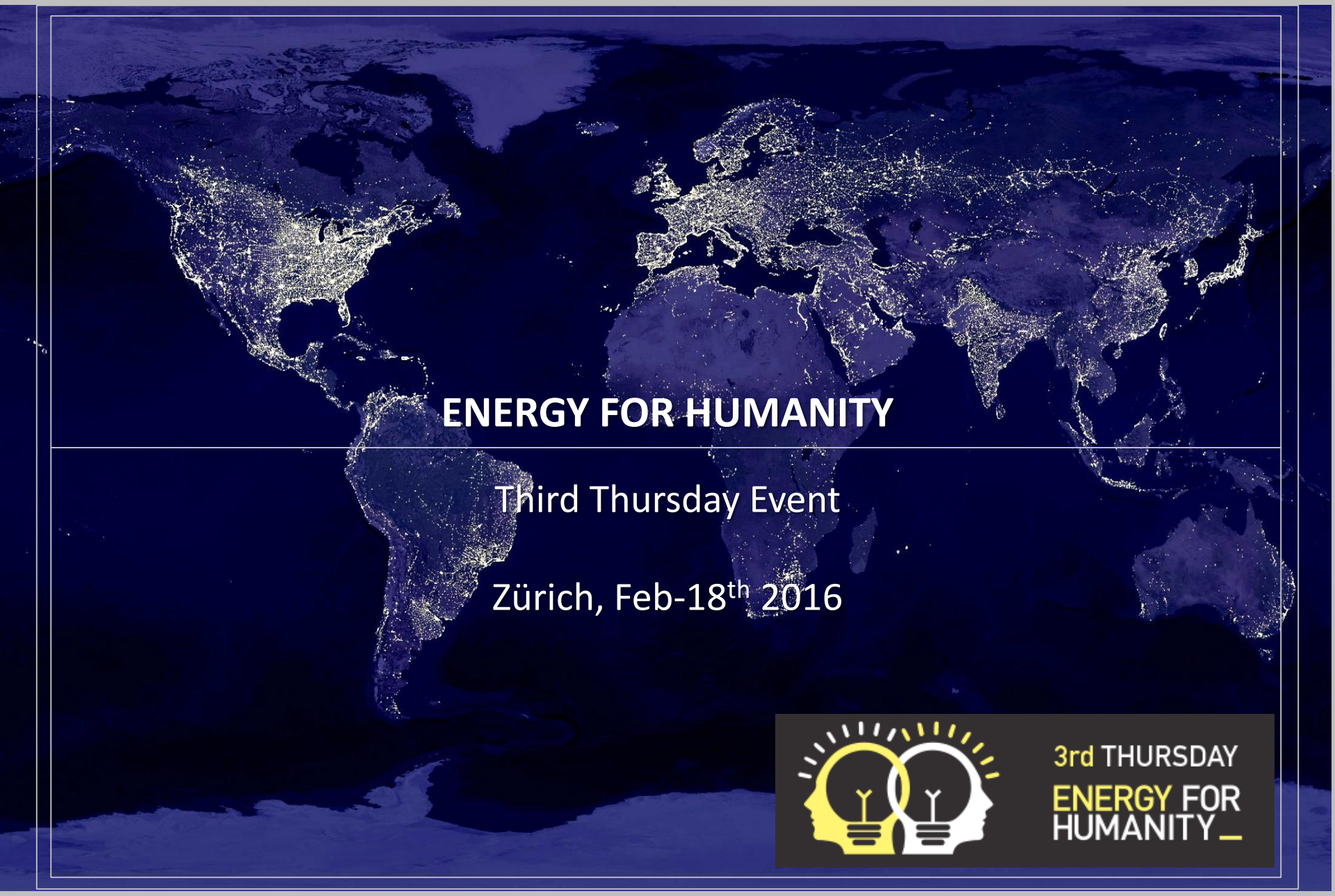

ENERGY FOR HUMANITY

Third Thursday Event

Zürich, Feb-18th 2016

3rd THURSDAY
ENERGY FOR HUMANITY_

Bringing Economic and Social Development in Sub-Saharan Africa Through Power

The Natural Gas Perspective

Luiz Eduardo Junqueira, MEng, PMP, MBA.

Lecturer Profile

Luiz Eduardo Junqueira

Capital Intensive Projects Expert – Investor Advisory

- MBA in International Management (*Swiss Business School, 2016*)
- Certified Project Management Professional - PMP® (*PMI, 2009*)
- Master in Project Management (*ITA, 2007*)
- Master in Industrial Engineering (*USP, 2006*)
- Civil Engineer (*UNESP, 2002*)

Experience in acquisition, development and execution of the following power projects:

- ✓ Hydro Power Plants (HPP and SHP);
- ✓ Wind Farms;
- ✓ Gas Power Plants;
- ✓ Transmission Lines, and
- ✓ General Infrastructure.

ContourGlobal · ALSTOM · TOMÉ International · quantum global · Brookfield Renewable Energy Partners · Associação Brasileira de Cimento Portland · Camargo Corrêa

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So this is Africa....

- ✓ 2nd largest continent
  - 30.2 million km^2
  - 20.4% earth's total surface
- ✓ 2nd most populous continent
  - 1.1 billion people
  - 36.4 hab./km^2
- ✓ 54 counties (+ 2 in dispute)
  - Western Sahara
  - Somaliland
  - Asia: 48 countries
  - EU: 28 countries
- ✓ 3'000 ethnic groups
- ✓ 2'000 different languages.

Africa is a world in itself!

✓ Lower GDPs *per capita* in the world (IMF, 2014)

Rank	Country	Int$
167	Benin	1,875
168	Haiti	1,757
169	Mali	1,742
170	Rwanda	1,703
171	Kiribati	1,690
172	Burkina Faso	1,688
173	Ethiopia	1,642
174	Gambia, The	1,605
175	Comoros	1,533
176	Guinea-Bissau	1,457
177	Togo	1,452
178	Madagascar	1,445
179	Guinea	1,257
180	Eritrea	1,200
181	Mozambique	1,178
182	Malawi	1,112
183	Niger	1,052
184	Burundi	914
185	Liberia	886
186	Congo, Dem. Rep.	729
187	Central African Republic	609

A world in the dark… (electrification rate is ~40%)

But wait, there is more….

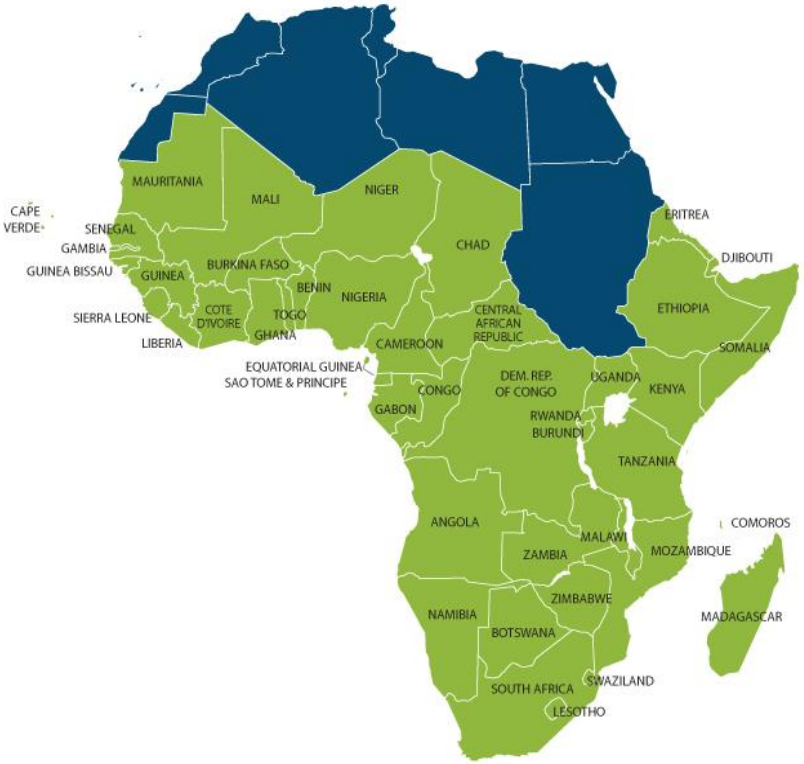
Sub-Saharan Africa

"Sub-Saharan Africa is, geographically, the area of the continent of Africa that lies south of the Sahara Desert."

Basically, it excludes countries in north Africa witch is considered part of the Arab World.

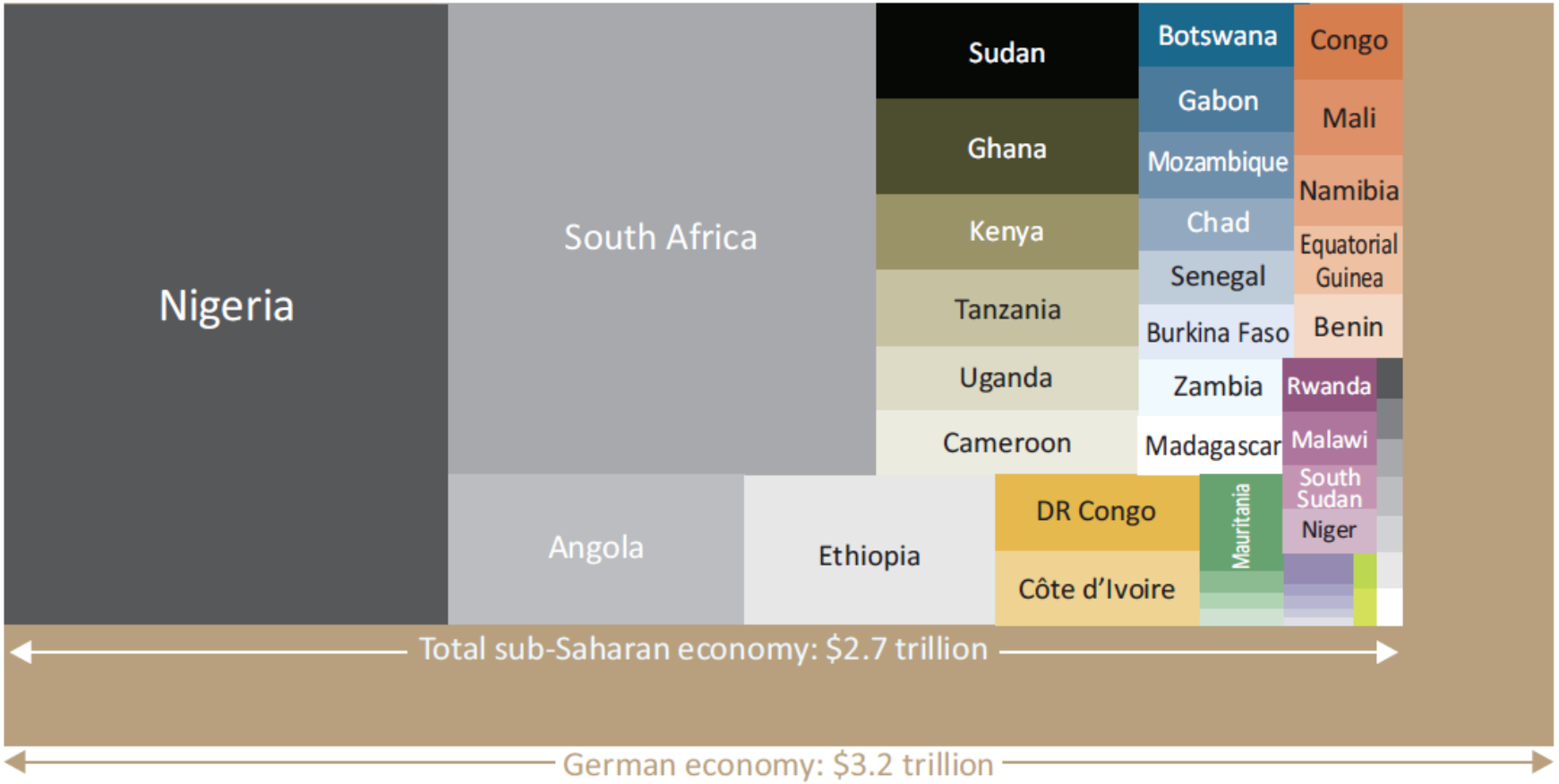
- ✓ 49 countries
- ✓ Low life expectancy - 58 years
- ✓ Low income - GDP *per capita* ~$1.600
- ✓ Primary education completion - 68%

and a darker world → Electrification rate is ~32%



The Size of the Sub-Saharan Economy

Sub-Saharan Africa GDP (PPP terms, 2013)

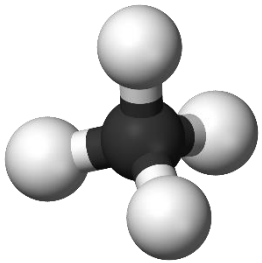


Sources: IMF; IEA Analysis

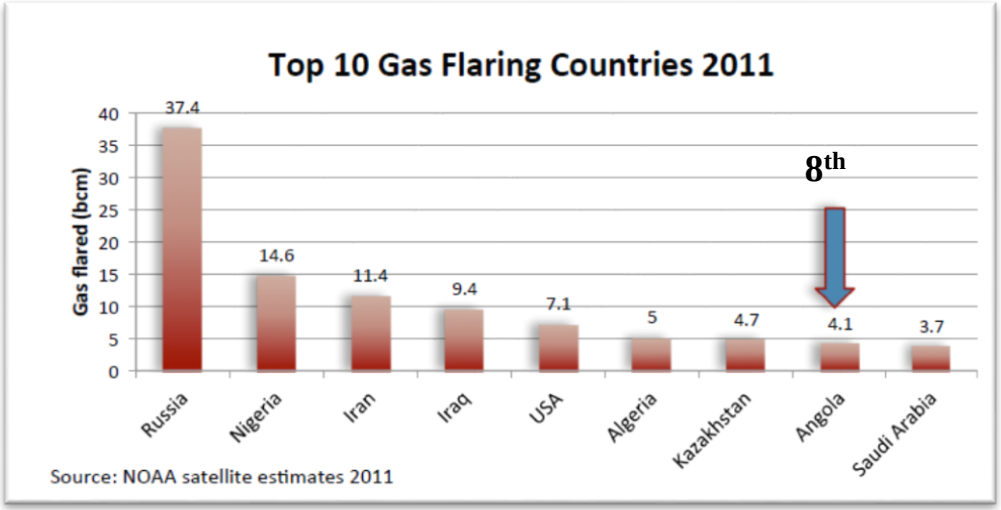
Republic of Angola

- ✓ Population: 24.383.301 (INE, 2014)
- ✓ Life expectancy at birth: 52 years (World Bank, 2014)
- ✓ GDP per capita: USD 4,062 (IMF, 2015)
- ✓ Main export: Oil, ~60% of GDP (WB, 2014)
  - 2nd largest African oil producer
  - OPEC member
- ❖ Independence war: 1961-1975
- ❖ Independence: 1975
- ❖ Civil war: 1975-2002
- ✓ Electrification rate: 29% (IEA, 2014)

Angolan Natural Resources – Hydrocarbons

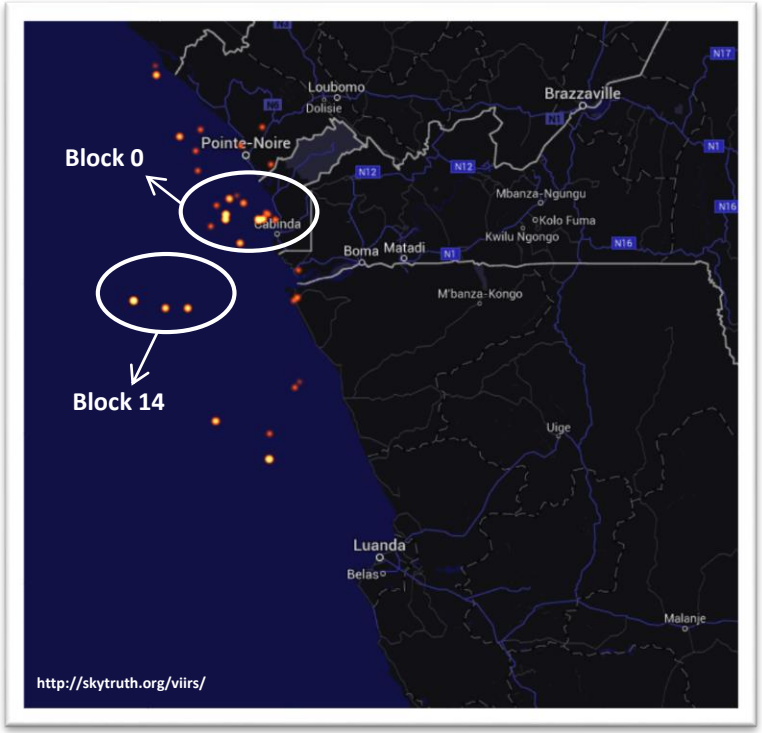


- ✓ Oil exports (2015): 1’608’000 barrels/day (16th)
- ✓ Gas exports (2015): 0 mcf



- ✓ CO2 emissions due to flare: 14.3Mt/y

(PDD – Angola LNG, 2014)



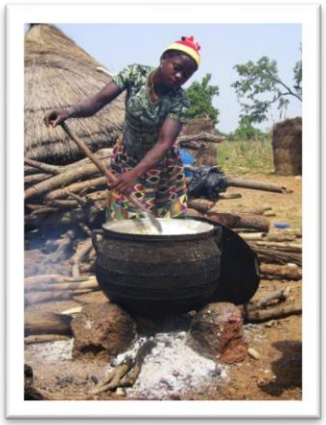
Gas Flaring in Angola (2014)

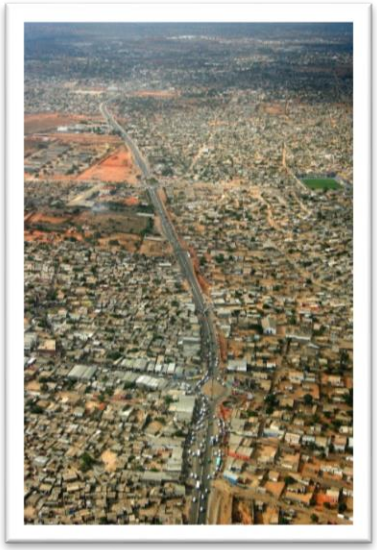
Angola – Challenges for Economic Development

The country has made huge improvements in its economy due to the large oil exploration initiated after the war in the north (Cabinda/Soyo provinces).

Many civil war heritage is still present:

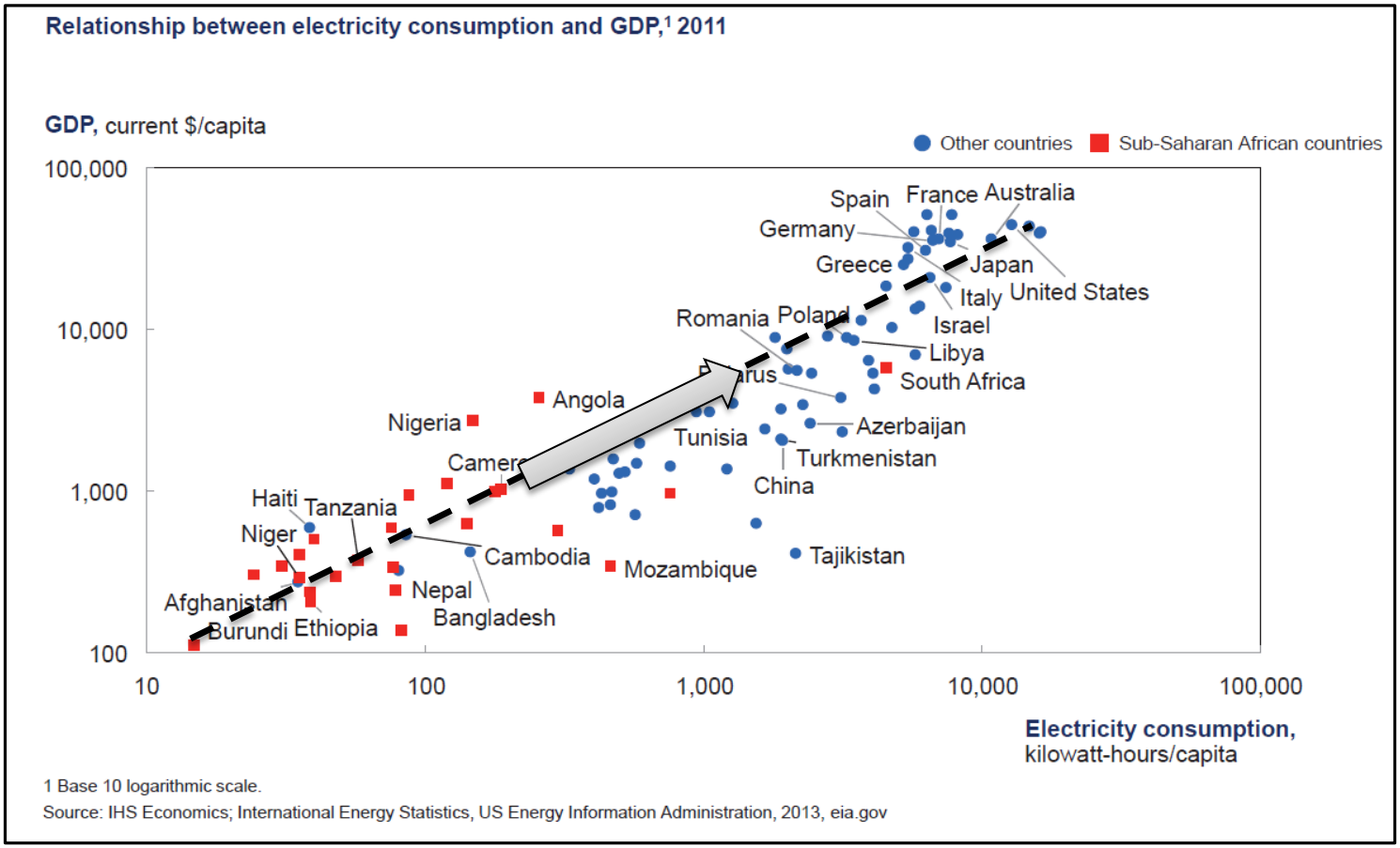
- Huge “unknown” land mine fields in all provinces;
- Infrastructure is the same as the colonial period, it has been destroyed during the war and the population grew 4x (from 6 million to 24 million);
- Low electrification rate, even among sub-Saharan countries.





Angola – Challenges for Economic Development

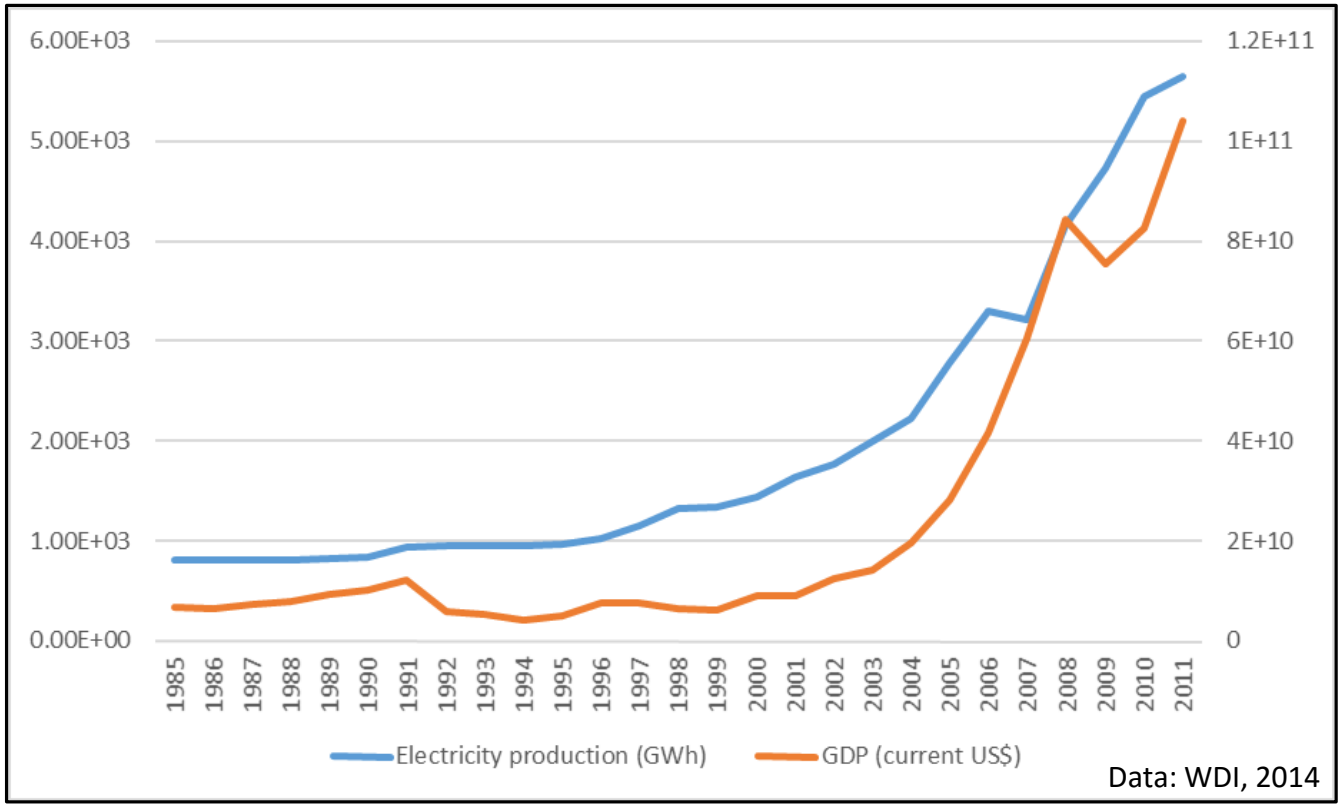
Electricity consumption and economic development are closely linked; growth will not happen without a step change in the power sector.



Angola – Challenges for Economic Development

Correlation of GDP and Electricity Production in Angola.

→ This correlation can be measured in terms of the elasticity factor.



Elasticity Factor

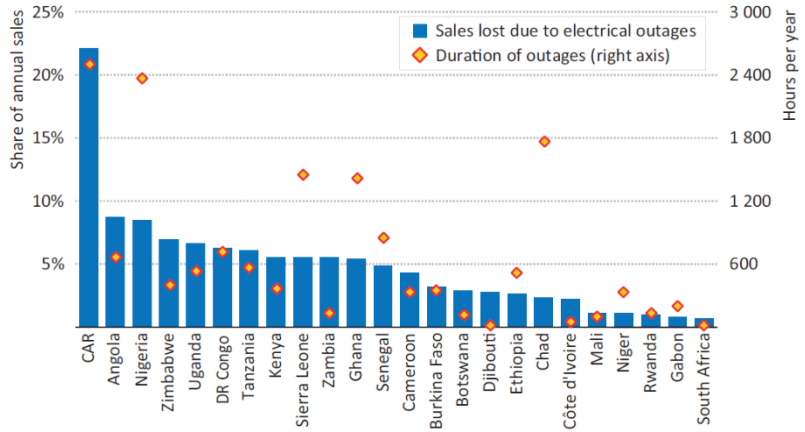
- ✓ Angola: 0.20
- ✓ Brazil: 0.45
- ✓ South Africa: 0.25

Each 1% increase in power consumption, the "grid connected" GDP will increase 0.20%.

Angolan Power Sector – Characteristics

- ✓ Manly state owned;
- ✓ Still in “recovery mode” for the old assets due to the long civil war;
- ✓ The grid is not reliable and restricted to few neighbourhoods / cities;
- ✓ Many cities are powered though diesel generators off grid;
- ✓ Huge power demand due to the economic activities that have been created because of the oil exploration and exploitation activities.

Duration of Electrical Outages and Impact on Business Sales



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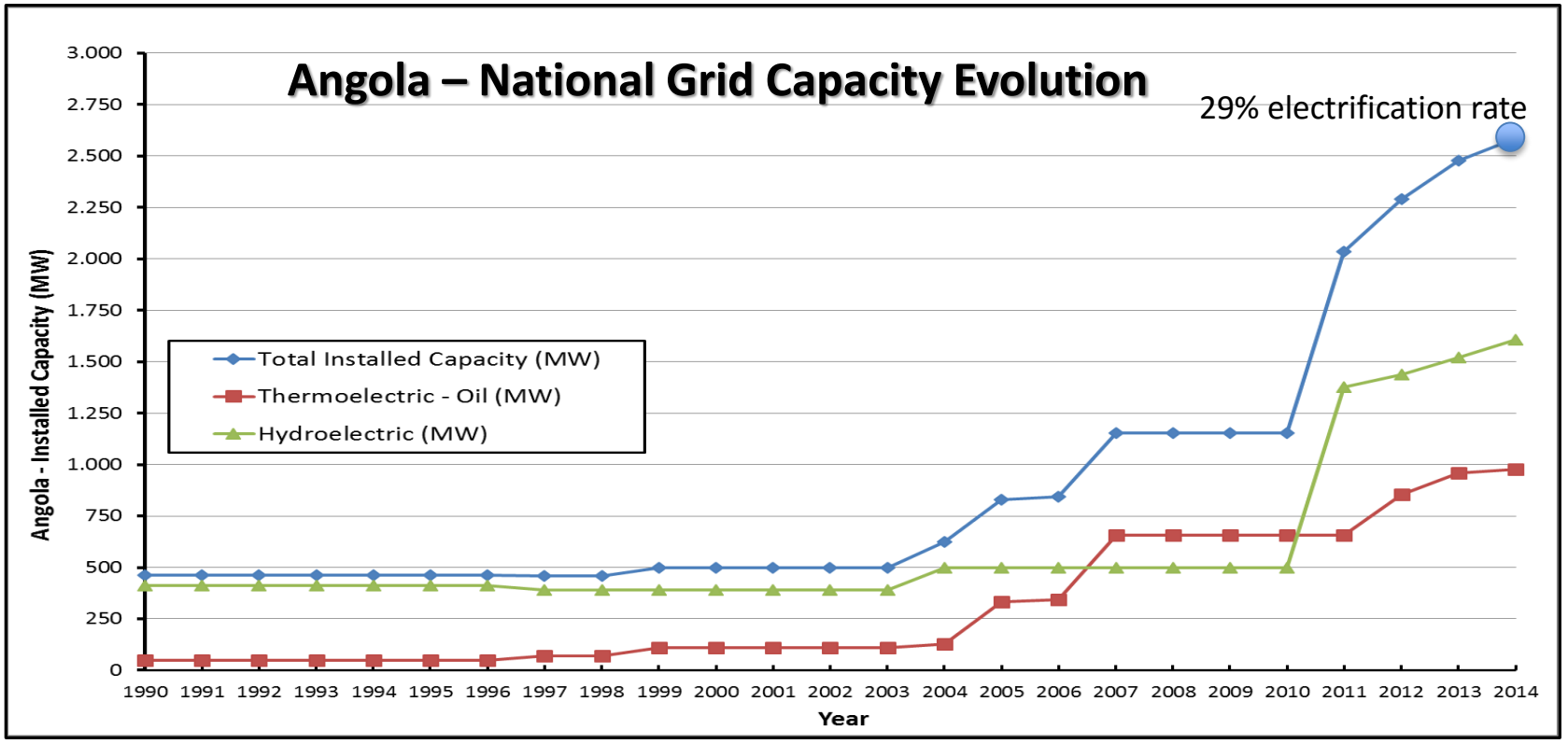
Angolan Power Sector – Characteristics

Total Installed Capacity: 2,595.4 MW

- ✓ Thermoelectric (Oil): 978.4 MW (37.8%)
- ✓ Hydroelectric: 1,607.0 MW (62.2%)



Increase Power Installed Capacity in Angola

The power sector in Angola faces a situation of undersized power generation, capacity, since the demand far exceeds the supply of the service. This situation is especially aggravated by high operational inefficiency in the existing old thermoelectric assets.

- ❑ Installed Capacity – Oil Power Plants: 8,571 GWh/y
- ❑ Actual Power Generation – Oil Power Plants: 2,306 GWh/y
- ❑ Actual Capacity Factor – Oil Power Plants: **26.9%**

Our proposal covers:

- ✓ Expansion of the actual country's installed capacity;
- ✓ Improve the efficiency of the national power grid;
- ✓ Use the natural gas resources associated or not with the oil production;
- ✓ Reduce flaring and reduce CO_2 emissions;
- ✓ Substantially increase the GDP, increase foreign reserves and generate jobs.

Increase Power Installed Capacity in Angola

Stage 1 – Increase Installed Capacity

- ❑ Install new 4x400MW open cycle Gas Power Plants: 1,600 MW
  - ✓ Installed capacity increment: 62% (2,585MW to 4.185MW)
  - ✓ Consumption increment: 115% (new source @50% capacity factor)

Stage 2 – Replacement of the Old Oil Power Plants and Increase Capacity

- ❑ Install new 2x400MW open cycle Gas Power Plants (REPLACE): 800 MW
- ❑ Install new 2x400MW open cycle Gas Power Plants (ADD): 800 MW
  - ✓ Oil Installed capacity replacement: 100% (decommission/emergency)
  - ✓ Installed capacity increment: 15% (4,185MW to 4,807MW)
  - ✓ Consumption increment: 111% (new source @60% capacity factor)

Plan Impacts – Stages 1 and 2

Technical Impacts

- Consumption of the 1.20 TCF of Natural Gas for 30 years of operation
- Reduction of the 2.7 billion litters per year in diesel usage/importation
- Improve grid reliability / sector efficiency in 40% (27% to 38%)

Environmental Impacts

- Reduction in CO_2 emissions by 1,177 kt/year or 35,310 kt during life span.

Economical and Social Impacts

- Stage 1: GDP increase by 23.7 pp / Save in FX USD 2.4 bi/year
- Stage 2: GDP increase by 22.9 pp / Save in FX USD 4.9 bi/year
- +4,200 local jobs during construction and +1,900 jobs during operations.
- Electrification rate increase in 36 pp (29% to 65%)

Carbon Financed Power Generation

Reduction in CO_2 emissions (Stage 1+ Stage 2): 35,310 kt of CO_2

Types of carbon emissions reduction monetization:

- ✓ Certified Emission Reduction (CER): *marked to market (today ~USD 5.00/t)*
- ✓ Social Cost of Carbon (USIAWG, 2015 and Pearce, 2003): USD 109/t

  "monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services."
- ✓ Carbon Tax (@Swedish standards): USD 150/t

- ❑ Project Costs (Stage 1 + Stage 2): USD 5,200 million
- ❑ Carbon Finance
  - ✓ CER: 3% of the project total cost
  - ✓ SCC: 74% of the project total cost
  - ✓ CT: 102% of the project total cost

Without considering historical emissions issue ("rights to pollute")

Carbon Financed Power Generation

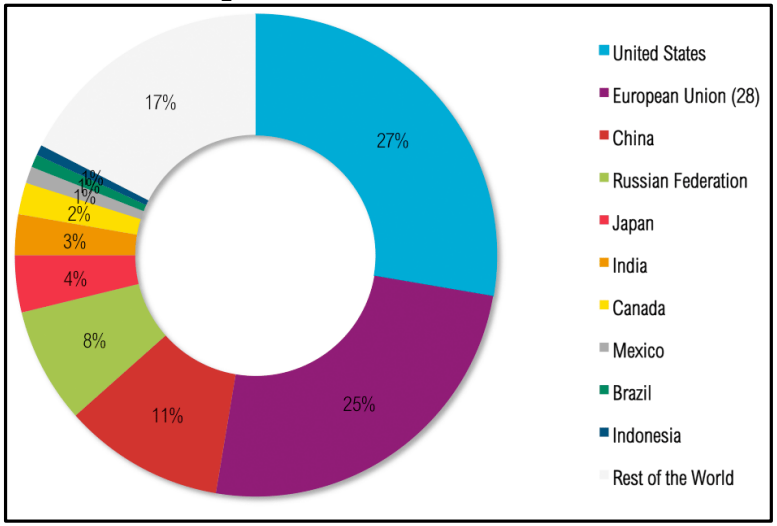
What if we consider the CO_2 historical emissions?

How to calculate the CO_2 credit/debt?

- ❑ World
  - ✓ Surface Area: 510,072,000 km^2
  - ✓ Historical CO_2 Emissions: 1,367,338 Mt
  - ✓ (1) Historical Rate: 2,681 tCO_2/km^2

- ❑ Angola
  - ✓ Surface Area: 1,246,700 km^2 (0.25%)
  - ✓ Historical CO_2 Emissions: 444 Mt (0.03%)
  - ✓ (2) Historical Rate: 356 tCO_2/km^2

Cumulative CO_2 Emissions 1850-2011 (% World Total)



Data available at: http://cait.wri.org/historical

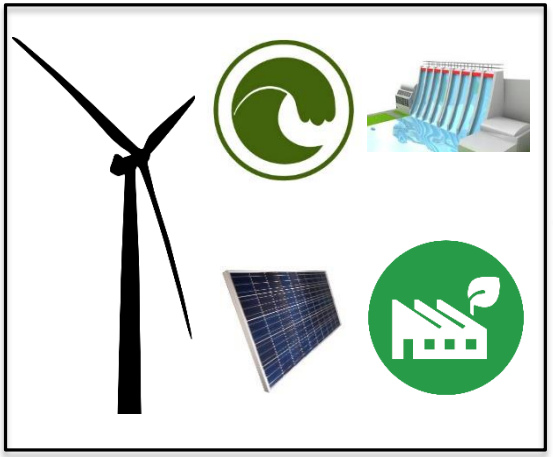
Angola historical CO_2 emissions credit: 2,325 tCO_2/km^2 or 2,898.6 Mt

At a price of USD 1,80 / tCO_2 it is possible to finance 100% of the project cost.

Improving Grid Reliability

In order to improve the low grid reliability in Angola, the following actions are necessary:

- Create the national grid entity in order to plan and manage the system;
- Modernize and improve preventive maintenance on the actual system;
- Maintain a healthy <u>Renewables-Non Renewables mix.</u>

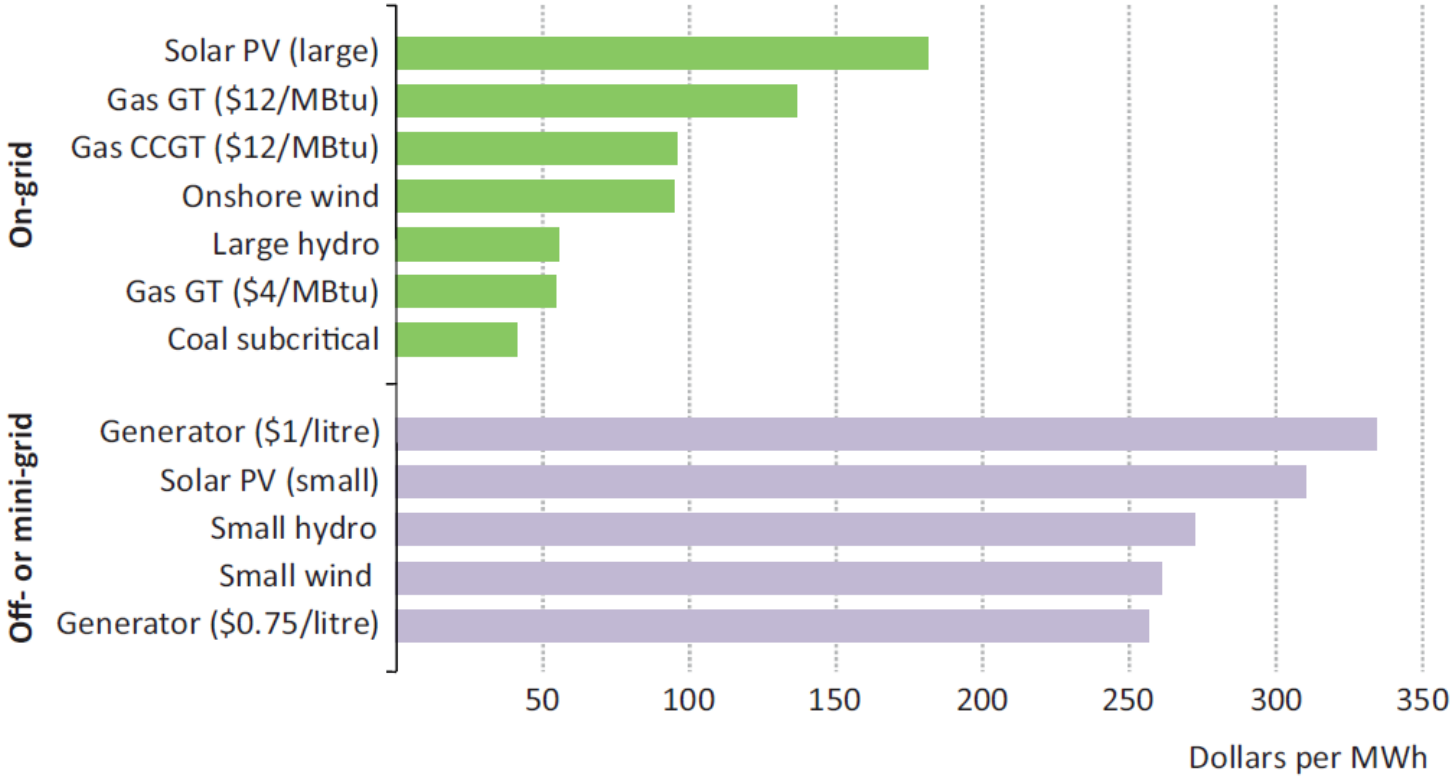


Availability decided by mother nature
Expensive storage (when possible)

Availability decided by human beings
Inexpensive storage (always possible)

Still, Gas Power Plants are highly feasible…

Indicative Costs of Electricity for On-Grid and Off-Grid/Mini Grid Technologies in Sub-Saharan Africa (2012)

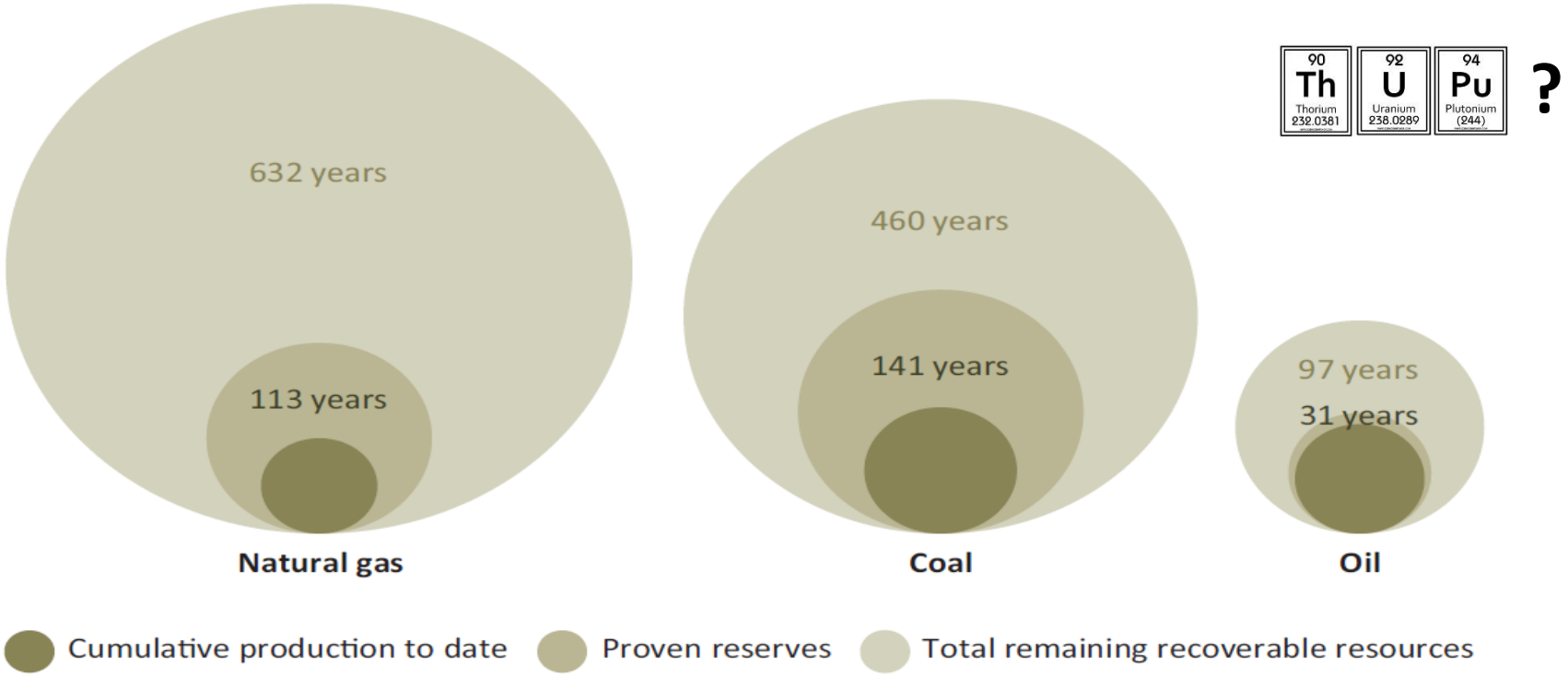


Notes: Costs are indicative and figures for specific projects could vary significantly, depending on their detailed design. GT = gas turbine; CCGT = combined-cycle gas turbine; MBtu = million British thermal units.

Source: Africa Energy Outlook (IEA, 2014)

And there is an abundance of natural resources...

Sub-Saharan Africa - Natural Gas, Coal and Oil Resources (end of 2013)



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Notes: All bubbles are expressed as a number of years production based on estimated production levels in 2013. Production numbers for gas include flaring – if flaring were to cease today, there would be sufficient resources for around 960 years of production at 2013 production levels. Remaining recoverable oil and gas resource numbers include conventional and unconventional resources.

Sources: USGS, Cedigaz, BGR and IEA

Finally, an incentive to change.....

"And it ought to be remembered that there is nothing more difficult to take in hand, more dangerous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new."

The Prince, Chapter 6 - Niccoló Machiavelli (1469, 1527)

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THANK YOU!

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