethiopian population.

28 28 See: Eastern Africa Power Pool (EAPP) and East African Community (EAC): Regional Power System Master Planand Grid Code Study, Executive Summary, p.16.

29 See: World Bank Data for Ethiopia: Access to electricity (% of population).

30 See: Ministry of Water and Energy (2013): Ethiopia's Renewable Energy Power Potential and Development Opportunities, slide 10.

31 See: International Rivers (2009): Clean Energy for Ethiopians, Not Damnation of River Dwellers.

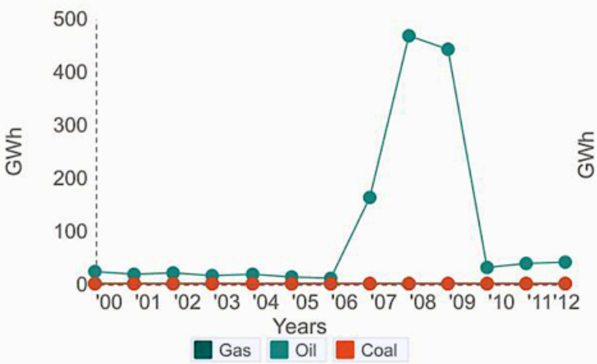
ETHIOPIA'S ELECTRICITY GENERATION

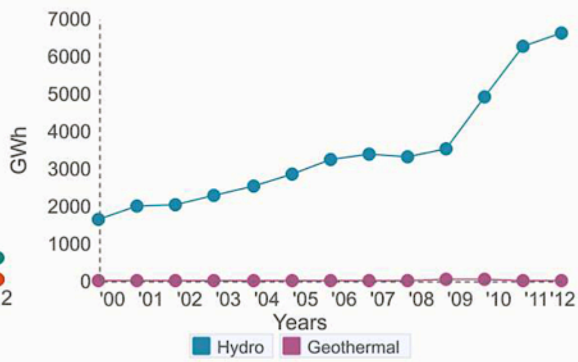
For more than a decade, hydropower has been the main source for Ethiopia's electricity generation, despite the country's constant struggle with water scarcity. Only recently Ethiopia started to diversify its energy sector.

Data from:

Electricity Production

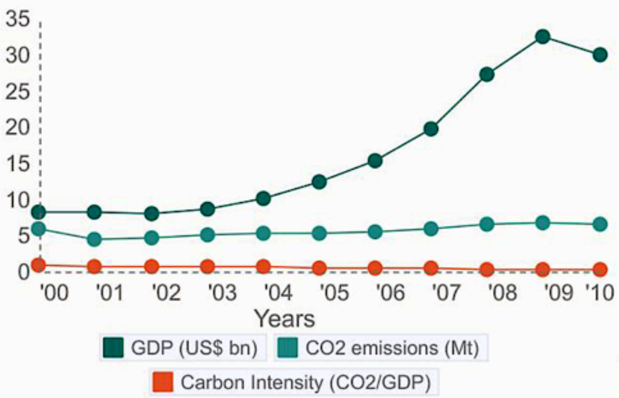
Electricity Production (GWh) from Fossil Fuels and Renewable Energy Sources



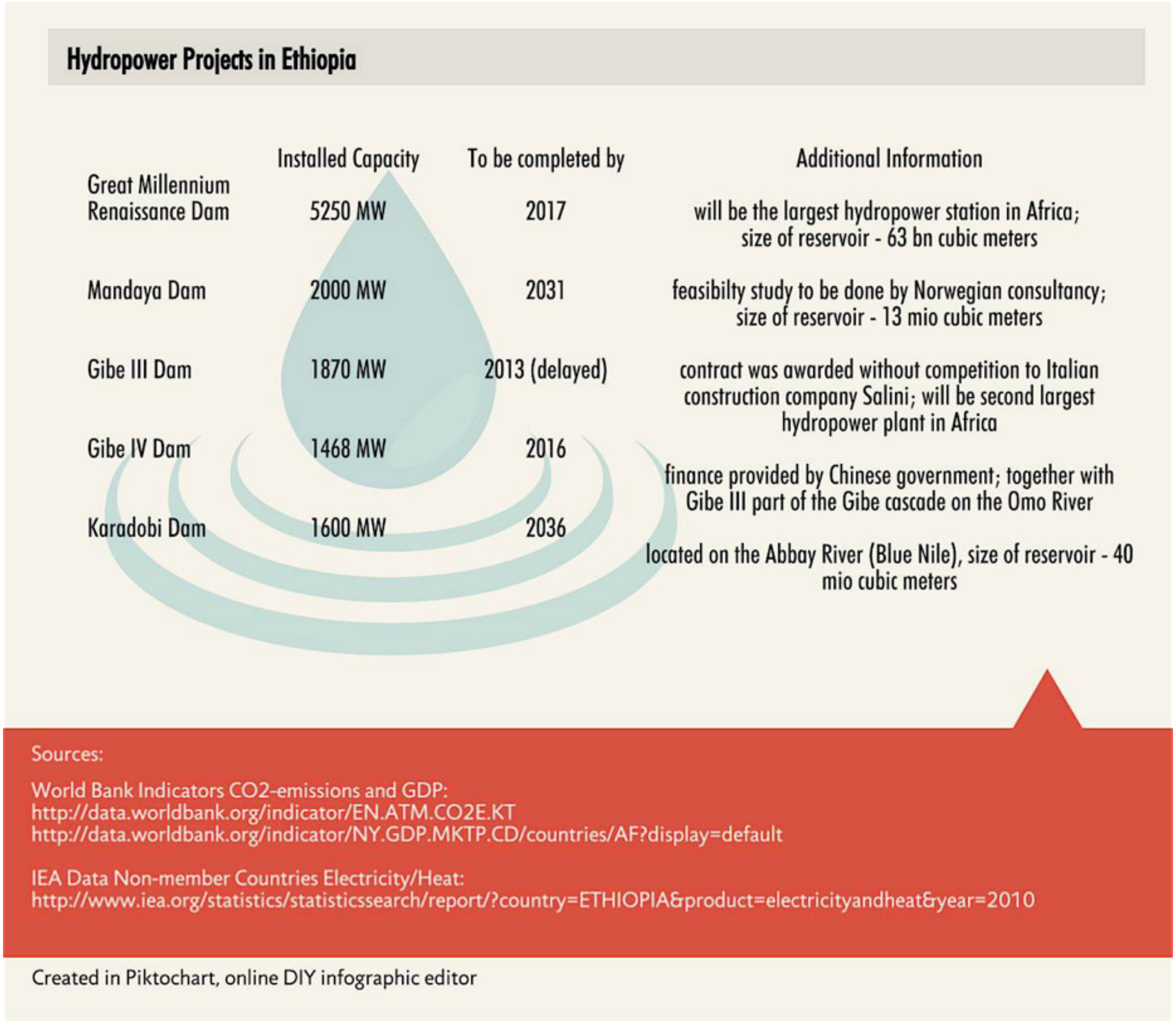


Hydropower clearly dominates the country's electricity production. Geothermal sources remain on a two-digit level and cannot yet compete with hydropower.

Carbon Intensity



Carbon intensity of energy generation is defined as the amount of CO_2 energy emissions per unit of GDP.



6. Conclusion

The world is running out of time when it comes to limiting global warming to 2°C. Profound changes have to be achieved in order to reduce GHG emissions – the main driver for climate change. The energy sector is one of the most important leverage points since emissions from energy production based on fossil fuel sources are the largest single human source of global GHG emissions.[32] The decarbonization of the energy sector is therefore essential. Apart from energy efficiency and conservation measures, the transformation of global energy generation is a fundamental step in the process.

[32] U.S. Environmental Protection Agency: Global Greenhouse Gas Emissions Data.

Emerging countries and developing economies may have an actual advantage when it comes to transforming their energy sector. Infrastructure development is currently the "talk of the town." The identified infrastructure gaps in Latin America, Asia and Africa offer the opportunity to fill them with sustainable, appropriate scale, renewable energy projects.

But despite having the potential to substantially rely on renewable energies for energy generation, many countries only slowly start to develop this potential. The ASEAN region is said to continue to rely on fossil fuels even in 2030. The development of new gas reserves like the East Natuna Gas Field in Indonesia in fact dwarfs any effort to diversify the energy sector. Also in the case of Argentina we have seen that despite having abundant unexploited wind resources, the use of fossil fuels is constantly rising. Gas and hydropower already dominate the country's energy sector and regional infrastructure strategies will only accelerate the dependence on large hydropower facilities.

A similar development is conceivable in Africa. PIDA heavily promotes the construction of large scale hydropower plants. In some cases like Ethiopia, hydropower already dwarfs energy generation from fossil fuels. Although being considered a low-carbon energy source, large hydropower plants come with a range of environmental and social consequences and often cannot satisfy expectations due to climate change related unpredictable water supply.

To date, regional energy infrastructure strategies superficially seem to consider CO_2-emissions as a factor in project prioritization. But the promotion of hydropower does not reflect the fact that carbon emissions are not the only factor in forging a sustainable energy future.

On the surface, these policies positively influence the countries' carbon footprints. Recently, the overall drop in carbon intensity – one indicator of decarbonization - has been highlighted.[33] However, as the case studies above exemplify, carbon intensity alone is not a sufficient indicator for a global energy transformation because its correlation to GDP is misleading. As long as the level of GDP grows faster than the CO_2-emissions, the level of carbon intensity will decrease and therefore may effectively mask increasing CO_2-emissions.

Finally, it is important to promote case-to-case-analyses when deciding which energy sources are most appropriate and benefitting, including not only economic aspects, but environmental and social impacts, too (e.g. CO_2 life cycle assessments). For hydropower is an option for low carbon energy generation, but it also comes with an assortment of negative side effects, both socially and environmentally (displacement, diversion of rivers, deforestation, etc.) There is a need to significantly scale up the use of alternative renewable resources, labeled as "green power" by the U.S. EPA, such as wind, solar, waste, and biomass and to diversify overall electricity production. More of the same will not contribute to a secure, stable and sustainable energy future. Only a diversified and low or no carbon energy sector can be immune to vulnerability due to the impacts of climate change.

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- World Bank Data: GDP (current US$); CO_2 emissions (kt); Rural polulation (% of total population); Access to electricity (% of population)
- IEA Non-member countries: Electricity/Heat
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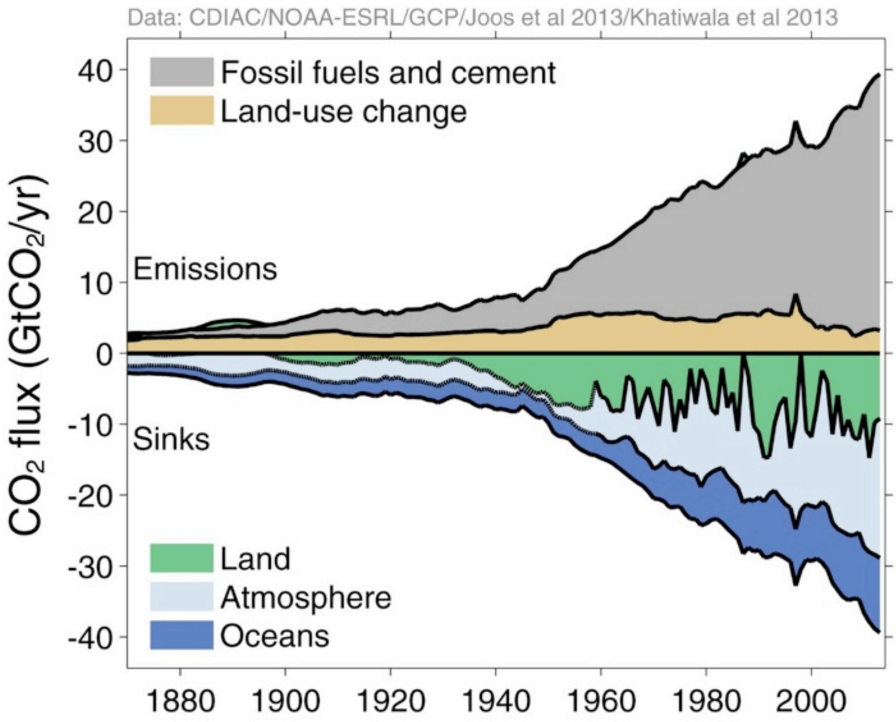
Appendices

Appendix 1: Global Carbon Budget 2014



Source: Global Carbon Budget 2014, Figure 13.

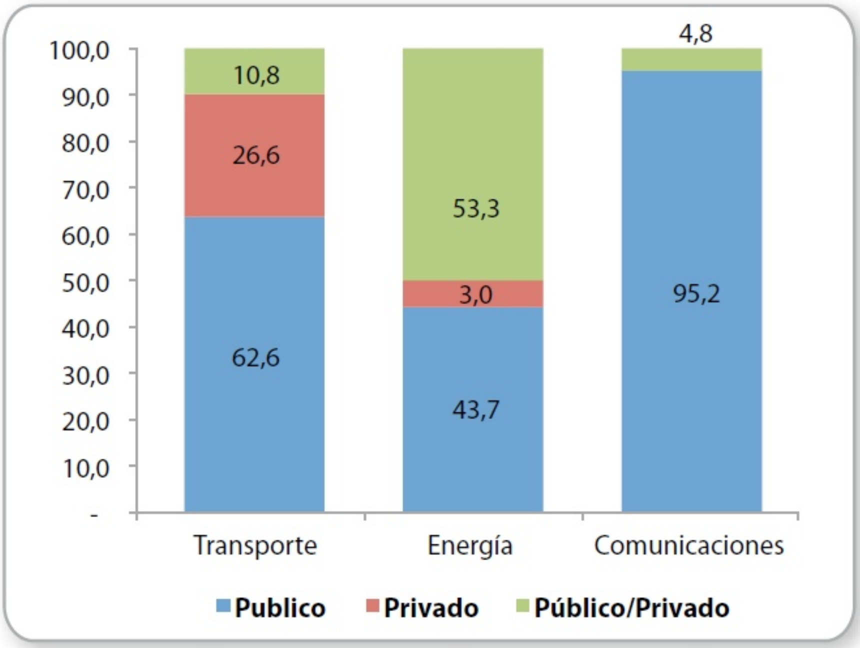
Appendix 2: South America

Appendix 2.1: IIRSA Integration and Development Hubs

Integration and Development Hubs
Andean Hub
Southern Andean Hub
Capricorn Hub
Paraguay-Paraná Waterway Hub
Amazon Hub
Guianese Shield Hub
Southern Hub
Central Interoceanic Hub
MERCOSUR-Chile Hub
Peru-Brazil-Bolivia Hub

Source: http://www.iirsa.org/Page/Detail?menuItemId=68

Appendix 2.2: Sources of Financing of the Portfolio Projects by Sector (% of the Investment Amount)



Source: UNASUR/COSIPLAN (2014): Cartera de Proyectos 2014: p.47.

Appendix 2.3: Distribution of Energy Projects in the Development Hubs

Hub	No. of energy projects	Investment US$ bn
Amazon	1	1.3
Andean	11	1.7
Capricorn	4	1.8
Guyanese	1	0
Paraguay – Paraná Waterway	7	1.4
Central	2	0.3
Mercosur	20	19.4
Peru-Brazil-Bolivia	5	28.3
Southern	3	0.5

Source: UNASUR/COSIPLAN (2014): Cartera de Proyectos 2014.

Appendix 2.4: Energy Projects in the Mercosur-Chile Hub

Projects	Status	Estimated Investment (US$ mio)
Generation		
Construction of the Corpus Christi Hydroelectric Power Station	Pre-Execution	4,200
Construction of the Garabí Hydroelectric Power Station	Pre-Execution	2,728
Construction of the Panambí Hydroelectric Power Station	Pre-Execution	2,474
Modernization of the Salto Grande Electric Power Plant	Pre-Execution	0
Yaycretá Hydroelectric Dam: Raise Reservoir Storage Level to 83	Completed	1,200
Atucha II Nuclear Power Plant	Execution	740
Repowering of Embalse Nuclear Power Plant	Execution	1,780
LNG Regasification Facilities in Uruguay	Execution	500
Punta del Tigre Combined Cycle Thermal Power Plant	Completed	170
Punta del Tigre Combined Cycle Thermal Power Plant II (500MW)	Execution	531

Projects	Status	Estimated Investment (US$ mio)
Generation		
Centurión and Talavera Micro-Hydroelectric Power Stations (65MW in total) on the Jaguarão River	Profiling	60
Itaipú Hydropower Plant System (Exisiting)	Completed	0
Transmission + Pipelines		
Yacretá – Buenos Aires Electricity Transmission Line	Completed	600
Itaipú – Londrina – Araraquara Electricity Transmission Line	Completed	149
Electricity Interconnection between Uruguay and Brazil	Execution	349
Electricity Interconnection between Salto Grande and Melo	Profiling	100
Northeastern Argentina Gas Pipeline	Pre-Execution	1,000
Aldea Brasileña – Uruguaiana – Porto Alegre Gas Pipeline	Execution	510
URUPABOL Gas Pipeline (Section II)	Profiling	2,300

Source: UNASUR/COSIPLAN (2014): Cartera de Proyectos 2014.

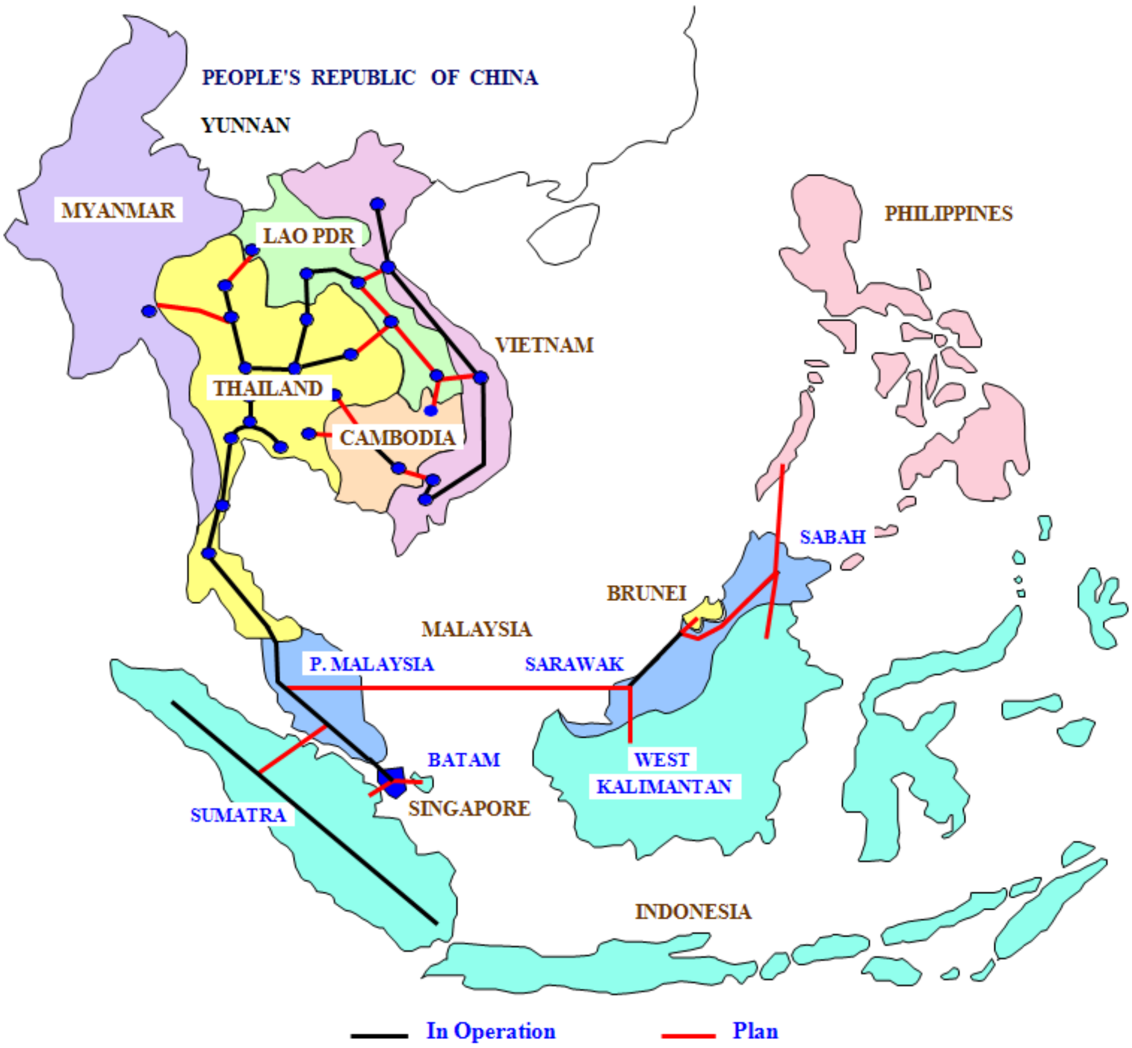
Appendix 3: Asia

Appendix 3.1: Map and Status of APG Interconnection Projects

Pipeline	Sub-Projects	Status
Malaysia – Singapore		2018
Thailand – Malaysia	Sadao – Bukit Keteri	Existing
	Khlong Ngae – Gurun	Existing
	Su Ngai Kolok – Rantau Panjang	2015
	Khlong Ngae – Gurun (2nd Phase)	2016
Sarawak – Malaysia		2015-2021
Malaysia – Sumatra		2017

Batam – Singapore		2015-2017
Sarawak – West Kalimantan		2015
Philippines – Sabah		2020
Sarawak – Sabah – Brunei	Sarawak – Sabah	2020
	Sabah – Brunei	Not selected
	Sarawak – Brunei	2012, 2016
Thailand – Lao PDR	Roi Et 2 – Nam Theun 2	Existing
	Sakon Nakhon 2 – Thakhek – Then Hinboun (Exp.)	Existing
	Mae Moh 3 – Nan – Hong Sa	2015
	Udon Thani 3 – Nabong (converted to 500kV)	2018
	Ubon Ratchathani 3 – Pakse – Xe Pian Xe Namnoy	2018
	Khon Kaen 4 – Loei 2 – Xayaburi	2019
	Thailand – Lao PDR (new)	2015 – 2023
Lao PDR – Vietnam		2011 – 2016
Thailand – Myanmar		2016 – 2025
Vietnam – Cambodia (new)		2017
Lao PDR - Cambodia		2016
Thailand – Cambodia (new)		2015 – 2020
East Sabah – East Kalimantan		2020
Singapore – Sumatra		2020

Source: Barriers and Opportunities for Electricity Interconnection. The Southeast Asian Experience, slide 10.

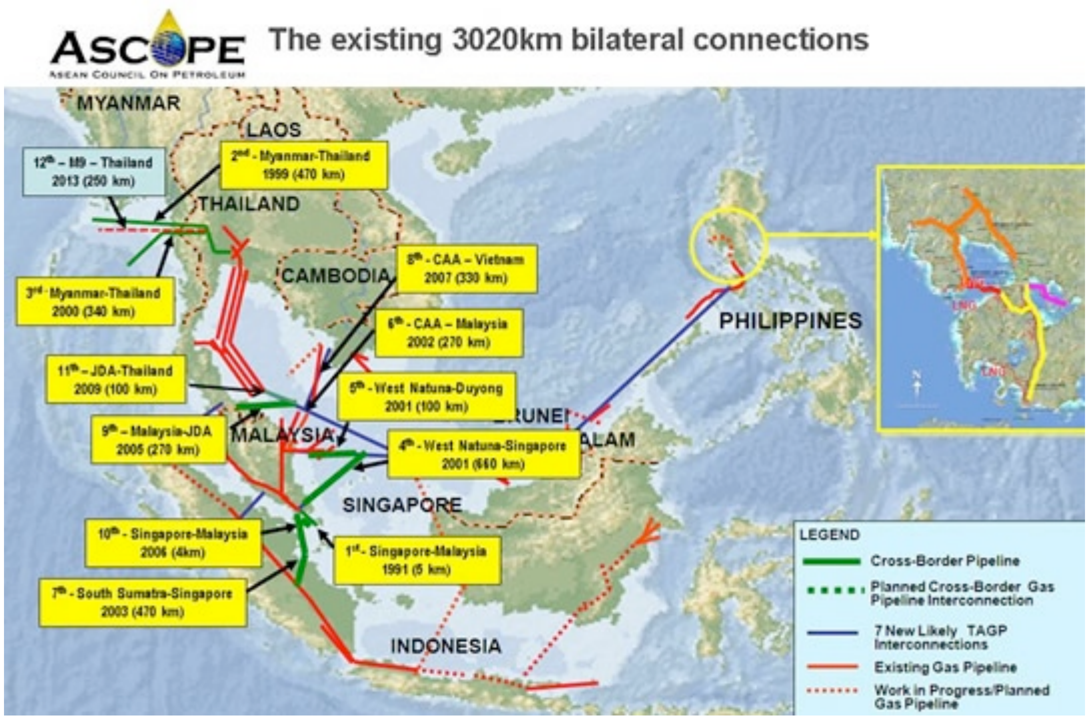


Source: http://www.sarawakenergynewsroom.com/2014/10/01/asean-power-grid-sarawak/

Appendix 3.2: Map and Status of TAGP Pipeline Projects

Pipelines	Status	Length
Singapore – Malaysia, via Johore Straits	Completed 1991	5km
Yadana, Myanmar – Ratchaburi, Thailand	Completed 1999	470km
Yetagun, Myanmar - Ratchaburi, Thailand	Completed 2000	340km
West Natuna, Indonesia – Singapore	Completed 2001	660km
West Natuna, Indonesia – Duyong, Malaysia	Completed 2001	100km
PM3 Commercial Arrangement Area (CAA) - Malaysia	Completed 2002	270km
South Sumatra, Indonesia – Singapore	Completed 2003	470km
Malaysia – Thailand Joint Development Area (JDA)	Completed 2005	270km
Singapore – Malaysia	Completed 2006	4km
CAA – Vietnam	Completed 2007	330km
JDA – Thailand	Completed 2009	100km
Offshore Block M9, Myanmar – Thailand	Completed 2013	250km

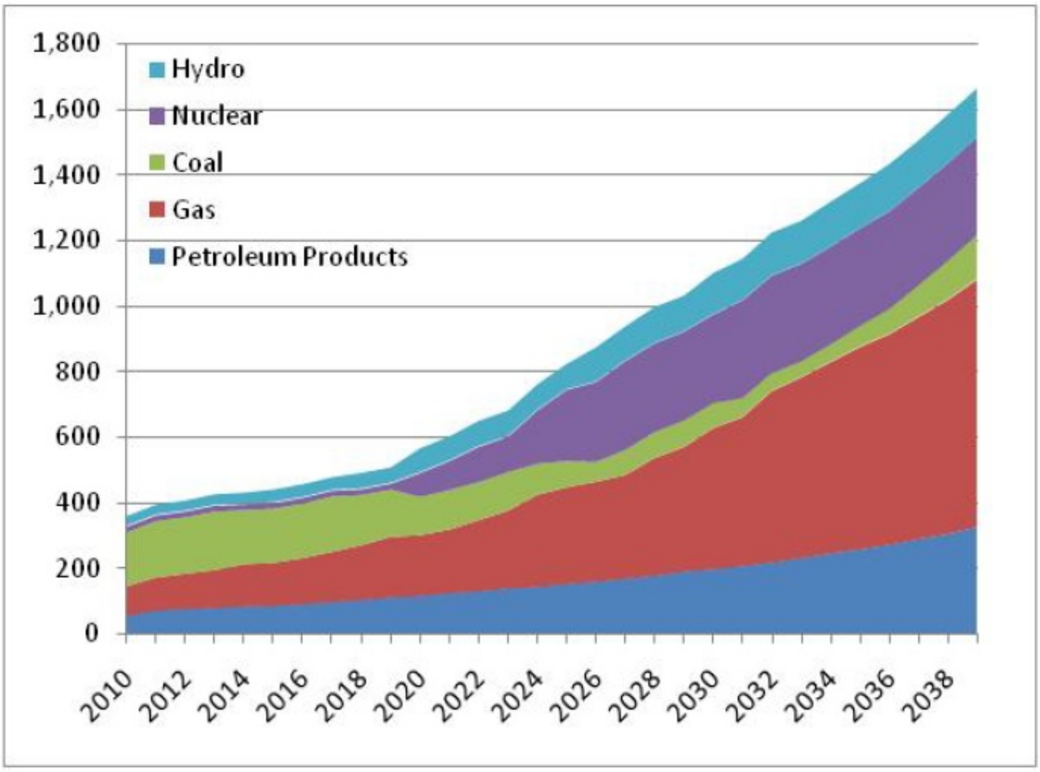
Source: [ASEAN Plan of Action for Energy Cooperation 2010-2015](), pp. 14f.



Source: http://ascope.org/component/content/article/6-projects/28-tagp.html

Appendix 4: Africa

Appendix 4.1: Consumption Fossil and Hydro Primary Energy of Africa (in million TOE)



Source: PIDA Study Synthesis, p.24.

Appendix 4.2: PIDA PAP Energy and Water Projects

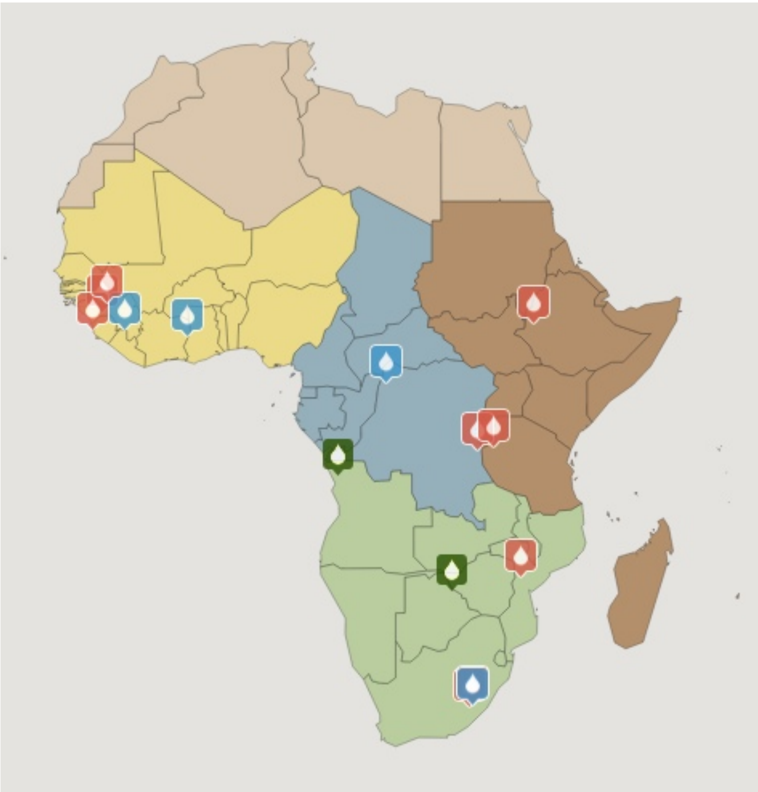
Energy Sector				
	Project	**Description**	**Status**	**Countries**
1	Central African Interconnection	3,800 km line from the DRC to South Africa through Angola, Gabon, Namibia and to the north to Equatorial Guinea, Cameroon and Chad	Concept stage	South Africa, Angola, Gabon, Namibia, Ethiopia
2	North - South Power Transmission Corridor	8,000 km line from Egypt through Sudan, South Sudan, Ethiopia, Kenya, Malawi, Mozambique, Zambia, Zimbabwe to South Africa	feasibility stage	Kenya, Ethiopia, Tanzania, Malawi, Mozambique, Zambia, Zimbabwe, South Africa

3	Mphamda-Nkuwa	Hydroelectric power plant with a capacity of 1,500 MW for export on the SAPP market	feasibility stage	Mozambique, Zambezi basin
4	Lesotho HWP phase II hydropower component	Hydropower programme for power supply to Lesotho and power export to South Africa	feasibility stage	Orange-Senqu River basin
5	Inga III Hydro	4,200 MW capacity run of river hydropower station on the Congo river with eight turbines	feasibility stage	DRC Congo River
6	West Africa Power Transmission Corridor	2,000 km line along the coast connecting with the existing Ghana-Nigeria line with a capacity of 1,000 MW	feasibility stage	Guinea, Guinea Bissau, Gambia, Sierra Leone, Liberia, Côte d'Ivoire, Ghana
7	North Africa Transmission	2,700 km line from Morocco to Egypt through Algeria, Tunisia and Libya	feasibility stage	Morocco, Algeria, Tunisia, Libya, Egypt
8	Nigeria-Algeria pipeline	4,100 km gas pipeline from Warri to Hassi R'Mel in Algeria for export to Europe	feasibility stage	Nigria, Niger, Algeria
9	Sambagalou	128 MW of hydropower capacity, 930 km from the mouth of the Gambia River to supply Senegal, Guinea, Guinea Bissau and Gambia	structuring and financing stage	Senegal, OMVG
10	Kaleta	Hydropower generation of 117 MW	structuring and financing stage	Guinea - OMVG
11	Batoka	Hydroelectric plant with a capacity of 1,600 MW to enable export of electricity	structuring and financing stage	Zambia/Zimbabwe, Zambezi basin
12	Ruzizi III	Hydroelectric plant with a capacity of 145 MW to share power among Rwanda, Burundi and DRC promoted by CEPGL	structuring and financing stage	Rwanda/DRC
13	Rusumo Falls	Hydropower production of 61 MW for Burundi, Rwanda and Tanzania	structuring and financing stage	Nile River basin
14	Great Millennium Renaissance Dam	Develop a 5,250 MW plant to supply domestic market and export electricity on EAPP market	implementation and operation stage	Ethiopia, Nile basin

15	Uganda-Kenya Petroleum Products Pipeline	300 km long pipeline for a lower cost mode of transport of petroleum products	implementation and operation stage	Uganda, Kenya
Water Sector				
16	Multisectoral Investment opportunity Studies	Identification and preparation of investment programmes in the basin	concept stage	Okavango River Basin
17	Noumbiel	Multipurpose dam with hydropower generation (for Burkina Faso and Ghana) component	concept stage / feasibility stage	Volta River Basin
18	Palambo	Regulaton dam to improve navigability of Obangui River with added hydropower component	feasibility stage	Congo River Basin
19	Gourbassy	Multipurpose dam located in Guinea: regulation of the Senegal river (four countries)	feasibility stage	Senegal River Basin
20	North-West Sahara Aquifer System	Prefeasibility studies for improved use of the aquifer system	feasibility stage	North West Sahara Aquifer System
21	Lullemeden Aquifer System	Prefeasibility studies for improved use of the aquifer system	feasibility stage	Lullemeden and Taoudeni/ Tanezrouft Aquifer System
22	Fomi	Hydropower stationin Guinea with irrigation water supply for Mali and regulation of the Niger river (nine countries)	structuring and financing stage	Niger River Basin
23	Lesotho HWP Phase II - water transfer component	Water transfer programme supplzing water to Gauteng Province in South Africa	structuring and financing stage	Orange-Senqu River basin
24	Nubian Sandstone Aquifer System	Implementation of regional strategy for the use of the aquifer system	implementation and operation stage	Nubian Sandstone Aquifer System

Source: Programme for Infrastructure Development for Africa - Interconnecting, integrating and transforming a continent, pp.17ff.

Appendix 4.3: Distribution of PIDA Hydropower Projects



Source: VPiC.