RENEWABLE ENERGIES. TEACHING&TRAINING ACTIVITY

ECOWAS/CEDEAO ECREEE AND AMENET-UAM

Electricity in Africa

Options for "Renewable Energies“

A look at the countries of North and West Africa:

Algeria, Morocco, Senegal, Cote d´Ivore, Nigeria

October, 16, 2020

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Part One: General Issues

The electricity comsumption is an indicator of poverty in Africa

- Average electricity consumption in Europe is over 5,000 kWh per person per year:

  + Spain: 5,356 kWh Germany: 7,035 KWh

- North Africa: Less than 2,000 kWh per person per year

  +Algeria: 1,263 kWh Morocco: 904 kWh

Year 2014

- West Africa: Less than 500 kWh per person per year

  + Senegal: 229 Cote d´Ivore: 275 Ghana: 351 Nigeria: 145

datos.bancomundial.org

One Question:Reduce GHG emissions

- Global emissions of energy origin: 35.000 millions t CO_2
- EU: 450 millions people …… Approximately 10%
- China: 1,400 millions people …… More than 25%
- Africa: 1,300 millions people …… Around 5%

Africa: Many questions

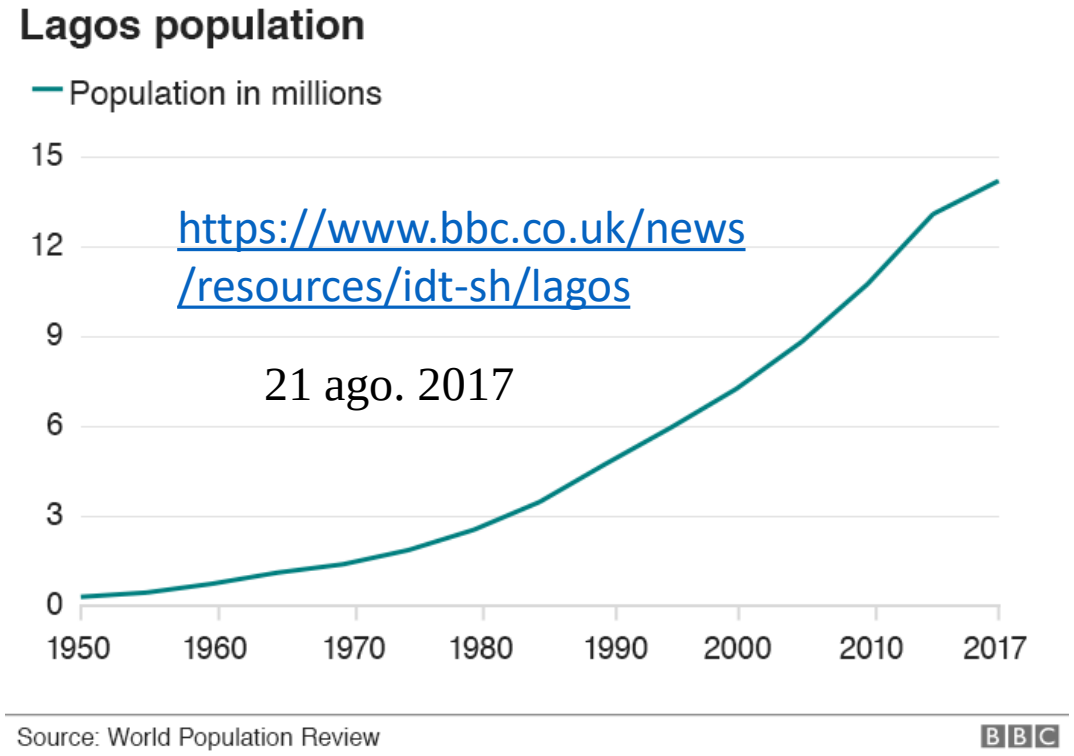
- Population can grow to 2 billion people in 2050
- It is necessary to dramatically reduce poverty
- Also keep people worthy in the field. (Rural areas)
- Providing services to everyone: cities and countryside
  - + Electricity for all

Africa's cities to triple in size

The number of people living in African cities will triple over the next 40 years and by **2050 60% of Africans will be city dwellers**, a UN report has said.

24 november 2010

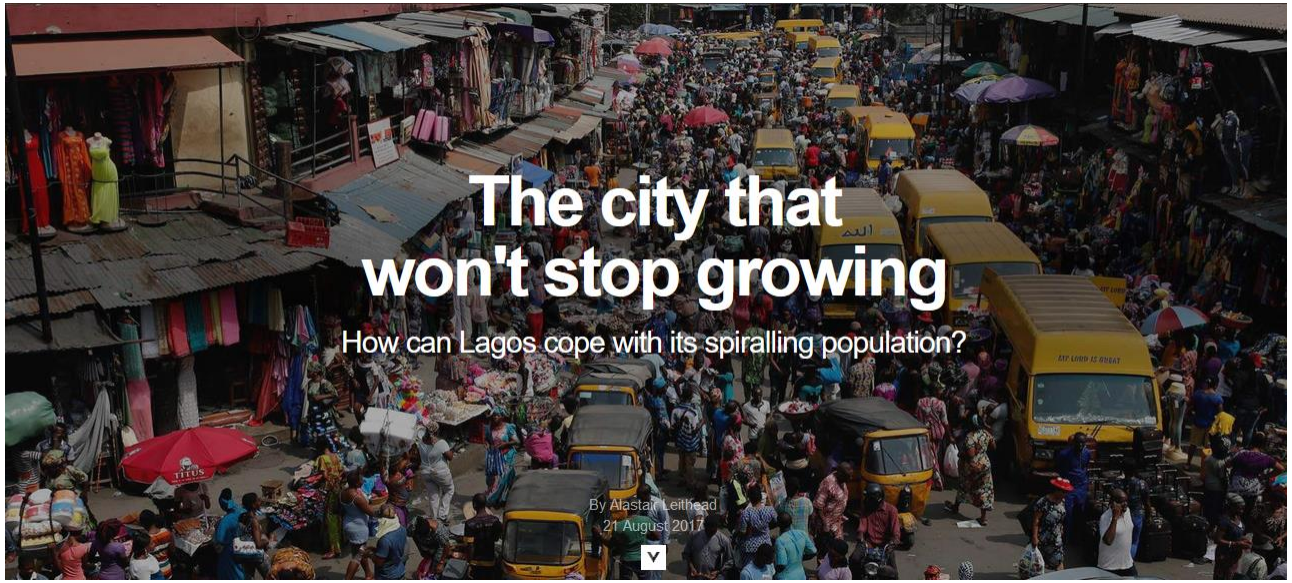
https://www.bbc.com/news/world-africa-11823146



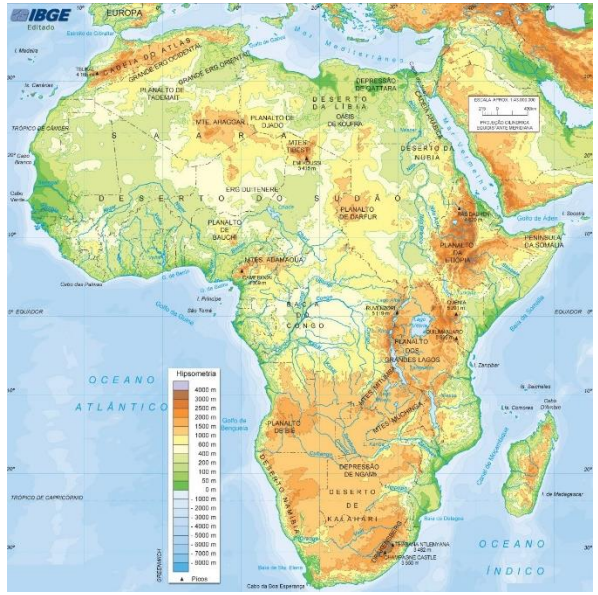
Africa: Very big cities

- Casablanca … More than 4 million people
- Lagos … … … 15 million people
- Many other smaller ones

Cities are a sink for: water and electricity



MAGREB.Population 180 million people. Emigration to France, Italy and Spain



In the 16th century, Europe positioned itself in the Gulf of Guinea. Buy gold and then slave trade.

(The name of the English currency: Guinea, comes from there)

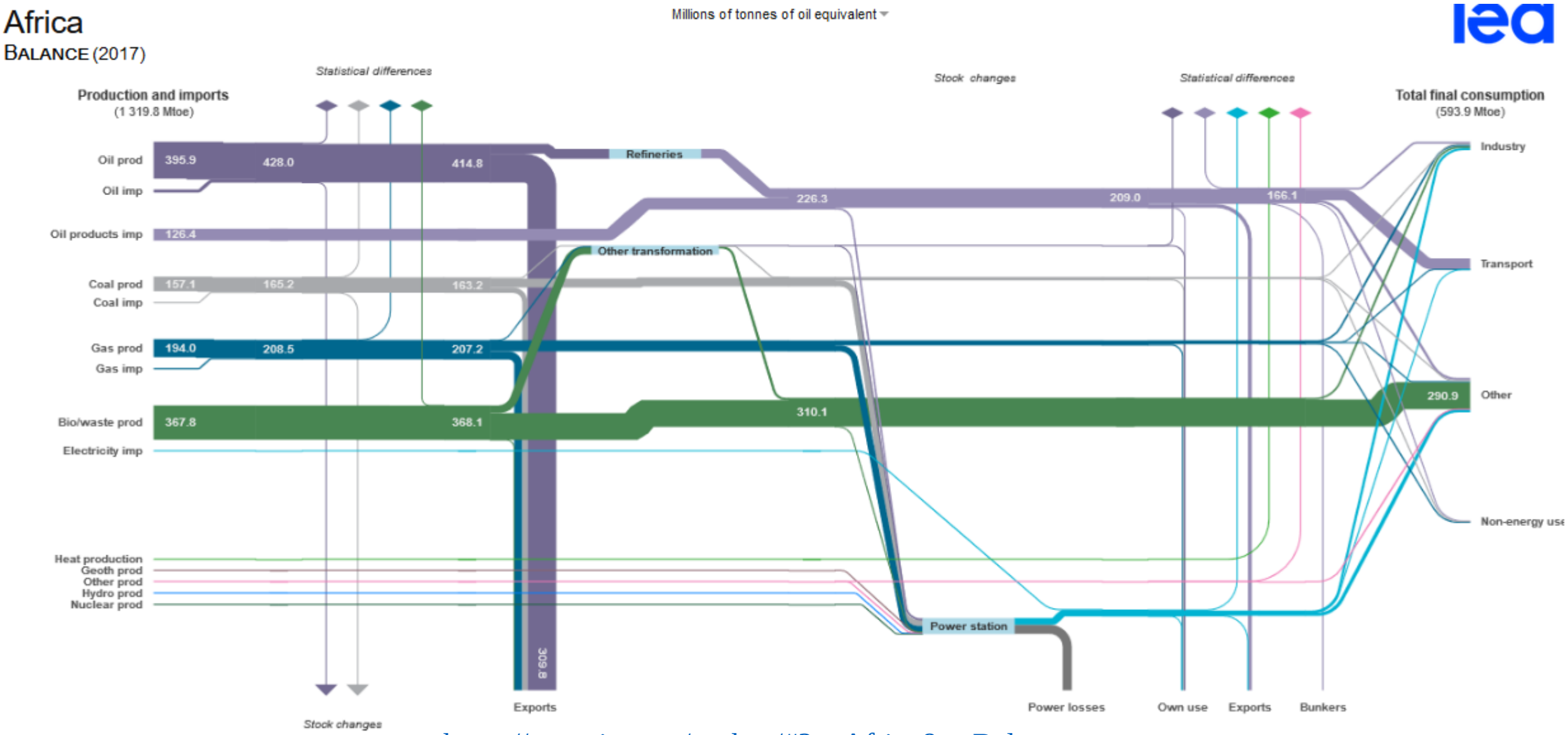
Population, more than 350 million people. High growth.

Nigeria will foreseeably have 300 million in the year 2050

Africa Energy: Some significant issues

- A significant volume of oil extraction
    - + Massive export of crude oil. Petroleum derivatives are imported
- Biomass as a contribution to final energy consumption. (FEC)
    - + Deforestation problems: Sahel and Maghreb regions
- Low participation of electricity in final energy consumption. About 10%. (Europe – 25%)

Africa Energy: Let's look at Sankey diagram



https://www.iea.org/sankey/#?c=Africa&s=Balance

Electricity in Africa: Uses

- Do we take Europe as a reference?

  + Three similar consumptions: Industry, Services, Residential uses

- Electricity destinations in Africa:

  + Industry 38% … … Basic industry. (Algeria, South Africa ...)

  + Buildings: Services and Residential Uses; 62% … (Cities)

  + Very low consumption in rural areas

Two ways of having electricity in Africa

- Through the electrical network

  + A total of 1,500,000 GWh is estimated

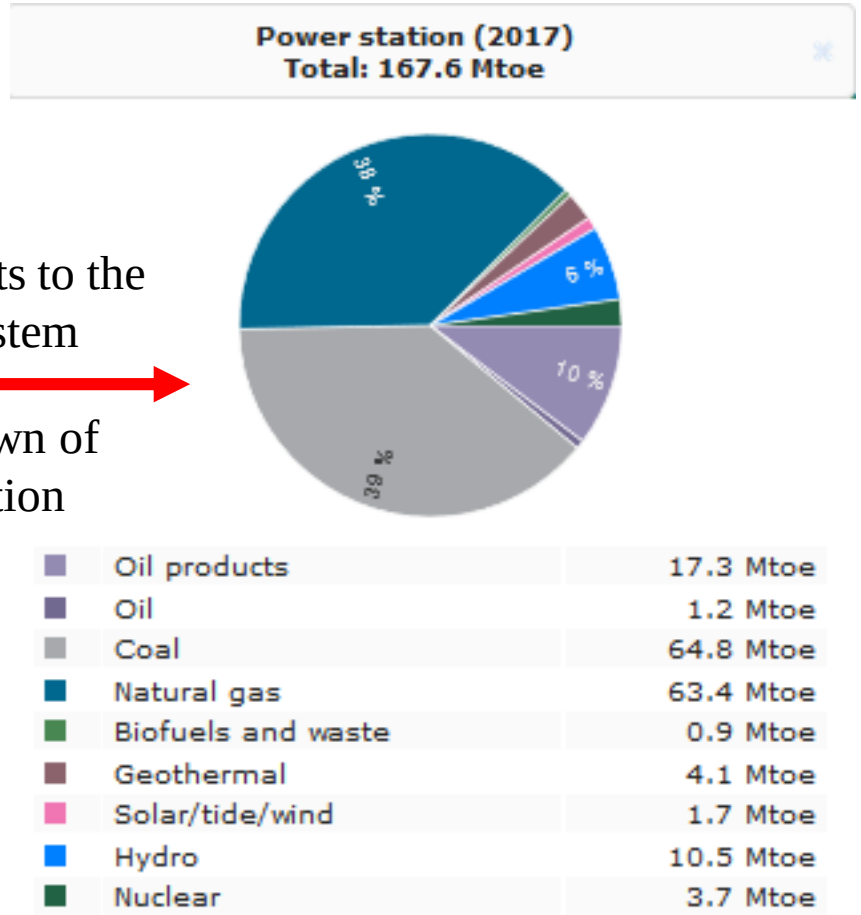
- Off- grid. Self-consumption

  + Estimated: 3.000 GWh

    - Combustion engines and photovoltaic

Energy inputs to the electrical system

No breakdown of final generation



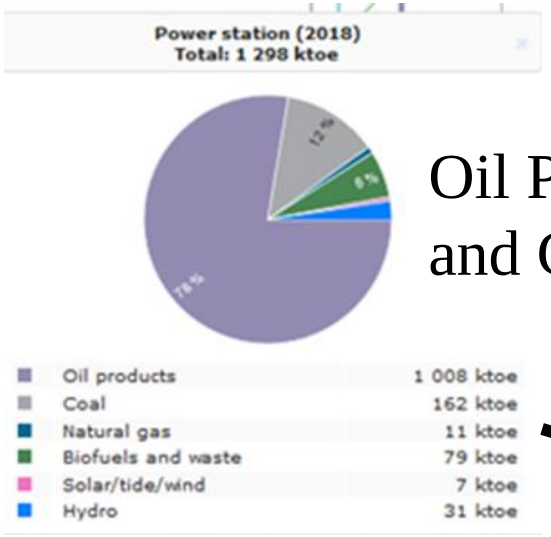
https://www.iea.org/sankey/

Africa: Sources of Electricity Generation

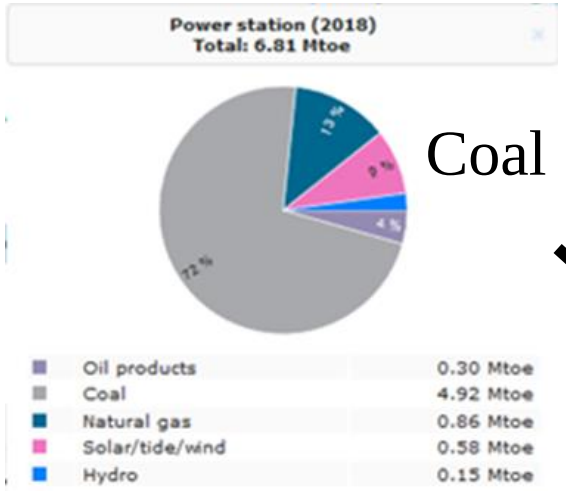
- Each country solves the supply as it can
- Coal.- South Africa, own extraction. Morocco import
- Natural Gas.- Algeria and Egypt, extract and export gas
- Oil derivatives.- Senegal. (Refinery Oil)

    + Combustion engines in the rural world

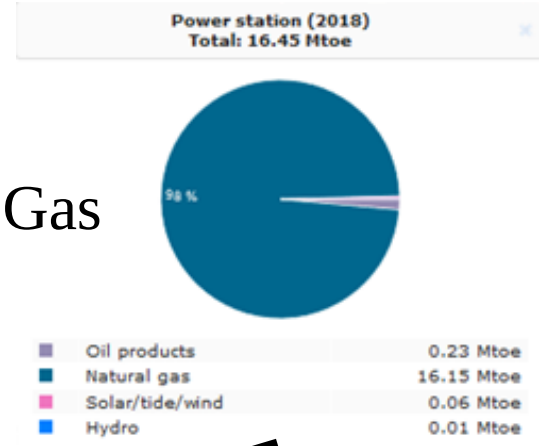
- Currently, minimal participation of renewable energy. But there are already significant facilities



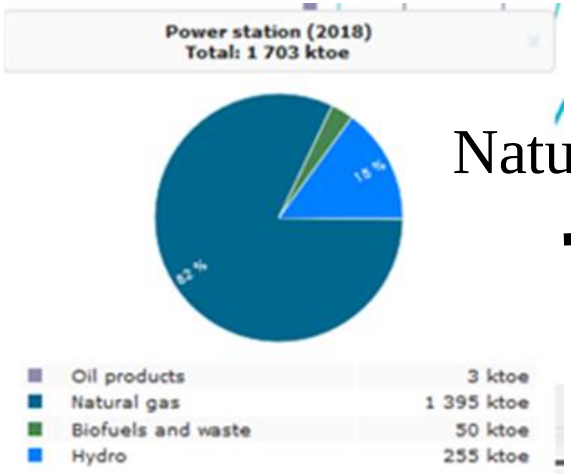
Oil Products and Coal



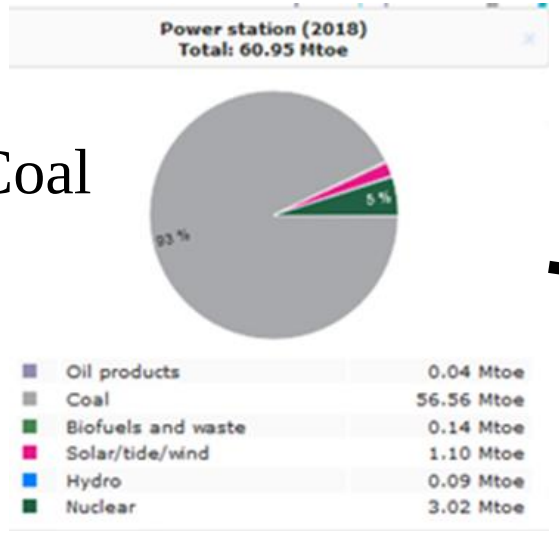
Coal



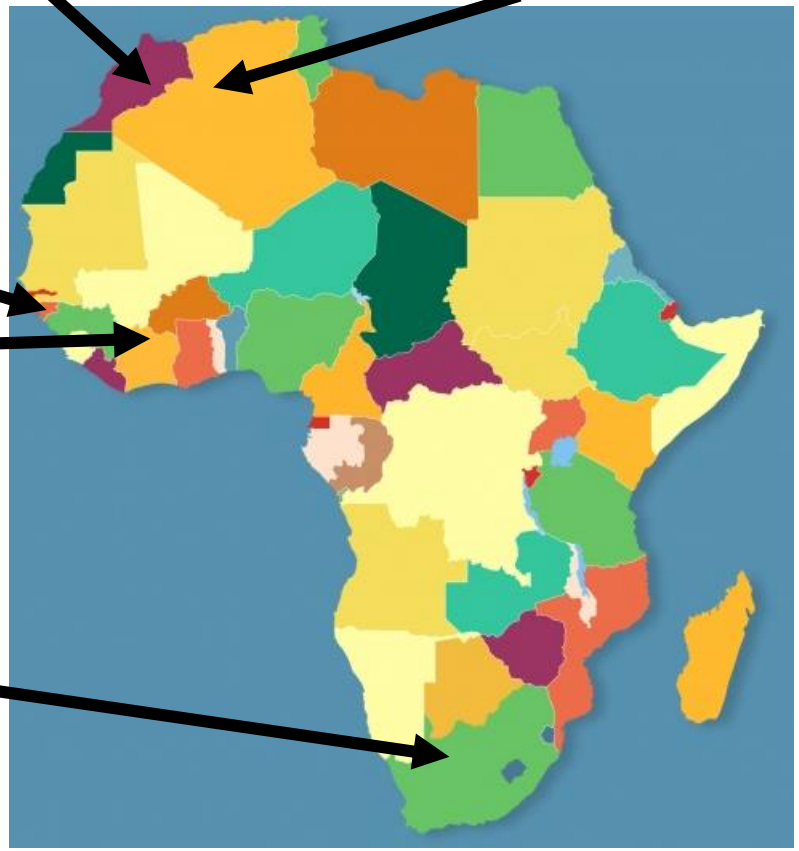
Natural Gas



Natural Gas



Coal



Nigeria, primarily natural gas.

We will see it at the end of the presentation, in more detail.

Many uncertainties on the way to Africa

- Freight transport and personal mobility are expected to increase

    + Increased consumption of oil derivatives. (Imported from Europe?

- An electricity consumption hypothesis: 1,500 kWh per person per year on average. (Year 2035)

    + Gross generation: 3,000 TWh / year?????

    + New renewable energies in this generation: 25%?????

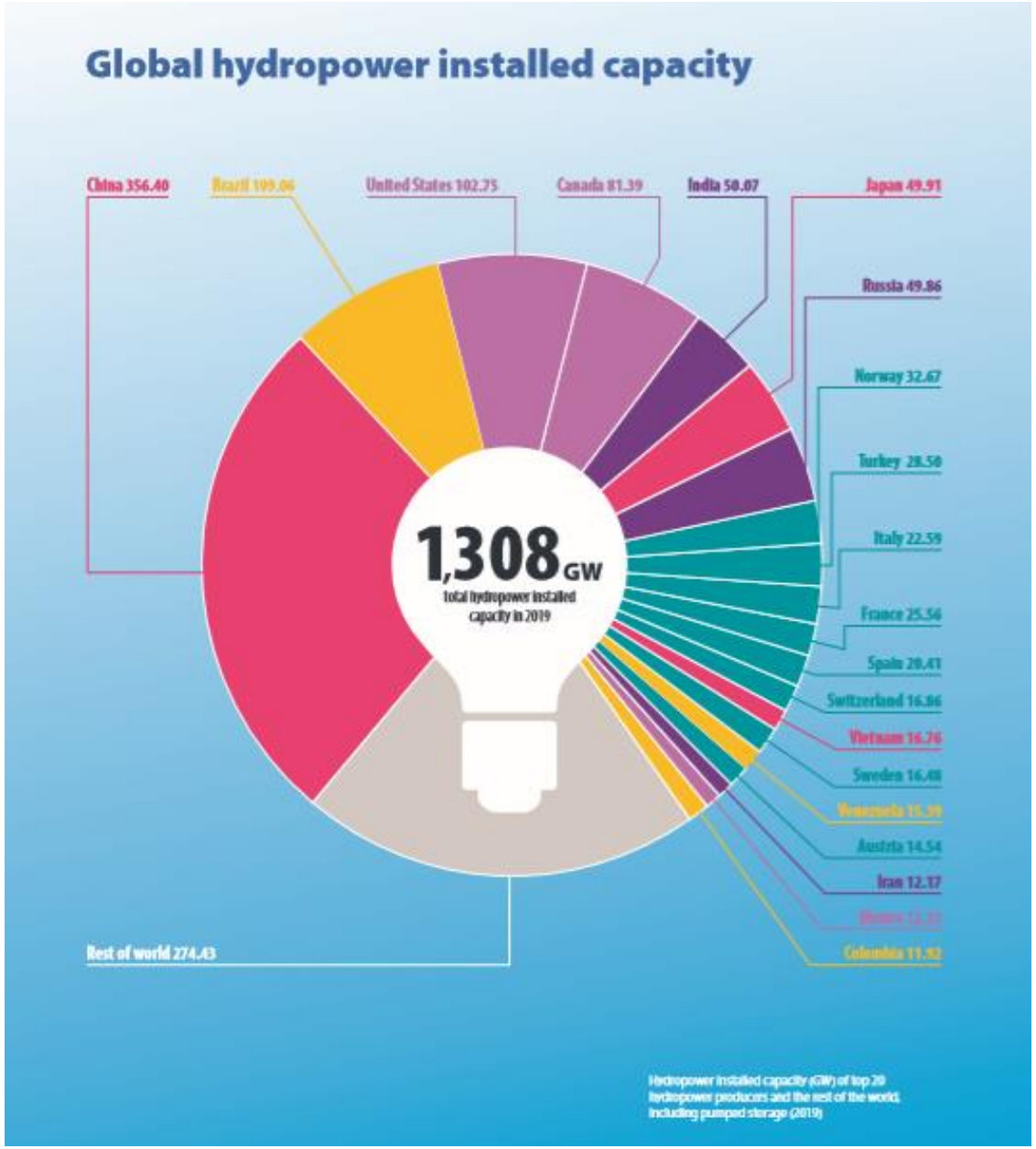
Africa hydropower:

- Historical developments. Aswan Dam on the Nile

  + 2.100 MW

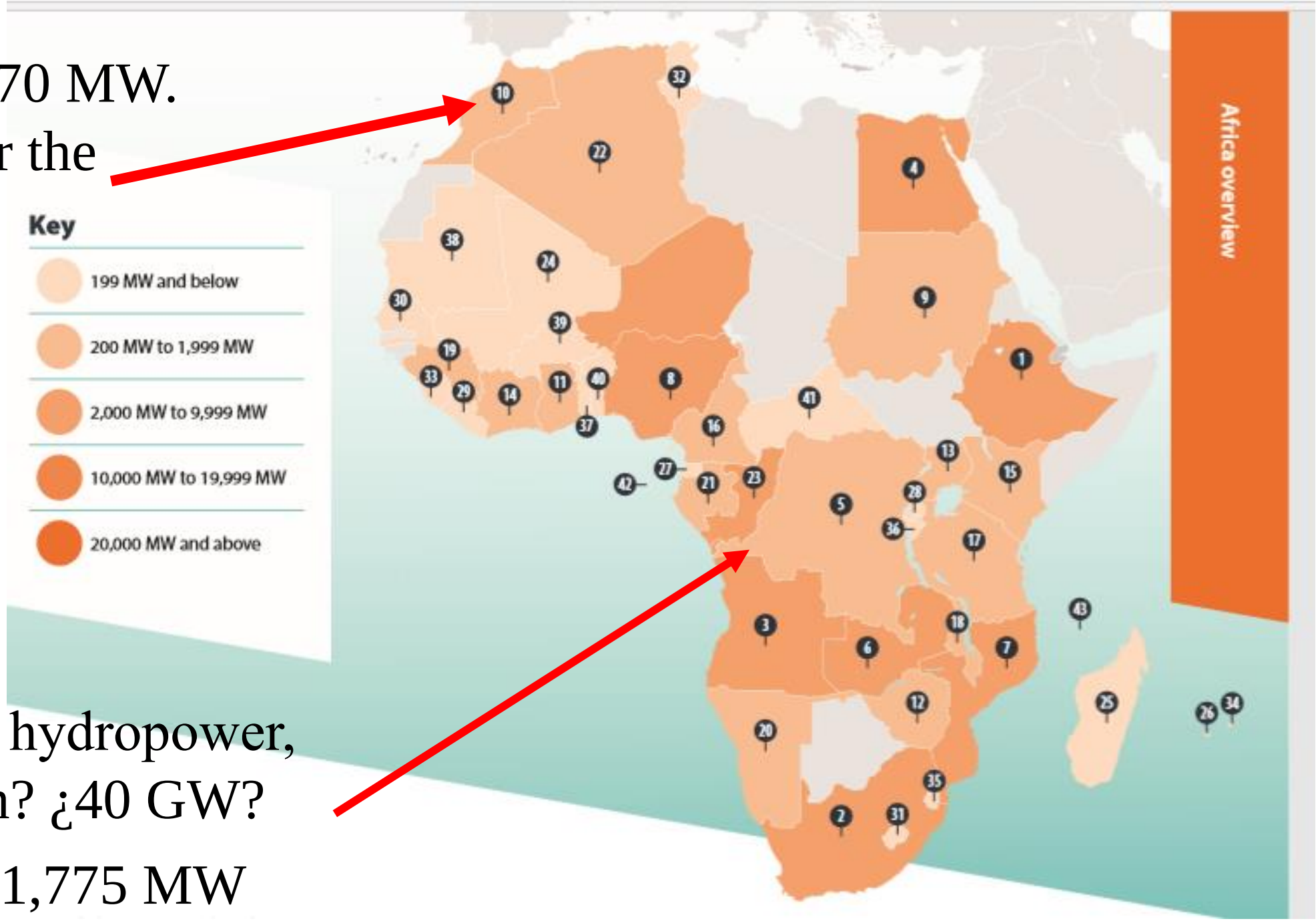
- Ethiopia. Great Renaissance Hydroelectric, 6,000 MW? Conflicts: Egypt - Ethiopia – Sudan. (Developing)

- Angola. The Lauca hydropower; 334 MW



https://www.hydropower.org/sites/default/files/publications-docs/2020_hydropower_status_report_-_28_may_2020.pdf

Morocco. 1,770 MW.
Conflicts over the use of water.
Zagora's case



"Grand Inga“ hydropower, is it a solution? ¿40 GW?

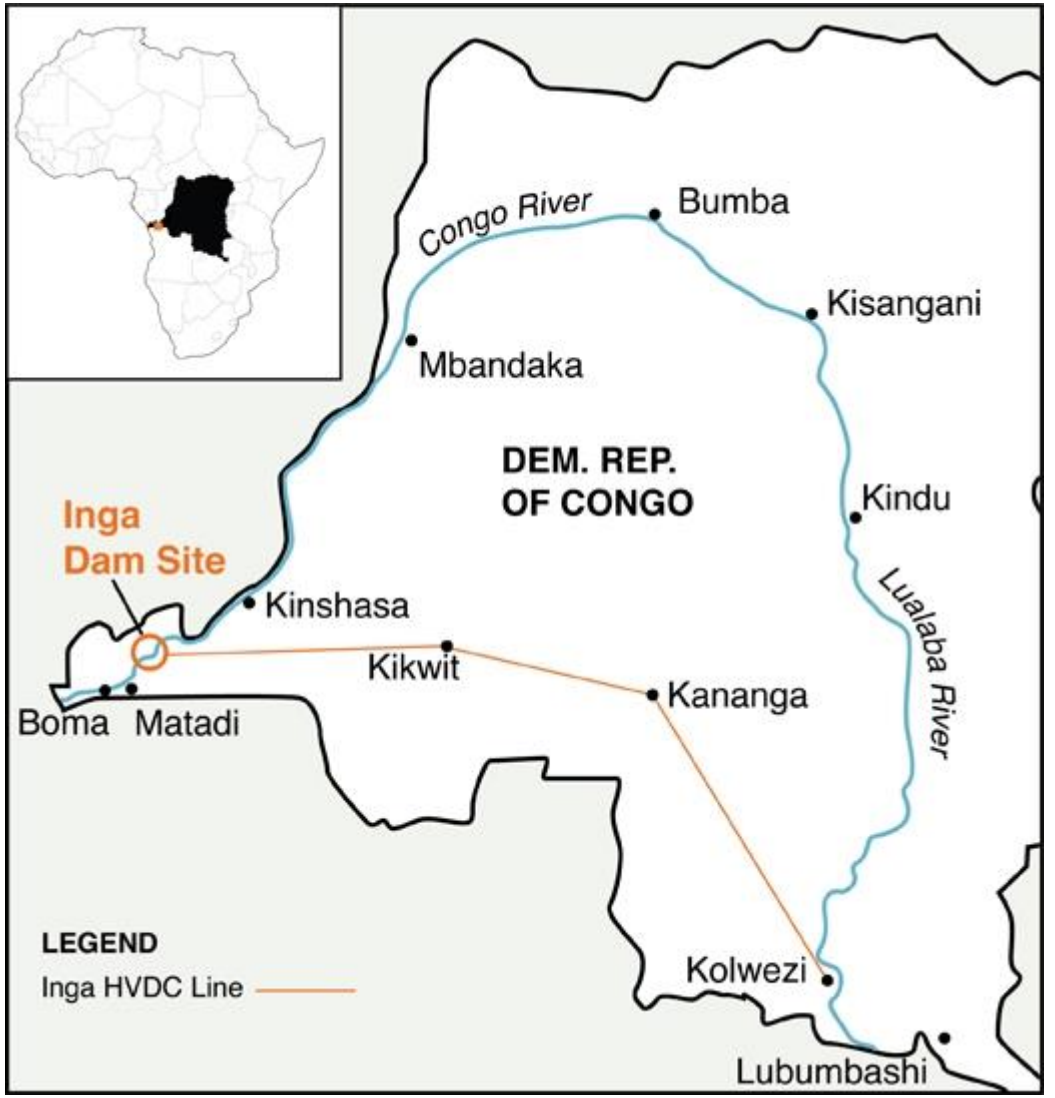
Inga I and II, 1,775 MW

Rank	Country	Total installed capacity (MW)
1	Ethiopia	4,074
2	South Africa	3,596
3	Angola	3,435
4	Egypt	2,876
5	Democratic Republic of the Congo	2,750
6	Zambia	2,400
7	Mozambique	2,216
8	Nigeria	2,110
9	Sudan	1,923
10	Morocco	1,770
11	Ghana	1,584
12	Zimbabwe	1,076
13	Uganda	1,040
14	Cote D'Ivoire	879
15	Kenya	826
16	Cameroon	792
17	Tanzania	586
18	Malawi	371
19	Guinea	368
20	Namibia	347
21	Gabon	331
22	Algeria	269
23	Congo	218
24	Mali	180
25	Madagascar	164
26	Reunion	134
27	Equatorial Guinea	128
28	Rwanda	111
29	Liberia	93
30	Senegal	81
31	Lesotho	73
32	Tunisia	66
33	Sierra Leone	64
34	Mauritius	60
35	Eswatini	60
36	Burundi	58
37	Togo	49
38	Mauritania	48
39	Burkina Faso	34
40	Benin	33
41	Central African Republic	19
42	Sao Tome And Principe	2
43	Comoros	1

Including pumped storage

Based on a feasibility study conducted by AECOM-EdF from 2011 to 2013, Grand Inga would be constructed in seven development phases with Inga 3 BC being the first of these phases. Inga 3 would be constructed in two steps, initially a low head and then a high head, extending the dam wall and making it higher. There would be no closure of the Congo River and no tunnels, just an open channel. About 6,000m3 m/s would be diverted for Inga 3 to a valley which runs parrallel to the Congo riverbed. If completed, Inga 3 BC would produce 4,800MW of electricity.

Further stages would necessitate the flooding of the Bundi Valley to form a 22,000-hectare reservoir, drowning the Inga 3 channel.



https://www.internationalrivers.org/campaigns/grand-inga-dam-dr-congo

RWE mulls green hydrogen imports via future German LNG terminal

https://www.rechargenews.com/transition/worlds-largest-hydro-dam-could-send-cheap-green-hydrogen-from-congo-to-germany/2-1-871059

World's largest hydro dam 'could send cheap green hydrogen from Congo to Germany‘. Africa commissioner Nooke reportedly backs plan for 44GW project that could export huge volumes of clean-H2 to Europe

A proposal like this does not appear to be a solution for Africa. European exploitation of Africa's natural resources continues.

A medium-hydropower plant takes 5 years to build

Top 5 countries by capacity added in 2019

1st	Angola	334 MW
2nd	Uganda	260.45 MW
3rd	Ethiopia	254.1 MW
4th	Cameroon	45 MW
5th	Malawi	8.2 MW

Attention to environmental and social issues

- Rivers are communication routes in Africa
- They are also fishing environments
- Several million people live in the inland delta of the Niger River
- A reservoir changes the flow conditions of the river and the life of its people

We have to look at the rivers carefully, they can give us electrical energy; but we must not repeat mistakes made in other places

Africa Renewable Energy Initiative - Increasing Renewable Energy Capacity on the African Continent

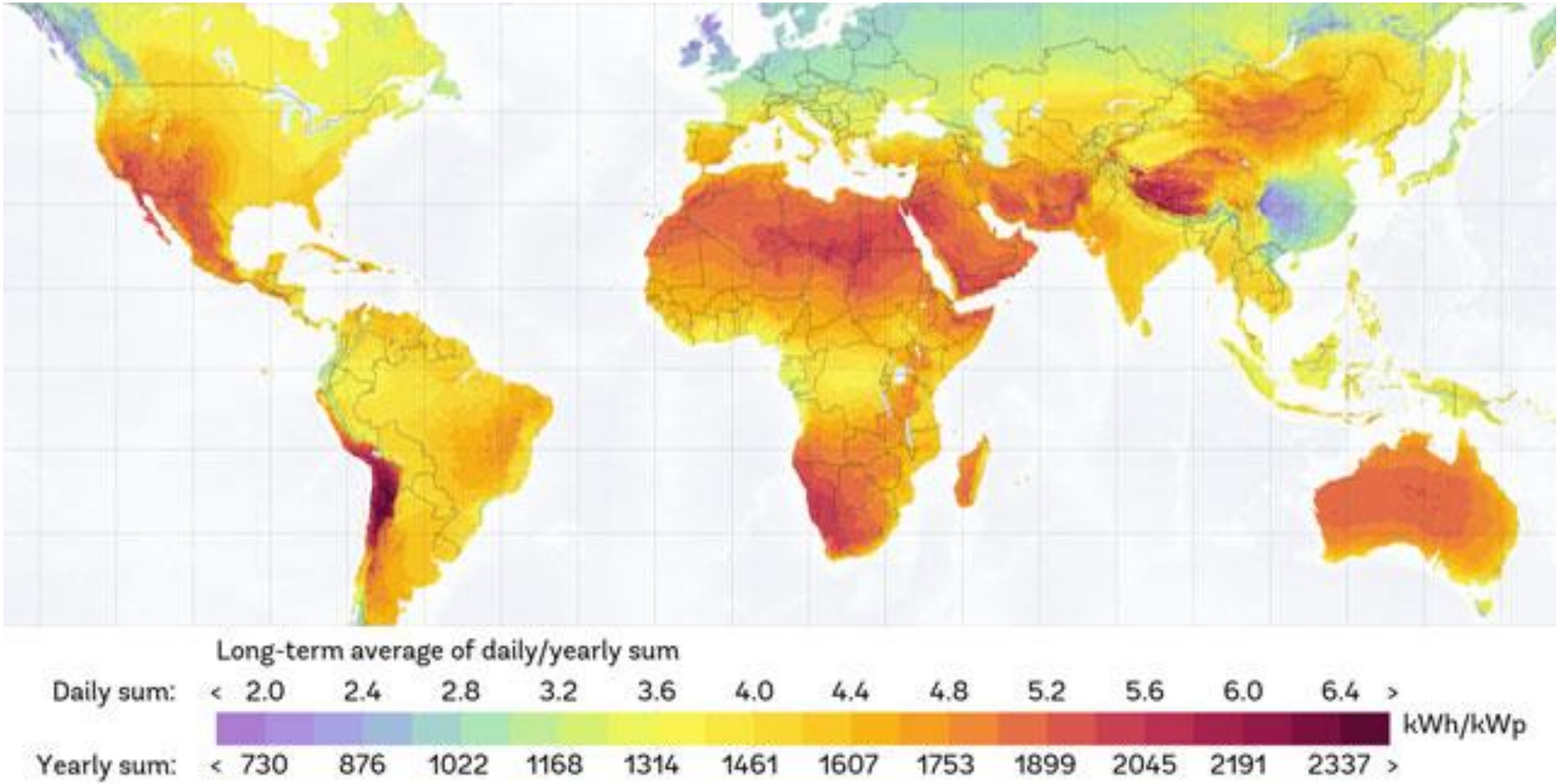
- The Africa Renewable Energy Initiative (AREI) aims at enabling the installation of large-scale renewable energy capacity on the African continent by 2020, which would have a considerable impact on the reduction of greenhouse gases emissions in the continent. At least $5 billion in public and highly concessional finance between 2016 and 2020, from bilateral, multilateral and other sources, including the Green Climate Fund, will be needed to leverage a further USD15 billion in other investments, for a total investment of at least USD20 billion pre-2020.

- The Initiative is led by the African Union's commission, the New Partnership for Africa's Development (NEPAD)'s Agency, the African Group of Negotiators, the African Development Bank, the UN Environment Program (UNEP), and the International Renewable Energy Agency (IRENA).

https://newsroom.unfccc.int/news/africa-renewable-energy-initiative-increasing-renewable-energy-capacity-on-the-african-continent

Solar Energy. A great option

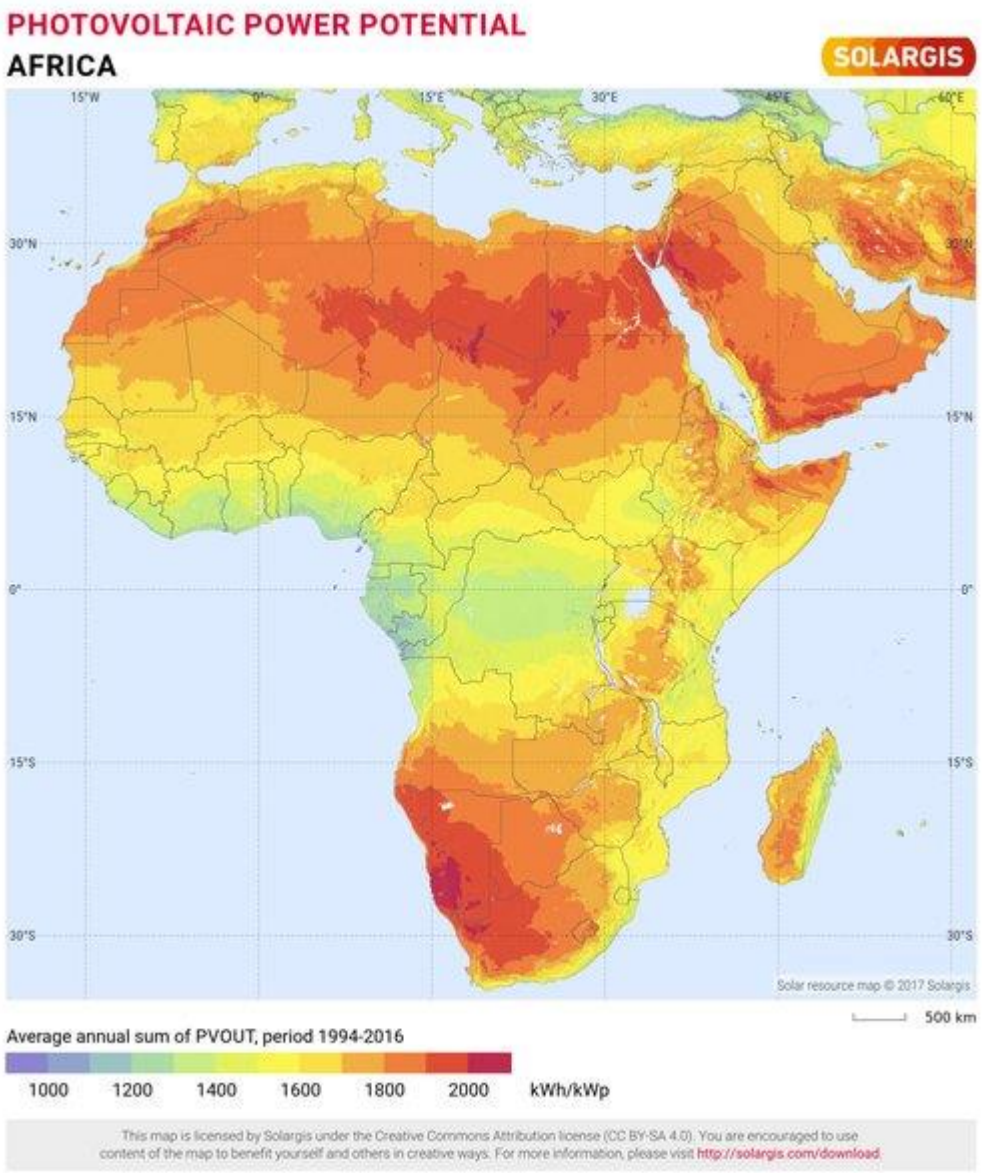
- The solar energy resource is wide and intense, as you know
- Specific investment has been reduced in photovoltaic designs
    - We can consider € 1,000 per kW installed
- There may be many villages in rural areas with a high degree of self-sufficiency
    - The support can be combustion engines with biofuels or oil products



Global Solar Atlas: http://www.gisandbeers.com/cartografia-de-radiacion-solar-mundial/

In North and West Africa you can think of all kinds of solar plants. Even in large solar thermoelectric units.

In the countries of the Gulf of Guinea, we can think of photovoltaic systems of medium and small power. (The northern areas of these countries support large installations.)



https://solargis.com/es/maps-and-gis-data/download/africa

Wind power. An option to study in each country

- Very different resource according to geographical areas
    - High potential in the areas near the North and West coast
- Wind is also a local phenomenon. Each country has to study its potential locations
    - Even in countries that seem to have no wind
- The specific investment can be € 1.5 million per MW installed

Global Wind Atlas

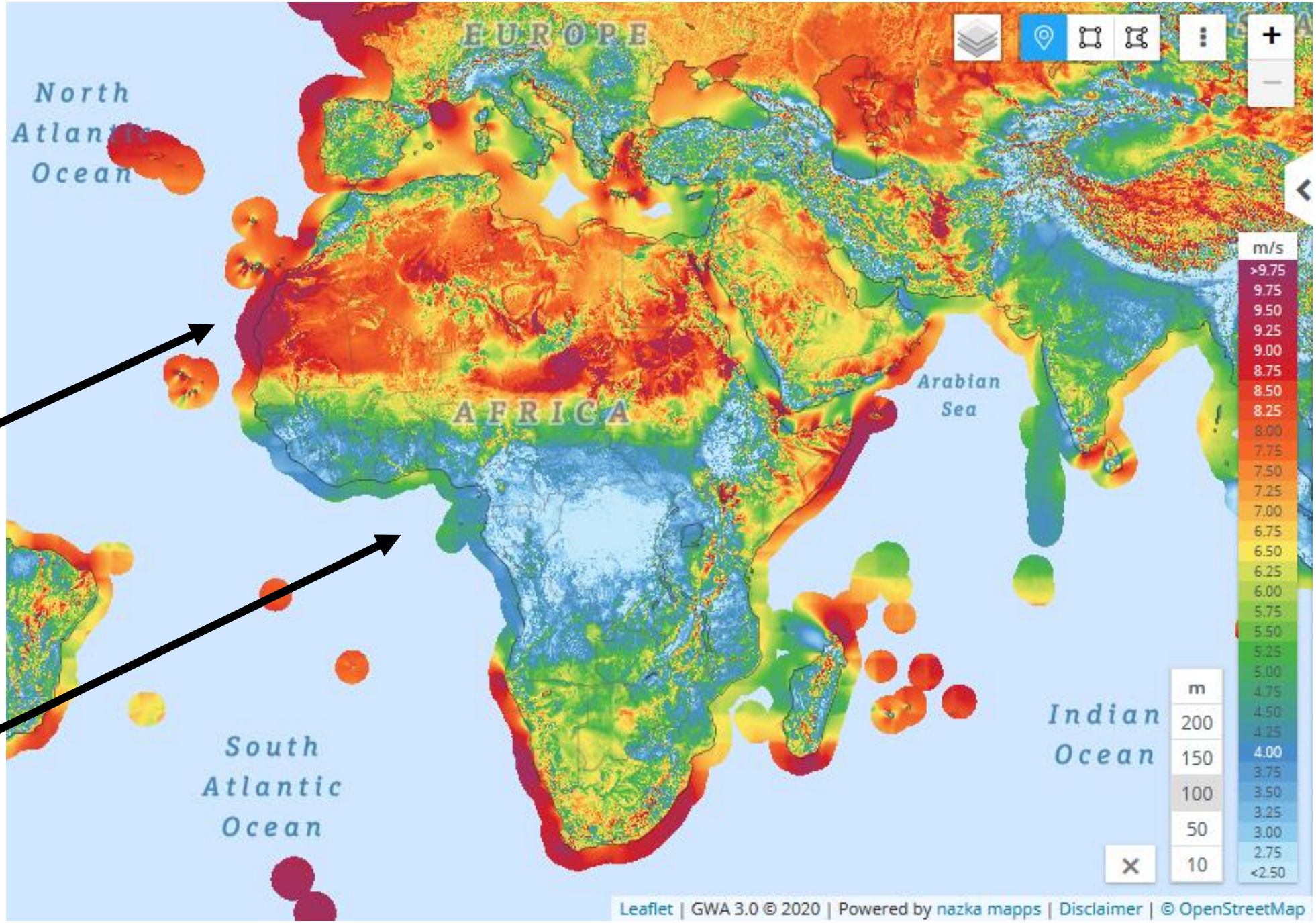
https://globalwindatlas.info/

Wind high potential

Moderate population

Low potential

High population



In Africa there are many families who maintain small sustainable crops.

Now I think of oil palm, which is compatible with other palms.

Photographs taken in Camerron

Claude Bakuome.- "***Oil Palm Sector in Africa***"

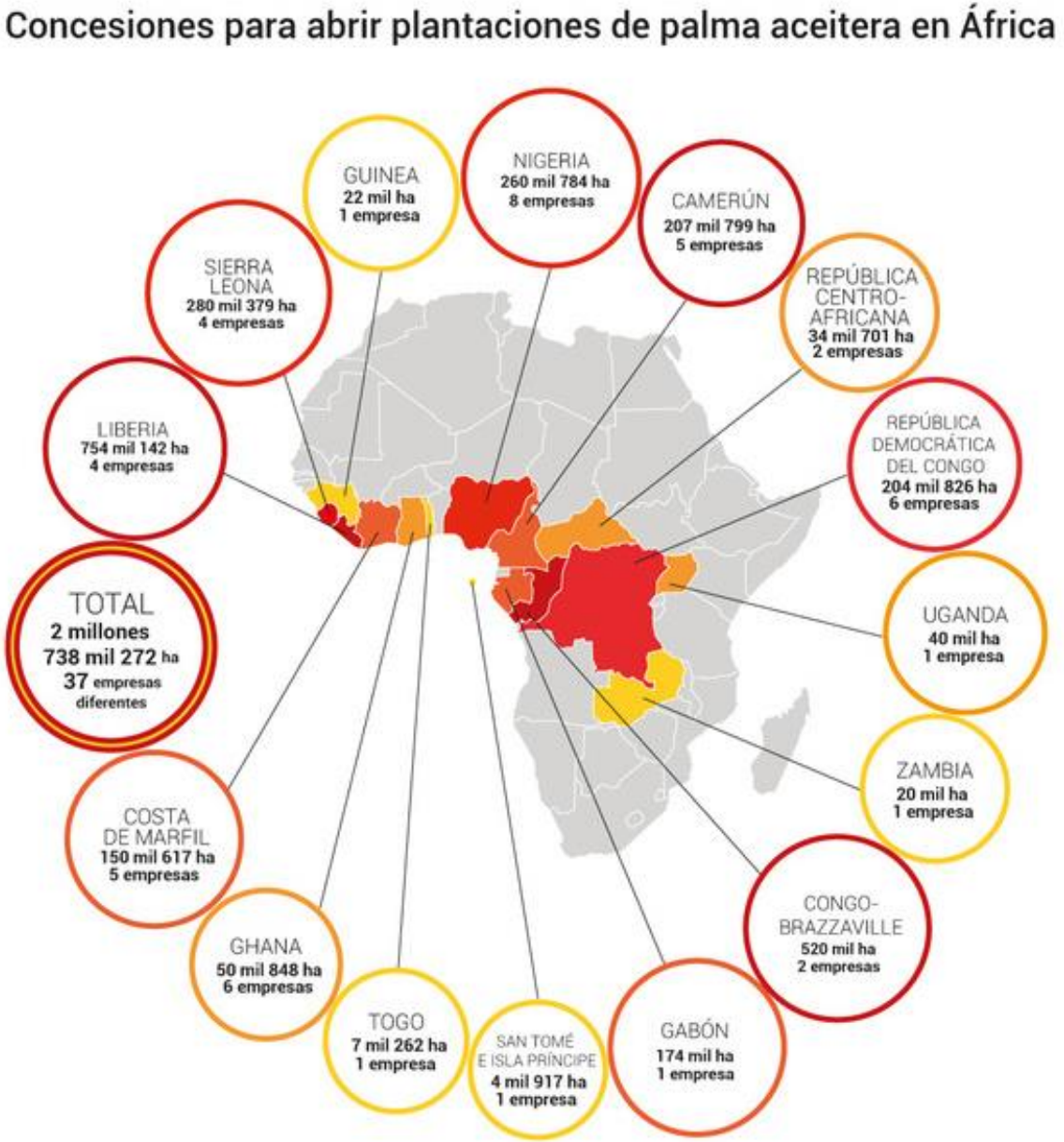
Is it logical to think of?

- ***Small or medium areas of oil palm cultivation***
- ***Local oil production for: traditional uses, energy uses, including electricity in combustion engines***

https://elpais.com/elpais/2020/08/21/planeta_futuro/1598006484_199336.html

Large areas of oil palm cultivation are not the solution.

Small crops and oil for various uses; one of them generating electricity



https://www.grain.org/es/article/6329-comunidades-africanas-luchan-contra-el-acaparamiento-de-tierras-para-el-cultivo-de-palma-aceitera

By the year 2035. Would it be possible to think about?

- Photovoltaic, 50,000 MW installed

    + Small facilities in towns. Solar farms of different sizes

- Another 30,000 MW of wind power plants

    + In North and West Africa. Also in special locations in other countries

- Different facilities to generate electricity with biomass

    +10,000 MW in rural areas. Including energy valuation of waste

One question: Who can and wants to make investments in Africa?

- In African countries, in general, there is low capacity to make investments
- Where can the aid go from: China, Arab Countries, European Union?
- Capital goods companies try to sell their products: Conventional plants and renewable energy
- Here we will look and make hypotheses with new renewable energy facilities

    + Transportation and distribution networks are also needed

Sometimes there are proposals for electrical integration

- They make us see options whose development is not easy

    + They should come from people in Africa, or from their organisms

        = I think there will be. Please send them to me

- A first connects the southern part of the continent with the Northeast

    + Think big hydraulic systems. Maybe also in wind and sun

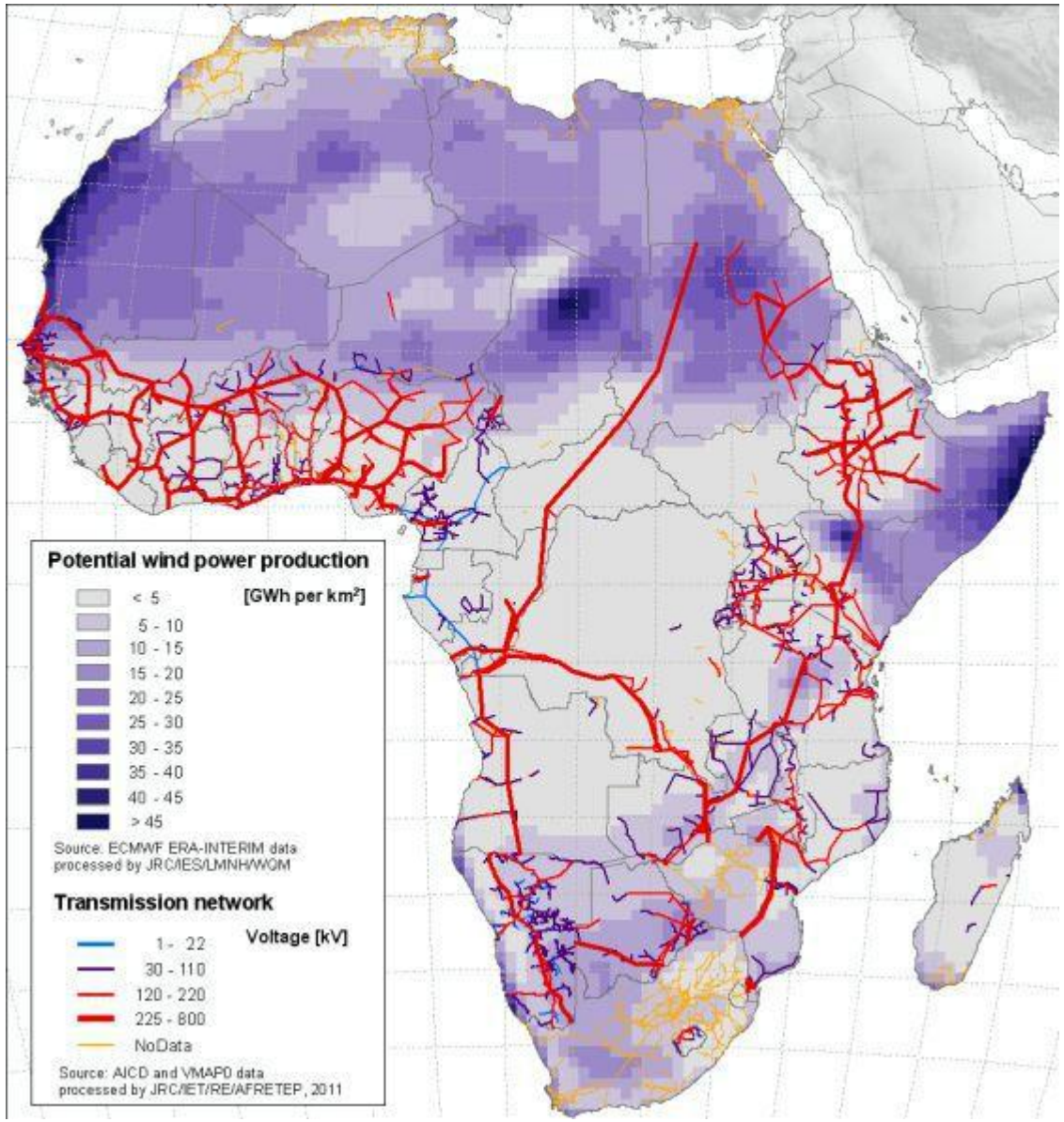
- Another was wind and solar, for North Africa and Europe

    + It was too European !!!!

Big energy investors for Africa. An idea (2019)

The Africa Investment Forum, held in the South African city of Johannesburg between the 11th and the 13th of this month and where some leaders participated, together with leaders in sustainable development and clean energy, discussed how to make a great leap for the expansion of the sector in the continent.

This sustainable energy development will require an investment of 67 billion dollars, according to the organizer of the Forum, the African Development Bank (AfDB).

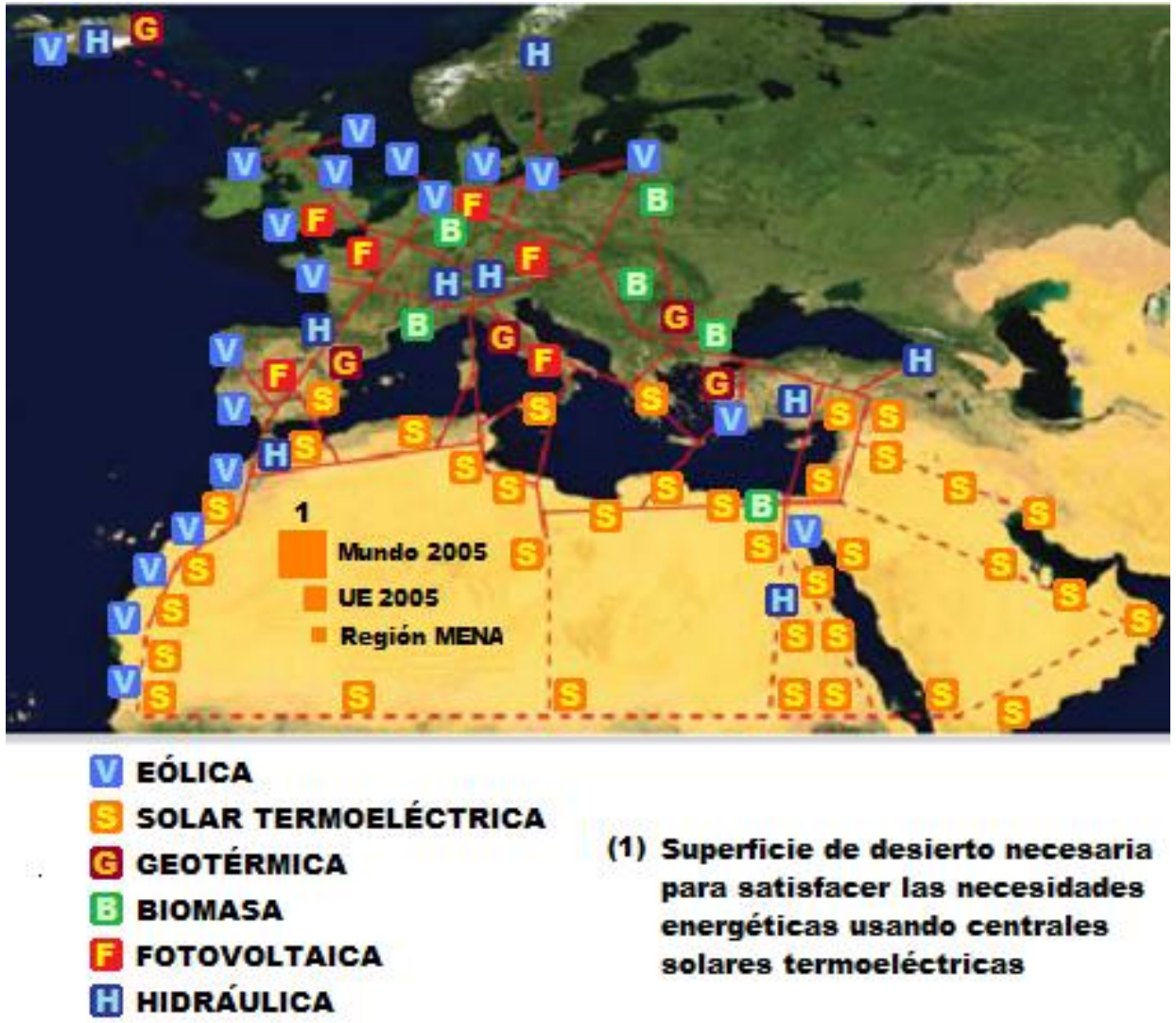


https://www.evwind.com/2019/11/19/inversion-para-hacer-de-africa-un-lider-mundial-en-energias-renovables/

DESERTEC: An idea that failed ((2008))

It was born thinking of clean electricity for Europe. It was not easy. Maybe I'm missing a "Great dialogue", and more.

The Desertec project has been scientifically developed and investigated by TREC together with the German Aerospace Center (DLR). TREC is the Trans-Mediterranean Renewable Energy Cooperation in English, an agency founded by the Club of Rome, the Hamburg Foundation for Climate Protection and the Jordan National Center for Research in the Field of renewable energy (NERC).



http://www.sitiosolar.com/el-proyecto-desertec/

Local generation of electricity and self-consumption

- It is a necessary option for the rural world to have social and economic development

    + Photovoltaic technology and small or medium power wind turbines (Algerie example)

- Do not forget the possibility of producing agrofuels in family or small-scale crops

    + Combustion engines using these fuels

- It is necessary to design cooperation programs from Europe

Need for extensive development of distributed electricity

- Both in local networks, for one or several towns

    + Technological options: photovoltaic, wind, and engines with locally produced biofuels

- Or self-consumption in individual facilities

    + Here significant share of photovoltaic technology

- Example: Algeria with off-grid 500,000 kW of photovoltaic installations

Electricity: Off-grid capacity

Total World … … … … 8.600 MW

+ Photovoltaic … 3.433 MW

Total Africa … … … … 1.354 MW

+ Photovoltaic … 1.000 MW

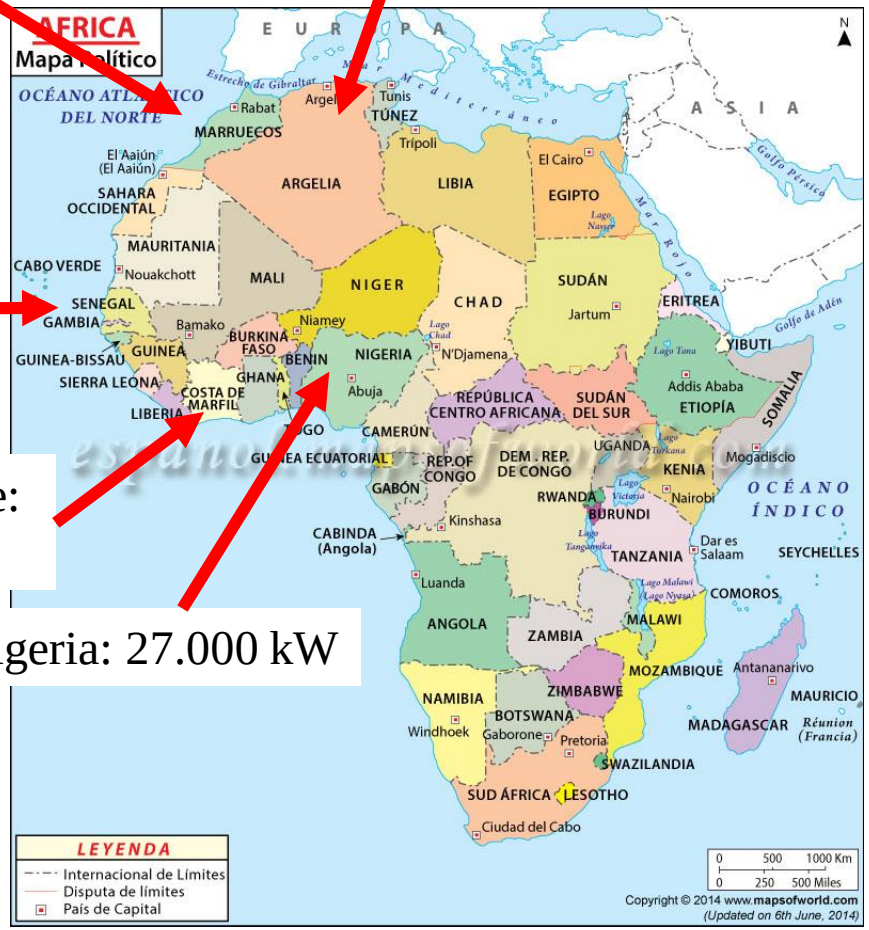
Algeria: 423.000 kW

Morocco: 24.500 MW

Senegal: 12.000 kW

Cote d´Ivore: 8.300 kW

Nigeria: 27.000 kW

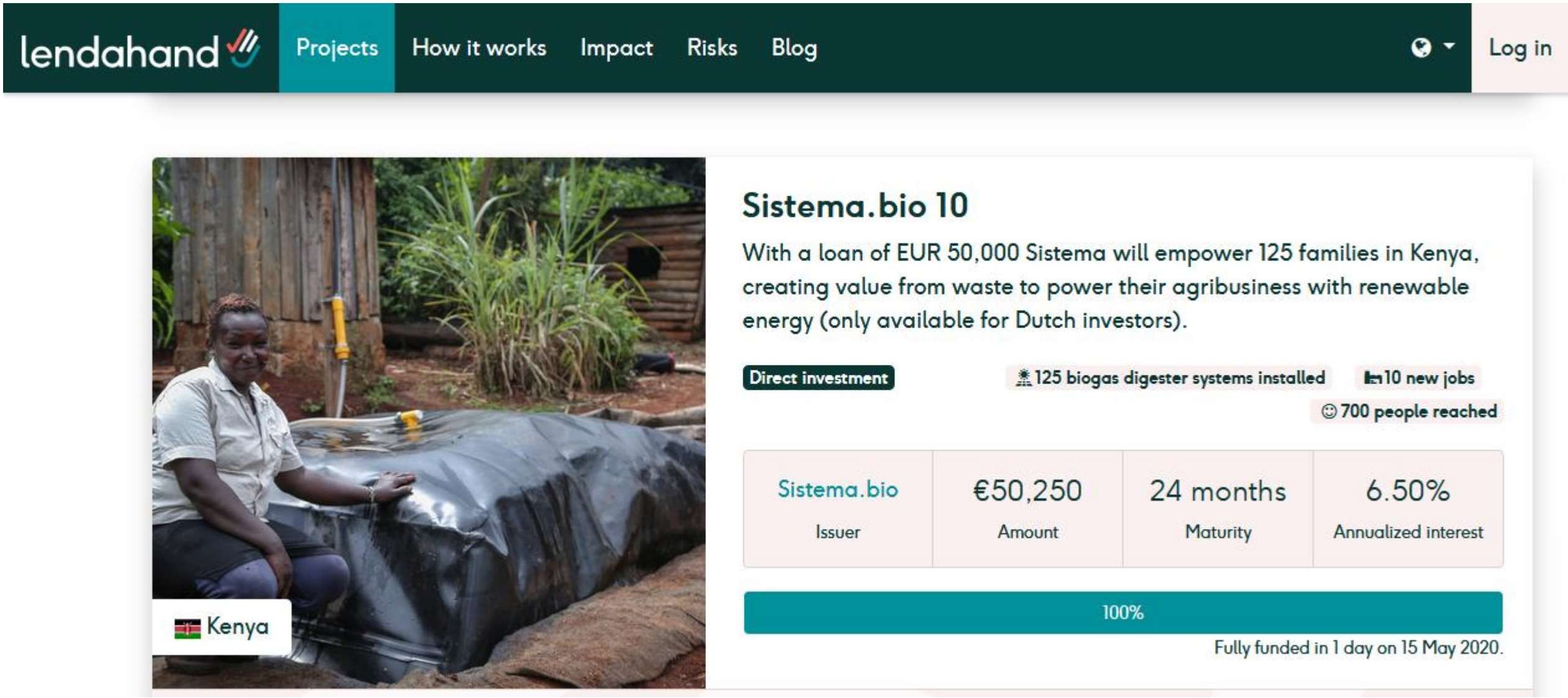


The importance of the extension of photovoltaic energy. Self-consumption

Countries with their own capacity to make photovoltaic programs. Others need help

https://www.irena.org/publications/2019/Dec/Off-grid-renewable-energy-statistics-2019

Investment fund development in Africa.-
https://www.lendahand.com/en-EU/projects/funded



Another example. (I have no criteria to evaluate them)

lendahand | Projects | How it works | Impact | Risks | Blog | Log in

SolarWorks! 13

Met deze lening van 75.000 euro kan SolarWorks leningen verstrekken voor de installatie van 350 solar home systems in Mozambique. Met 50% SIDA garantie!

50% guaranteed | Direct investment | 10 new jobs | 500 people reached

SolarWorks!	€75,000	24 months	6.50%
Issuer	Amount	Maturity	Annualized interest

100%

Fully funded in 5 hours on 15 May 2020.

Continue reading

+ 210 other investors

Part Two: Case Study

Algeria: The country of natural gas

- 2.2% of world reserves. 2.4% of world extraction

    + Participates in world exports with 3.1% of the total

        - Largely to Europe

(BP Statistical Review o f World Energy 2019 | 68th edition)

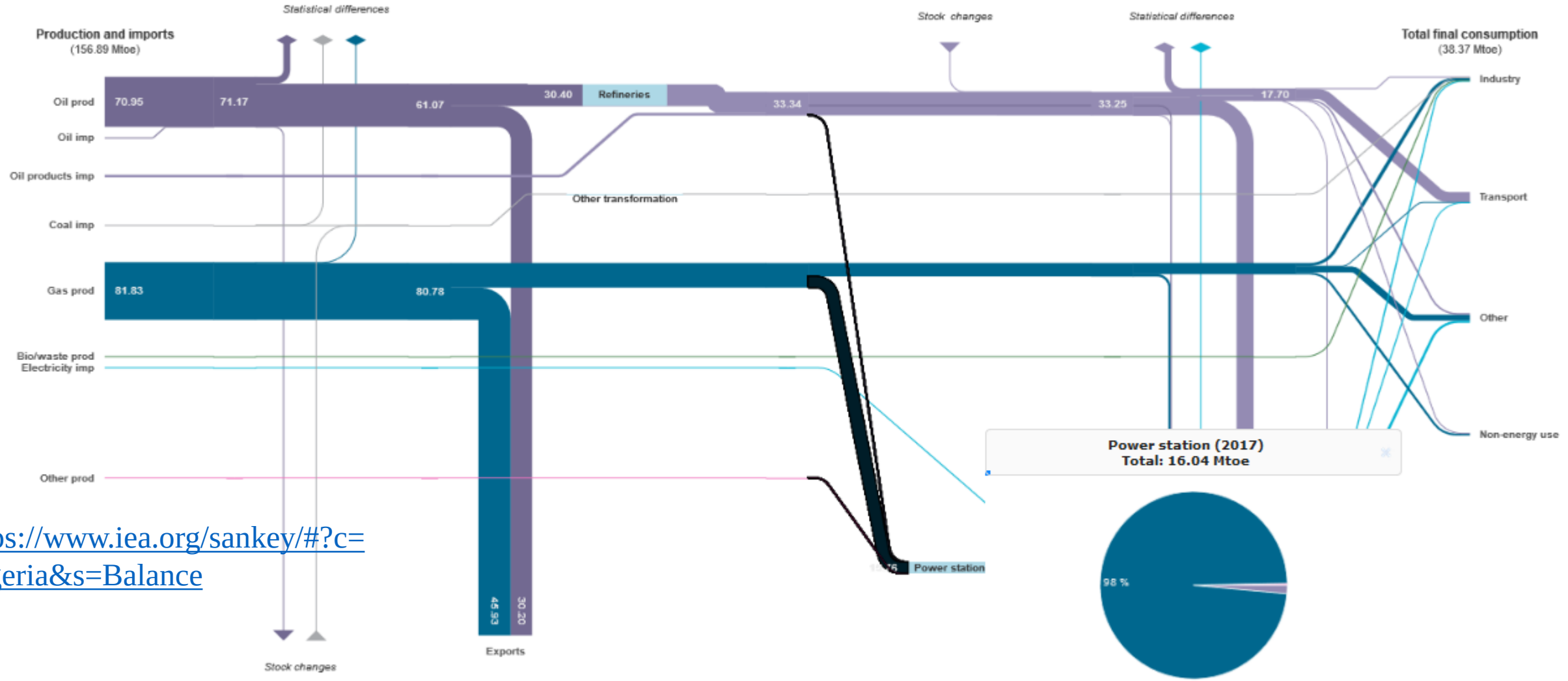
- It also extracts oil and partly exports it

- Its electricity comes mainly from natural gas

Algeria

BALANCE (2017)

Millions of tonnes of oil equivalent



https://www.iea.org/sankey/#?c=Algeria&s=Balance

Country List | Colour Legend | Time Graph | Move Flows | Pie Chart | Glossary | Help | Print Mode

1.8x 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999

2013 2015 2017

Under development in solar and wind energy. Broad expectations for the year 2030

- Wind Power: 1 park 11 MW

    + Forecasts of reaching 5,000 MW in 2030

- Installed photovoltaic capacity: 423 MW; (year 2019)

    + Forecasts of reaching 13,500 MW by 2030

- Concentrated solar power: 25 MW

https://irena.org/publications/2020/Mar/Renewable-Capacity-Statistics-2020

République Algérienne Démocratique et Populaire
Ministère de l'Enseignement Supérieur et de la Recherche Scientifique
Direction Générale de la Recherche Scientifique et du Développement Technologique
Centre de Développement des Energies Renouvelables

Programme National des Énergies Nouvelles et Renouvelables

L'Algérie s'engage dans une nouvelle ère énergétique durable. Le programme des énergies renouvelables actualisé consiste à installer une puissance d'origine renouvelable de l'ordre de 22.000 MW à l'horizon 2030 pour le marché national, avec le maintien de l'option de l'exportation comme objectif stratégique, si les conditions du marché le permettent.

Morocco: A country with social problems

- Its population is 35 million people. 20 million as urban population

    + About three million people have migrated to Europe

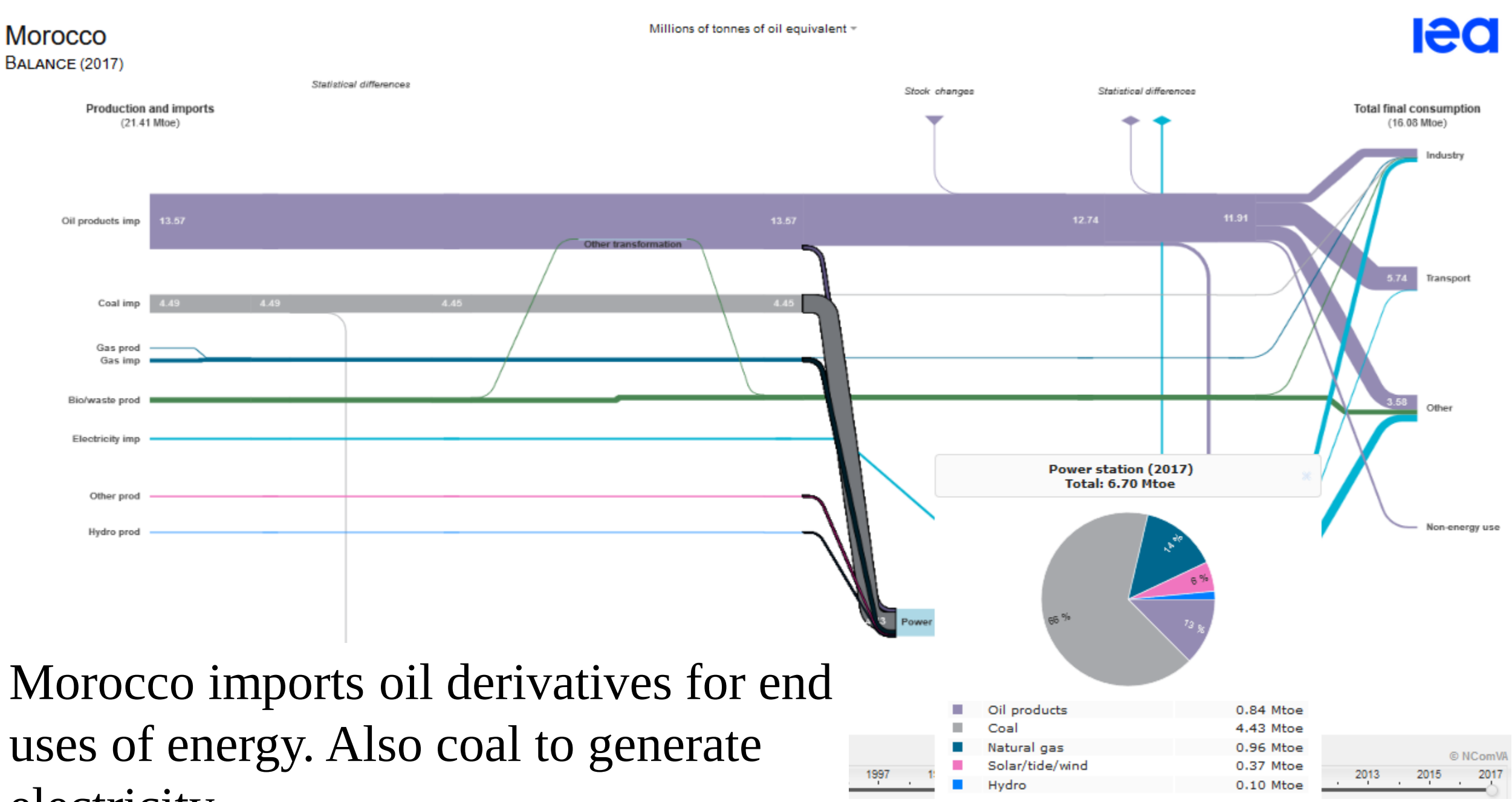
        - Every summer these people cross Spain on their vacations

- Attempt to create industrial zones

    + An example, the area of the port of Tanger - Med

Tánger

Med



Morocco imports oil derivatives for end uses of energy. Also coal to generate electricity

Morocco has approximately 6,000 MW in coal-fired power plants

Thermal [edit]

Thermal power station	Community	Coordinates	Fuel type	Capacity (MW)	Year completed	Owner
Jorf Lasfar Thermal Power Station	Jorf Lasfar	33.105225°N 8.636734°W	Coal	2,016[3]	2001	TAQA Morocco
Safi Thermal Power Station	Safi	32.147652°N 9.281060°W	Coal	1,386[4]	2017	Safi Energy Company (GDF Suez + Mitsui & Co + Nareva)
Nador Thermal Power Station	Nador		Coal	1,320	Est. 2021[5]	ONEE
Al Wahda Thermal Power Station	Al Wahda		Natural gas	800	2010	Endesa/ONEE
Kenitra Thermal Power Station	Kenitra		Coal Natural gas	300 315	1978 2012	ONEE
Mohammedia Thermal Power Station	Mohammedia	33.681114°N 7.435791°W	Fuel oil & Coal	600	2007[6]	ONEE
Jerada Thermal Power Station	Jerada		Coal	515	2017	ONEE
Tahaddart Thermal Power Station	Tangier		Natural gas	384	2005	Endesa/ONEE

Safi Power Plant, Morocco

The 2×693 MW Safi coal-fired power plant is located close to the city of Safi in Morocco. With a capacity of 1,386 MW, this plant is the largest in Morocco.

Safi is the first coal-fired power plant in Africa to use ultra-supercritical technology. The aim is to significantly reduce CO2 and to lower fuel costs by raising efficiency by 10 percent compared to conventional coal-fired plants. The project is part of Morocco's national strategic plan to cover rising electricity demand at low cost, whilst protecting the environment.

Work began in 2015, and is being carried out by our customer Daewoo Engineering & Construction Co. (South Korea). Operation and maintenance will be provided by Safi Energy Company. The total investment value is USD 2.6 billion. By the time of delivery of the project in 2017, HeidelbergCement's subsidiary Ciments du Maroc estimates that it will have delivered 220,000 tonnes of marine and high-performance cement.

https://www.heidelbergcement.com/en/safi-power-plant

Wind resources in Morocco are good

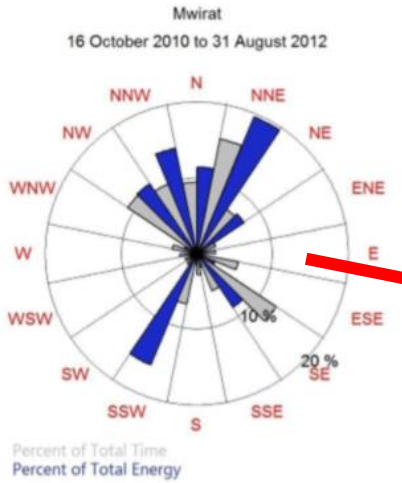


Figure 7. Rose des vents de Mwirat

Mwirat (Essaouira)

Vitesse moyenne: 6.68 m/s

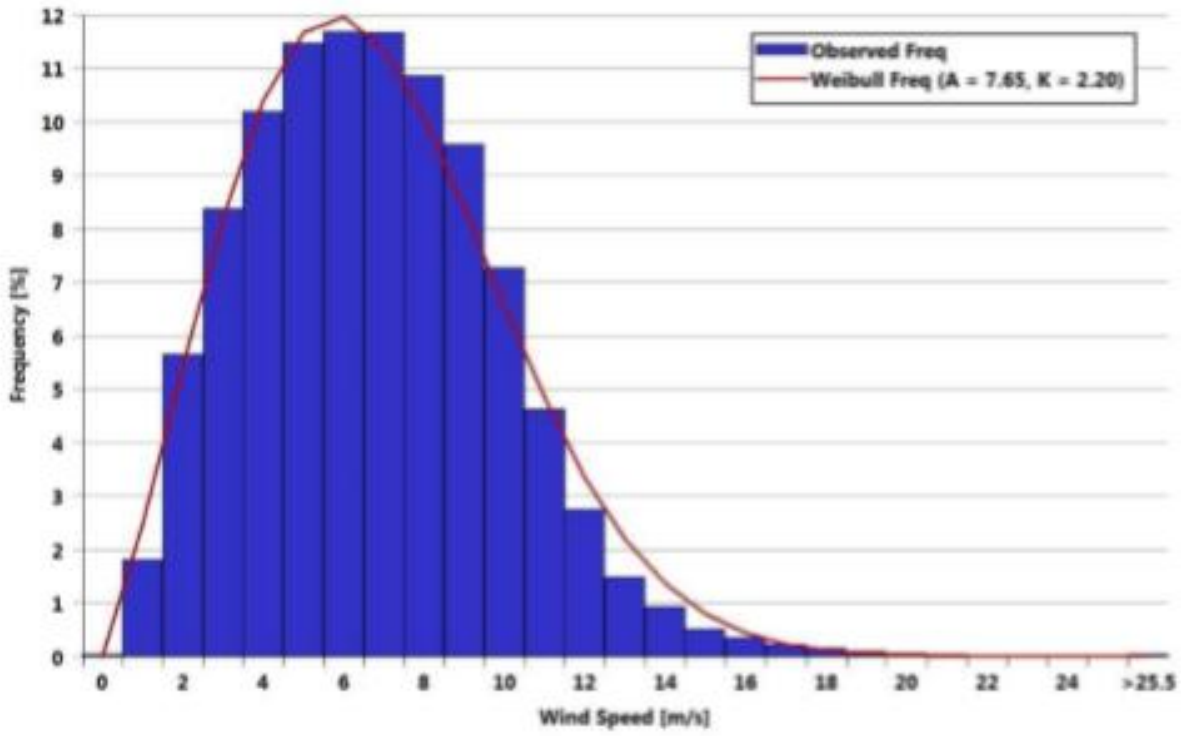
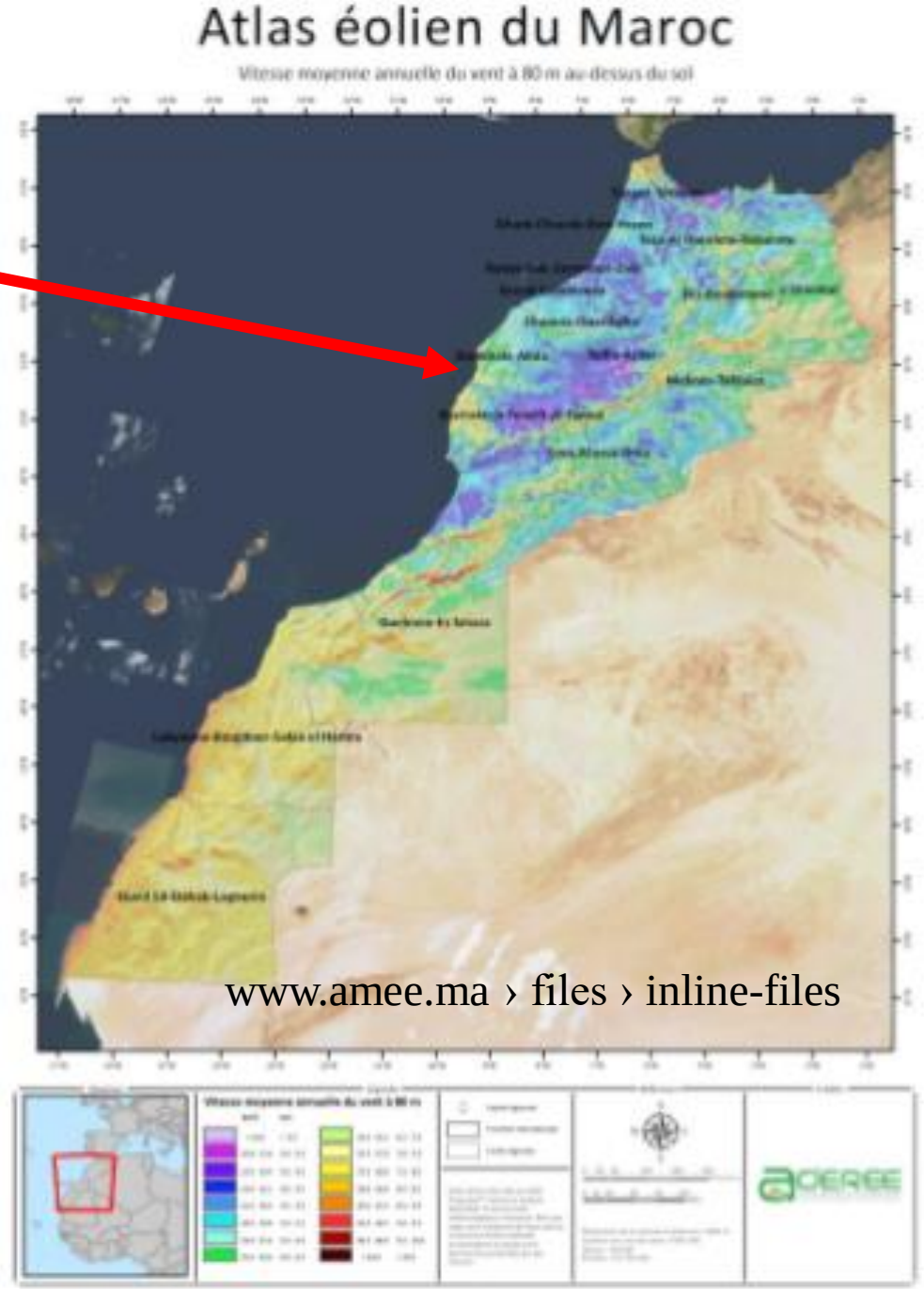
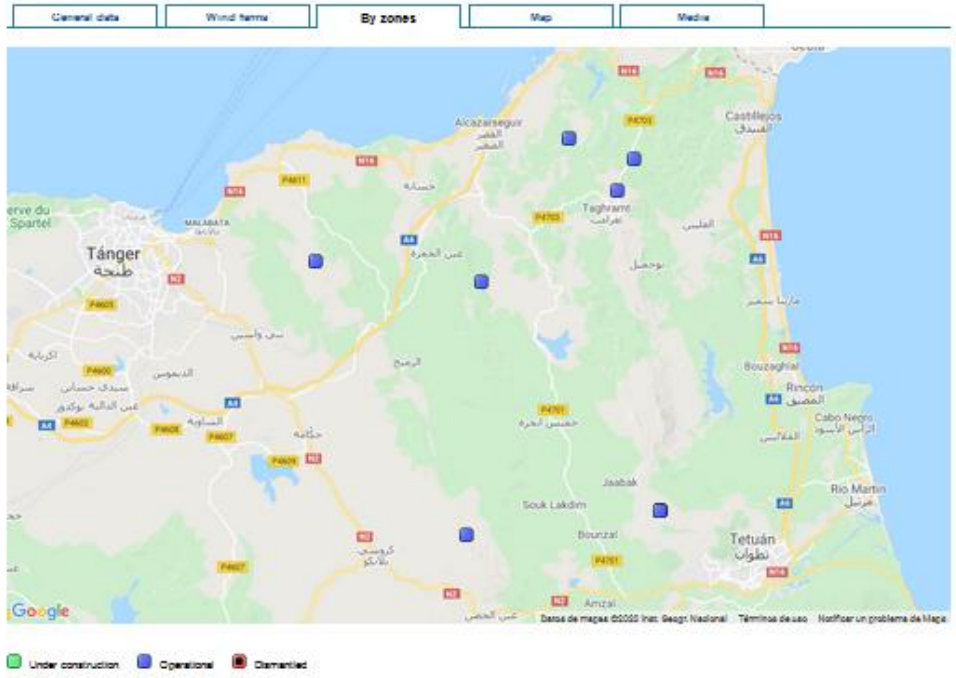
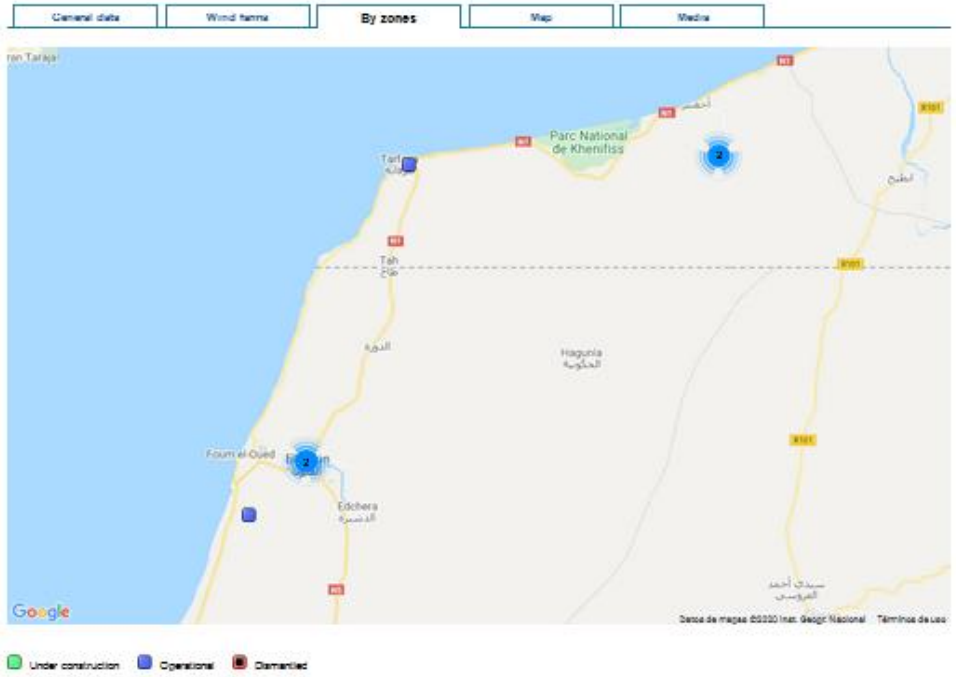


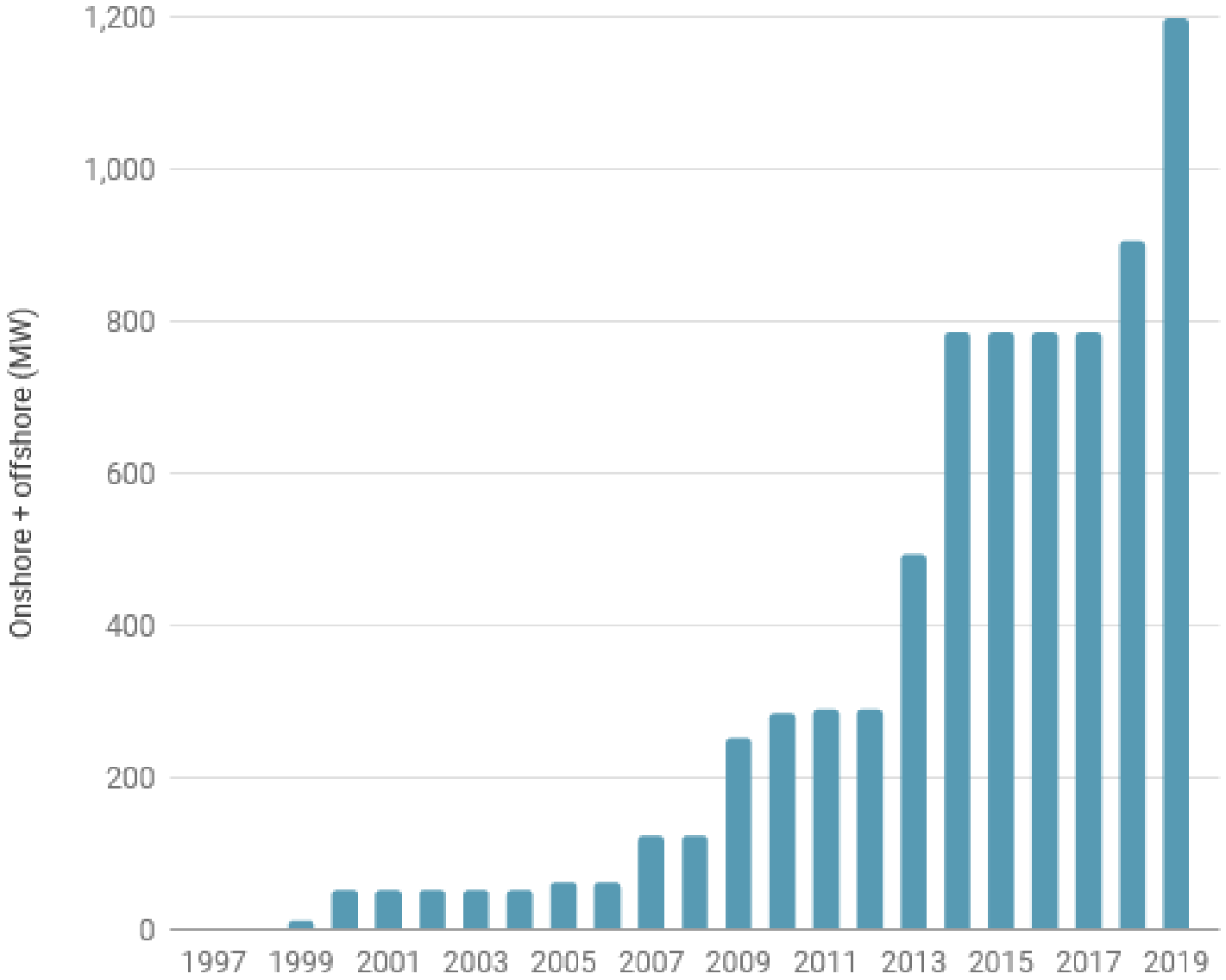
Figure 6. Distribution de Weibull de Mwirat







https://www.thewindpower.net/



PROJETS HYDRAULIQUES

Projet de la STEP Abdelmoumen (350 MW)

Afin d'améliorer les conditions techniques et économiques de fonctionnement des moyens de production et du réseau de transport, l'ONEE a lancé le projet de la 2ème Station de Transfert d'Energie par Pompage (STEP) Abdelmoumen, qui sera implantée au niveau du barrage Abdelmoumen situé à 70 km environ au Nord-Est de la ville d'Agadir.

D'une puissance de 350 MW, cette station va participer à la satisfaction de la demande en électricité du pays en période de pointe ainsi qu'à l'optimisation de l'exploitation des moyens de production notamment celles à base d'énergies renouvelables. Le projet sera développé par l'ONEE dans le cadre d'un marché clé en mains.

Electrification Rurale. <L'électricité pour tous>

- Le programme d'Electrification Rurale Global (PERG) a connu une grande réussite grâce à son caractère global et son mode de financement participatif.

- Le Programme d'électrification Rurale Global a permis en 2018 l'électrification de 513 villages par réseaux interconnectés , permettant ainsi à 13 383 nouveaux foyers ruraux de bénéficier de l'électricité.

- Depuis le lancement du PERG en 1996, à fin 2018, le bilan de l'électrification rurale se présente comme suit :

- L'électrification, par raccordement aux réseaux de 40 456 villages regroupant 2 124 483 foyers.

- L'équipement par kits photovoltaïques de : 51 559 foyers dans 3 663 villages durant la période 1998 – 2009 ; 19 438 foyers dans 900 villages dans le cadre du projet solaire INDH au cours de la période 2016-2018.

Morocco kicks off tender for 400 MW solar park. (800 MW)

https://www.pv-magazine.com/2020/01/31/morocco-kicks-off-tender-for-400-mw-solar-park/

- The Moroccan Agency for Sustainable Energy(Masen) has issued a call for expression of interest to pre-qualify developers for the construction of a 400 MW solar power plant.

- The plant is part of the first phase of the Noor PV II project, under which several PV arrays will be built across eight different locations. According to Econostrum, interested developers and investors have until Feb. 28 to pre-qualify for the tender.

- Morocco intends to build at least 2 GW of generation capacity under the Noor Solar Plan. In line with these aims, Masen kicked off another tender for the 230 MW CSP/PV Noor Midelt II project in July.

- In early January 2019, the agency also launched a tender for the Noor Atlas projects, a 200 MW scheme to deploy seven PV plants in the southern and eastern parts of the country. German development bank KfW is backing the plan.

- Technology: Central tower.
- Tower height: 250 m.
- Total reflective area: 1,300,000 m^2
- Surface area of the solar field: 550 Ha.
- Turbine power capacity: 150 MWe.

Central receiver plant Noor Ouarzazate III

https://www.energy.sener/project/central-receiver-plant-nooro-iii

Senegal: A country that looks to the sea

- Population: 16 million inhabitants

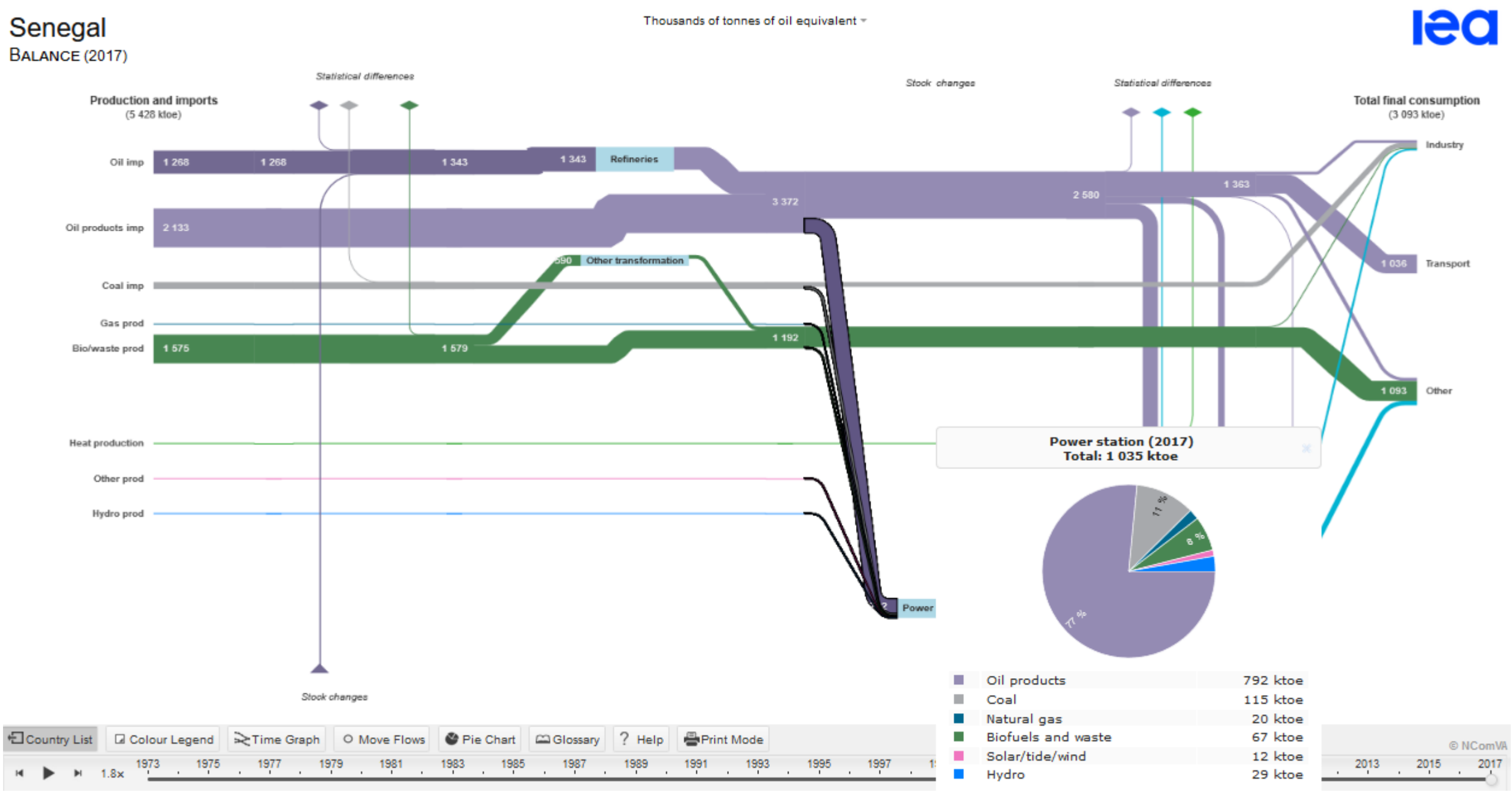
    + Two cities on the coast: Dakar and Saint Louis. Half of the country's population

    + Fishing is an important activity in its waters. (Foreign ships)

- Energy: The country imports oil and its derivatives; exports derivatives to other countries and supplies ships, (bunkering)

Senegal

BALANCE (2017)



https://www.iea.org/sankey/#?c=Senegal&s=Balance

Electricity from: oil products, coal, and natural gas…

- Several fossil fuel medium power plants.(700 MW)

- Wind power: 50 MW, plus Taiba Ndiaye wind farm

  + High wind potential. In particular in the coastal strip

Photography in Isla da Sal, Cabo Verde; from off Senegal

- Solar energy: 134 MW. More expectations of new projects

  + Possibilities of multiple photovoltaic installations for self-consumption

Senegal:

- Taiba Ndiaye wind farm
- 46 wind turbines
- Total power: 158 MW
- Electricity for two million people
- Investment: $ 342 million

https://atalayar.com/content/senegal-inaugura-el-mayor-parque-e%C3%B3lico-de-%C3%A1frica-occidental

Atalayar
ENTRE DOS ORILLAS

Sénégal : deux centrales solaires produiront l'électricité la moins chère d'Afrique de l'Ouest

- Deux centrales électriques solaires vont être construites au Sénégal pour un montant de 47,5 millions d'euros, grâce à l'initiative Scaling Solar de la Banque mondiale. Mathieu Peller, responsable du fonds d'investissement Meridiam, décrypte pour Jeune Afrique les spécificités de ces projets.

- Kabone ... ... 35 MW

- Kael ... ... 25 MW

https://www.jeuneafrique.com/806869/economie/senegal-deux-centrales-solaires-produiront-lelectricite-la-moins-chere-dafrique-de-louest/

Cote d´Ivoire: The country of cocoa, which is then chocolate in Europe

- Cote d´Ivore. Population: 25 million people

    + It receives migrants, who work on the cocoa plantations

    + Migrants to Europe also leave this country

- This country and Ghana produce more than half of the world's cocoa

    + All this production is for raw export

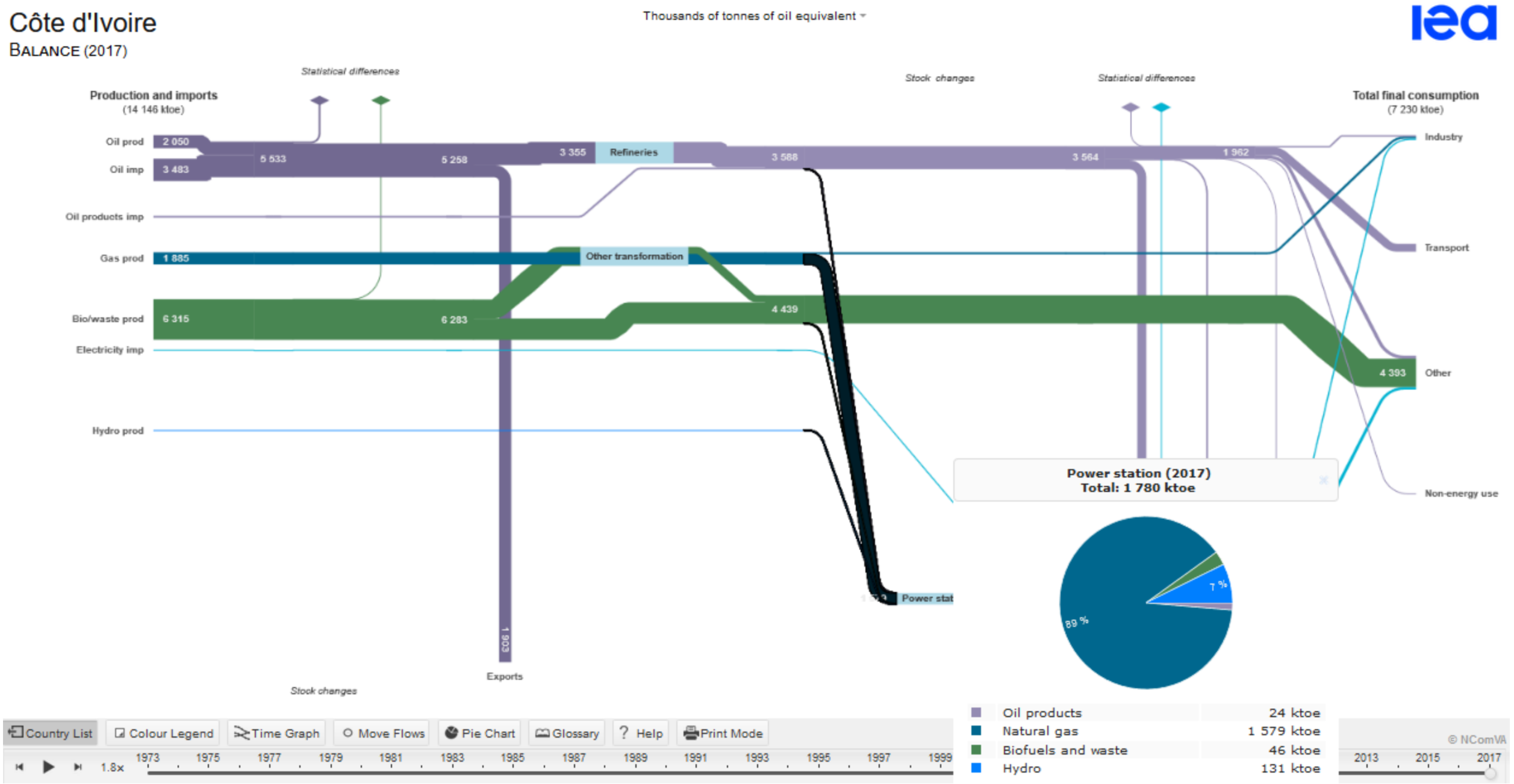
Cote d´Ivoire cocoa threatened by deforestation

(https://www.france24.com/es/20191224-el-cacao-de-costa-de-marfil-amenazado-por-la-deforestaci%C3%B3n)

- Global warming could lead the world to face a chocolate shortage. In Ivory Coast, one of the largest cocoa producers, deforestation is threatening the conditions of stable temperature and high humidity that the trees of this fruit need to develop. The authorities have realized this situation and are beginning to act to prevent the production of this grain from disappearing. Report by Thaïs Brouck.

https://www.france24.com/es/20191104-cacao-amenaza-de-embargo-estadounidense

Cocoa farmers are very poor. Big chocolate makers are rich



https://www.iea.org/sankey/#?c=C%C3%B4te%20d'Ivoire&s=Balance

Electricity: Own natural gas and imported coal (https://h2gconsulting.com/west-africa/el-sector-de-la-energia-en-costa-de-marfil/)

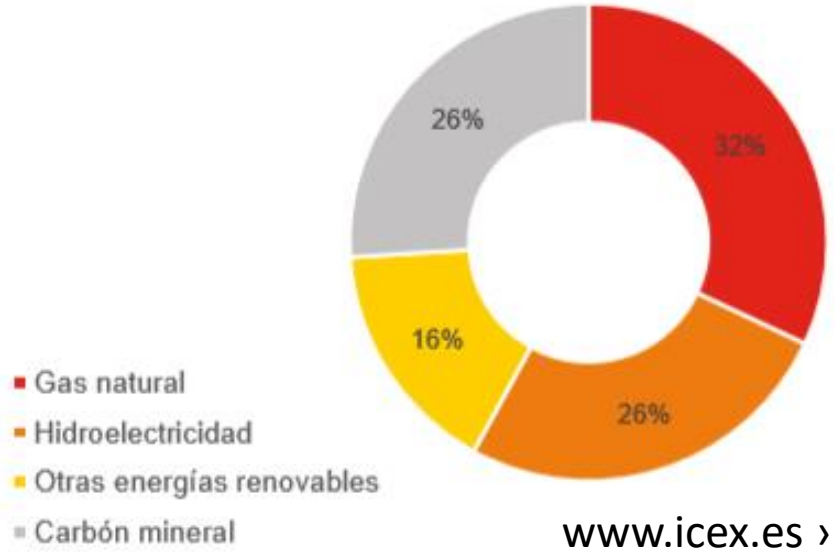
- Ivory Coast is the main electricity producer in the UEMOA and is undergoing an ambitious infrastructure program to become the energy hub of ECOWAS (Economic Community of West African States), which includes Ghana and Nigeria among its 15 member states.

- The Ivorian country currently exports 14% of its production to Togo, Benin, Ghana, Mali, Burkina Faso and Liberia, with a new interconnection line to Guinea Conakry Sierra Leone of 1,300 km under construction, so it is not surprising that be one of the main drivers behind the creation of the WAPP (West African Power Pool), a regional electricity market that will allow it to increase its exports to the 14 countries that will be interconnected with each other.

- With an installed capacity of 1,383 MW in 2010 that went down to 2,199 MW in 2017, the Government plans to reach 4,000 MW in 2020 and 6,000 MW in 2030, with an increasing use of renewable energies to represent 42% of the global energy mix in 2030 (16% excluding hydroelectric power).

Cote d´Ivoire: Forecast of an electric development supported by three sources: natural gas, coal and hydropower.
(Moderate development of the other renewable energies)

GRÁFICO 2. PRONÓSTICO DE LA COMPOSICIÓN DEL MIX ENERGÉTICO DE AQUÍ A 2030



www.icex.es › mde5 › odiz › ~edisp › doc2019823442

Elaboración propia a partir de los datos de la CPDN de Costa de Marfil

The rural world is very important in Cote d'Ivore. They should collaborate in its maintenance by extending photovoltaic energy in small installations

PROGRAMME D'ELECTRIFICATION RURALE : 5.000 VILLAGES ELECTRIFIES A FIN 2018

- Abidjan, le 04 novembre 2018 –

Démarré il y a trois ans, le Programme National d'Electrification Rurale (PRONER) qui vise l'électrification des villages de plus de 500 habitants, va permettre à fin 2018, le raccordement au réseau électrique de 5 000 localités, a indiqué, le dimanche 04 novembre, le ministre en charge de l'Energie, Thierry Tanoh.

http://www.gouv.ci/_actualite-article.php?recordID=9382

Nigeria: A country of concern

- Population of 200 million people. Rapidly growing
- Some cities with a very high population volume: Lagos, Abuya and others
- High diversity of ethnic and cultural groups
- Migrations to Europe. Those who arrive live here in terrible conditions

Armed conflicts for decades

Oil has been present in some of them

https://elordenmundial.com/mapas/la-geopolitica-de-nigeria/

Nigeria: a country with hydrocarbon export earnings

Almost everything is for export!!!!

- Oil: 2.2% of world reserves

    + Also, it extracts 2.2% of the world total

- Natural gas: 2.7% of world reserves

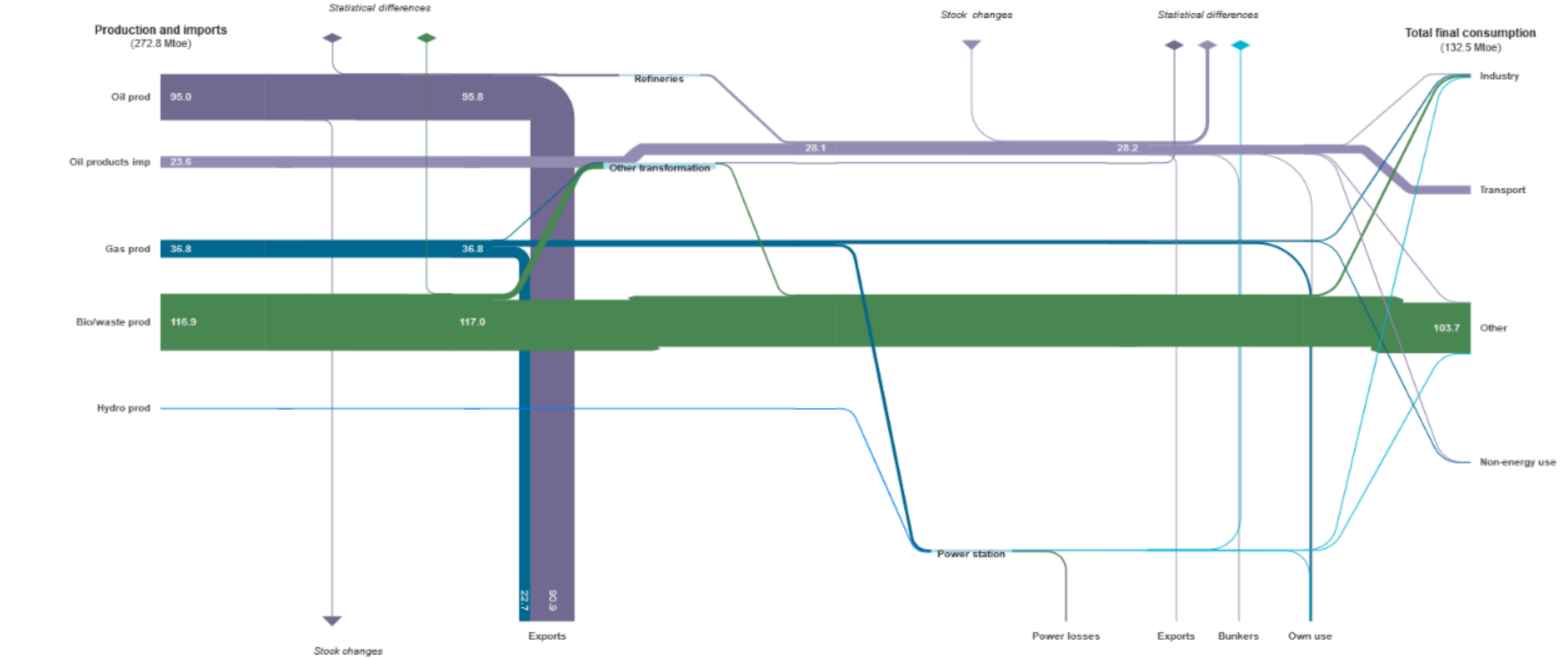
    + Extracts only 1.3% of global volume

- What will Nigeria's economic balance be like at the end of the "hydrocarbon era"? (Year 2070?)

Nigeria

BALANCE (2017)

Millions of tonnes of oil equivalent



Country List | Colour Legend | Time Graph | Move Flows | Pie Chart | Glossary | Help | Print Mode

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1.8x

1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017

https://www.iea.org/sankey/#?c=Nigeria&s=Balance

Oil extraction, environmental degradation and poverty in the Niger Delta region of Nigeria

In Nigeria, environmental problems are severe, particularly in the Niger Delta region of the country. In that region, crude petroleum activities damage the fertility of the soil, and destroy wildlife and the breeding ground for marine fishes because of the toxicity of oil and gas.

International Journal of Environmental Studies
Volume 62, 2005 - Issue 6

In 1995 environmental and social activist Ken Saro-Wiwa was killed.
(https://www.britannica.com/biography/Ken-Saro-Wiwa)

We cannot say that in 25 years the situation has greatly improved.

Nigeria: Minimal development of the electrical system

- Natural gas power plants: open cycle and combined cycle. (8.000 MW)

    + It is the preferred option. Natural gas at a low price

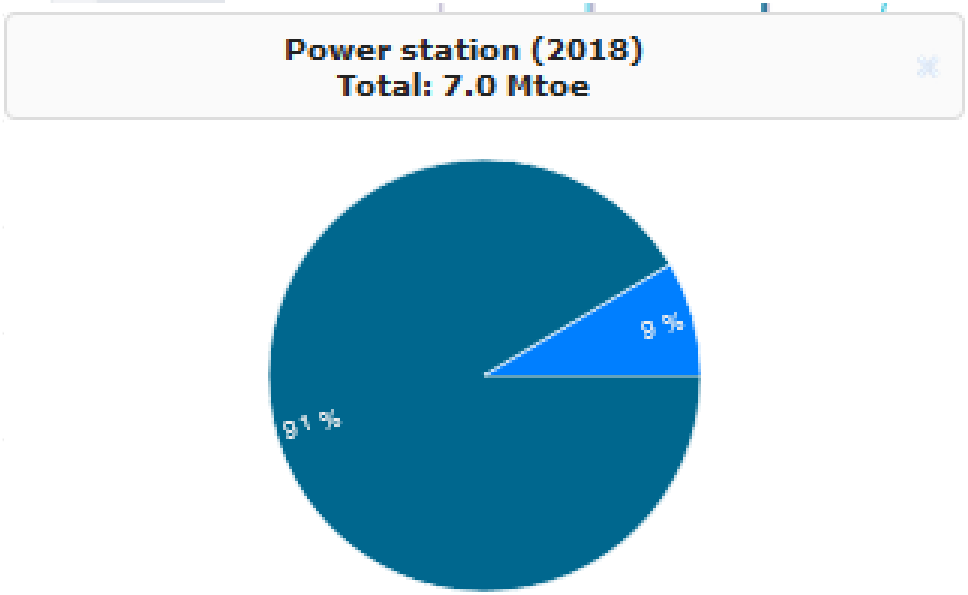
- About 2,000 MW in hydroelectric plants

    + Under project: Mambilla Power Station; (3.000 MW)

- Coal.- Under project: Itobe Power Plant; 1.200 MW Circulating Fluidized Bed technology

https://datos.bancomundial.org/indicador/EG.USE.ELEC.KH.PC?locations=NG

Year 2014



Natural gas is the main contribution to electricity generation. There may be many combustion engines burning petroleum products

An example of interest in natural gas plants

- Set to become one of the world's lowest cost natural gas-fired power plants, a Nigerian 550MW gas-to-power facility will provide 4.5TWh of secure, affordable energy when it becomes fully operational in 2022.

- Themis, an Africa-focussed power company backed by Denham Capital announced a new partnership with Kingline Development Nigeria Limited (Kingline) to develop a 550MW natural gas-fired power plant in Ondo State, Nigeria.

- The Kingline Power Project is currently in its development stage with a target to proceed to financial close by Q2 2020, becoming fully operational in 2022. It will be located on 111 hectares of land in the Ondo State Industrial Park, adjacent to the existing Omotosho Power Plant.

https://www.esi-africa.com/industry-sectors/renewable-energy/natural-gas-fired-power-takes-shape-in-nigeria/

Nigeria: Power in electricity with renewable energy

- Hydropower ……. 2.111 MW …… Total World … 1.310.300 MW
- Wind energy …… 11 MW …… Total World … 622.700 MW
- Solar energy …… 28 MW …… Total World … 588.400 MW
- Bionergy …… 10 MW …… Total World … 123.800 MW
- Renewable waste 10 MW …… Total World … 101.100 MW
- Bagasse …….. 5 MW …… Total World … 19.000 MW
- Off-grid capacity 40.400 kW …… Total World … 8.600.000 kW

Nigeria kicks off 1 GW solar IPP program for rural electrification

Nigeria's Rural Electrification Agency is seeking consultants to conduct feasibility studies and develop a masterplan design for the ambitious program, which aims to establish a new energy infrastructure in the state of Jigawa. The program is backed by the African Development Bank.
September 7, 2018 Emiliano Bellini

https://www.pv-magazine.com/2018/09/07/nigeria-kicks-off-1-gw-solar-ipp-program-for-rural-electrification/

Eauxwell Nigeria Limited, established in 1987, is the leading water and renewable energy-engineering firm in Nigeria. Eauxwell is committed to the growth of the alternative power sector in Nigeria through the use of innovative products and concepts. The company specialises in product sales, installation and project services in the field of solar street lighting, solar water pumping, rooftop and ground mounted off-grid systems, as well as hybrid and backup power supply systems.

https://www.ruralelec.org/project-case-studies/eauxwell-nigeria-ltd-mini-grids-remote-and-rural-communities-nigeria

Thanks for your attention. Good luck in your work for Africa

emilio.menendez@uam.es