# “SUSTAINABLE ENERGY MIX FOR AFRICAN AND MENA REGION COUNTRIES”

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Brussels: October 2017

# IRENA

Figure 1 | **Africa's energy landscape: Present***


** Note: statistics refer to 2013, except for access to electricity which refers to 2012.*

# AFRICA

- Africa is a poor energy continent
- This hampers the economic progress & development
- North African and South Africa are major exceptions
- Meeting the current & future energy demand posses a major challenge in sub-sahara African.

- the population in Africa is mostly rural (**59.6%** in 2011) and the access of population to electricity is still limited to **22.7%**.
- Sub-Saharan Africa is in an especially difficult situation, with large number of the population without access to electricity

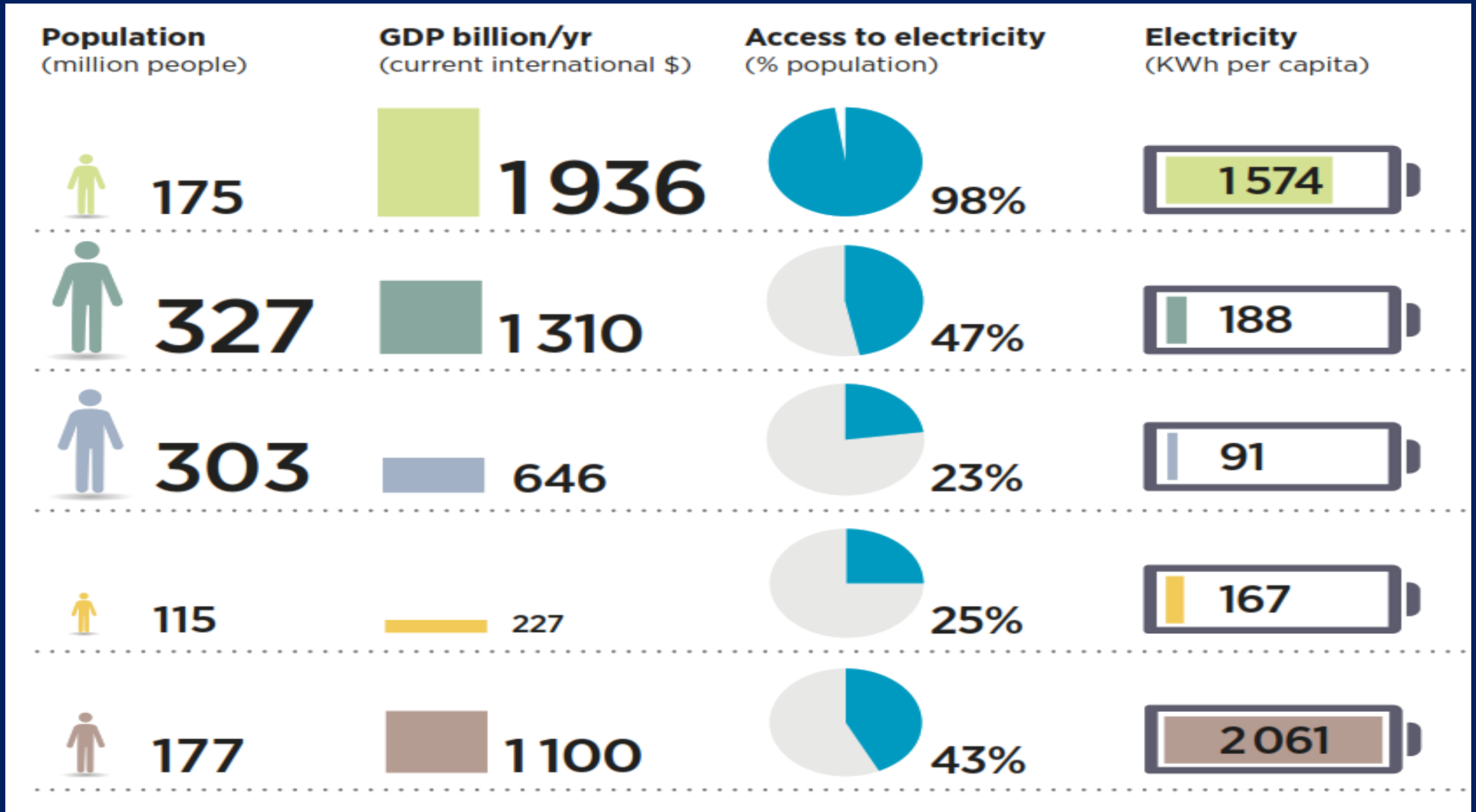
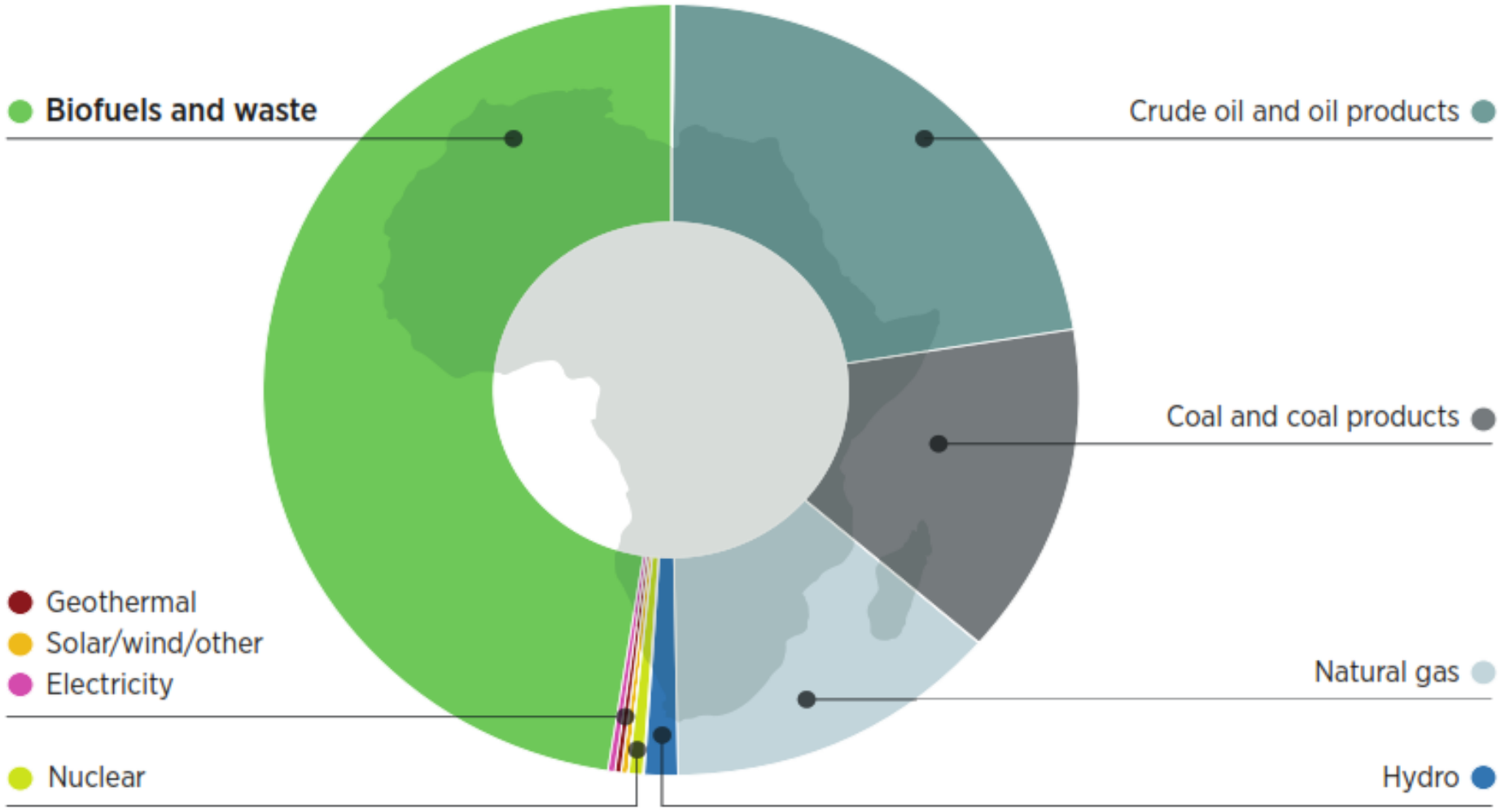

Population
(million people)
GDP billion/yr
(current international $)
Access to electricity
(% population)
Electricity
(KWh per capita)
175
1 936
98%
1574
327
1 310
47%
188
303
646
23%
91
115
227
25%
167
177
1 100
43%
2 061

Figure 2

**Breakdown of total primary energy supply of Africa, 2013**




*Source: IEA (2015)*

# Photovoltaic Solar Energy Potential

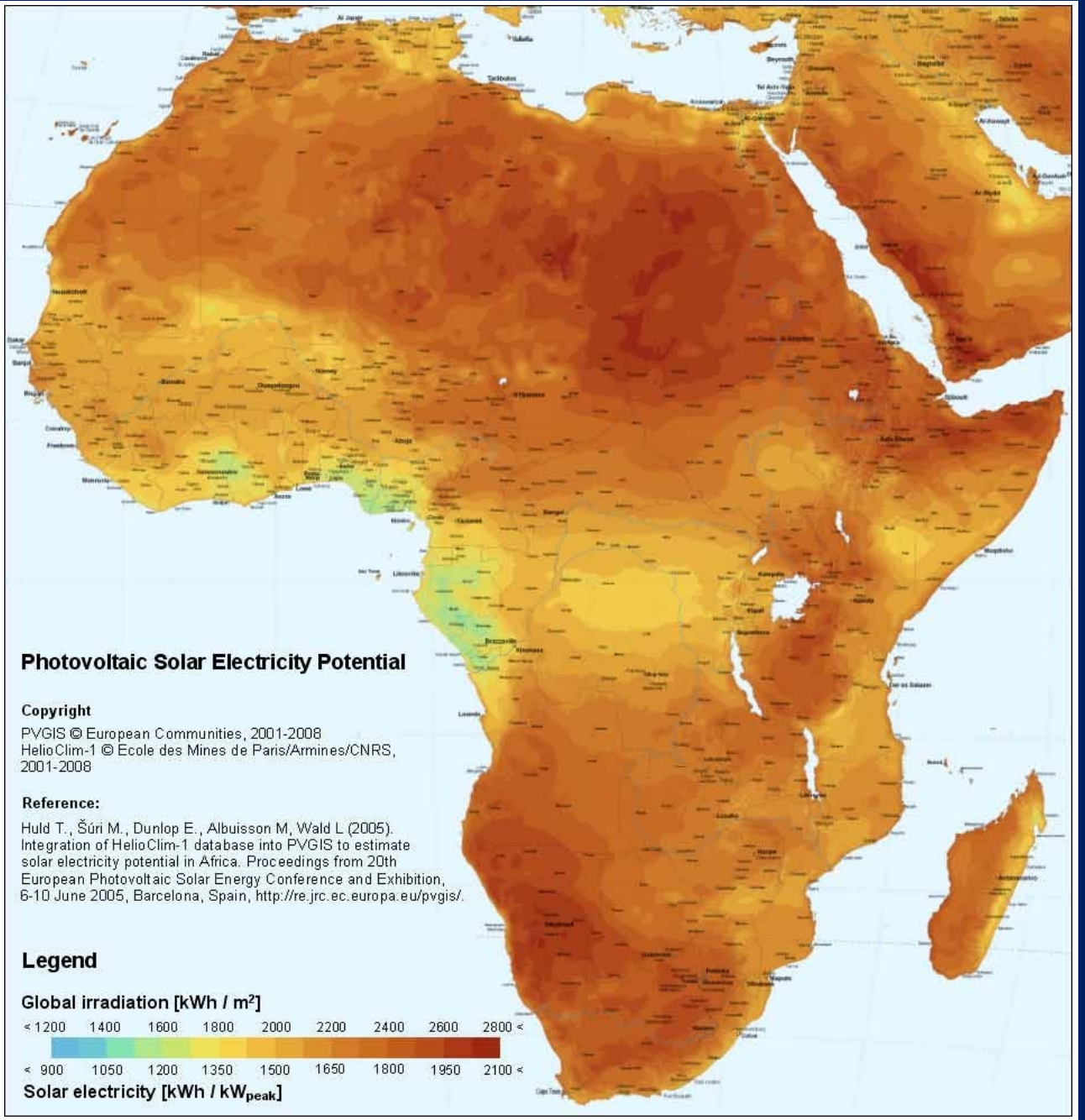
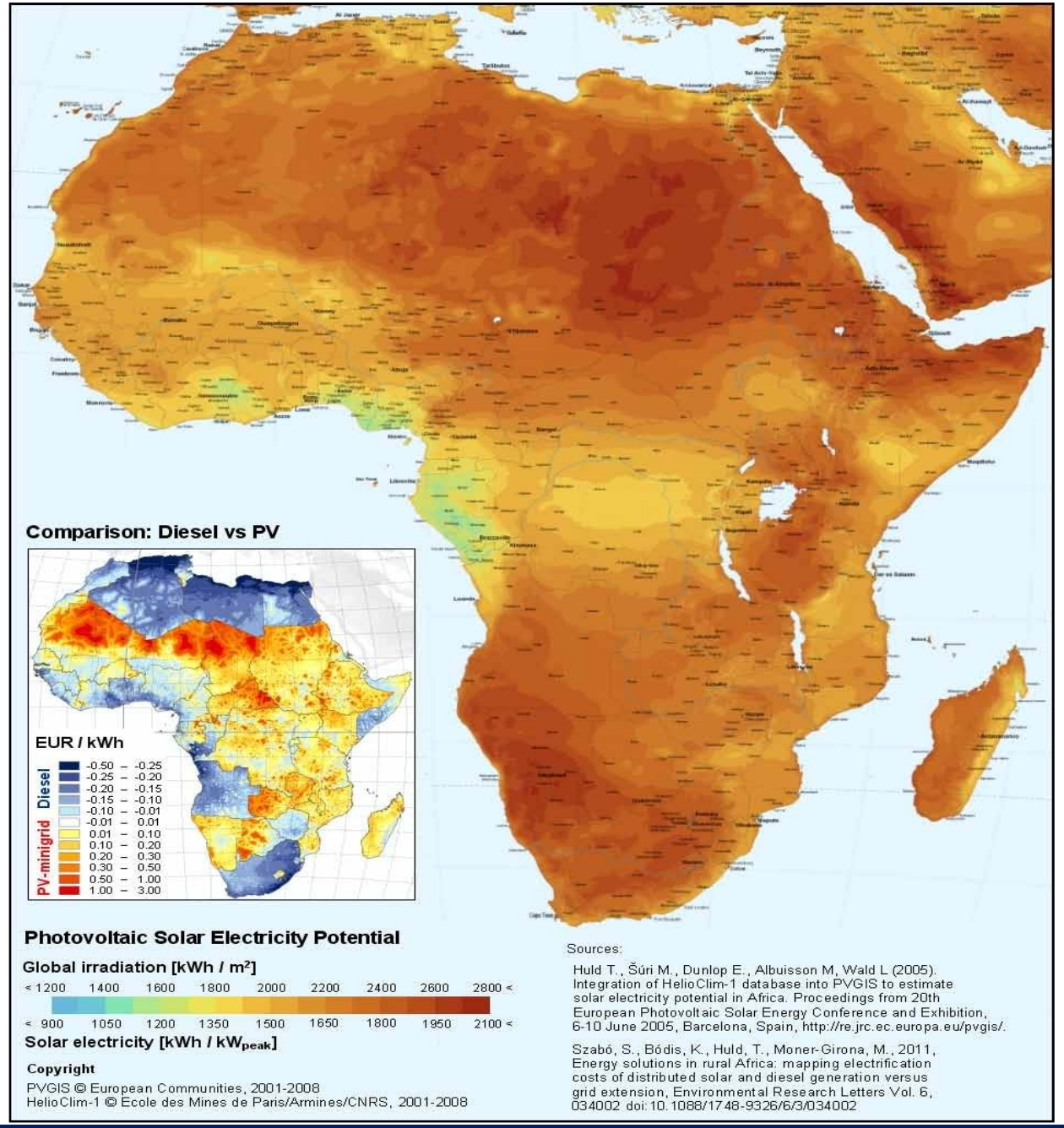


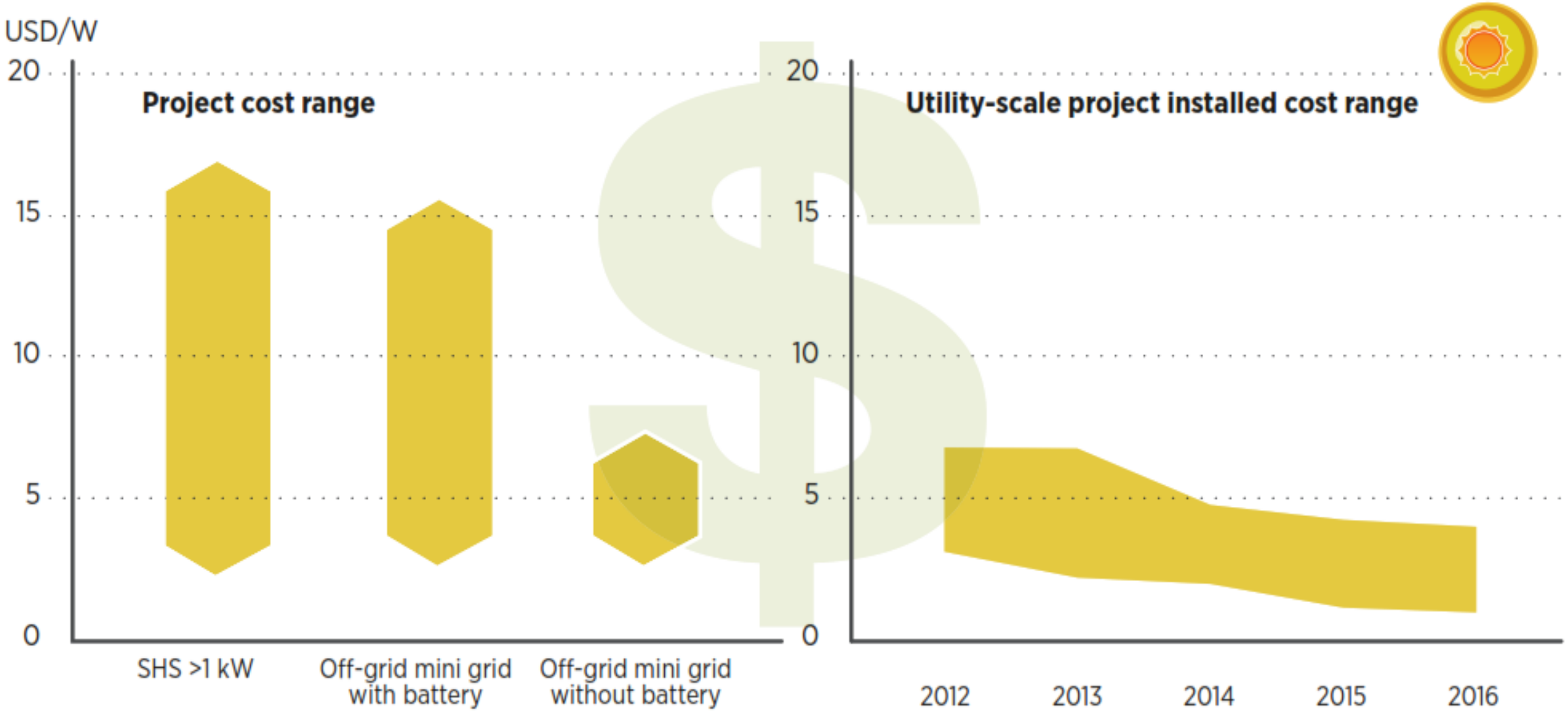
***Photo Voltaic Solar Electricity Potential*** **as computed by PVGIS [kWh/m2] and comparison of costs between diesel and photovoltaic electricity generation (detail).**



*infrastructure, construction etc.*

Figure 4 **Solar PV cost ranges in Africa by market segment and size***

*Source: IRENA (forthcoming)*



# Wind Energy Potential in Africa

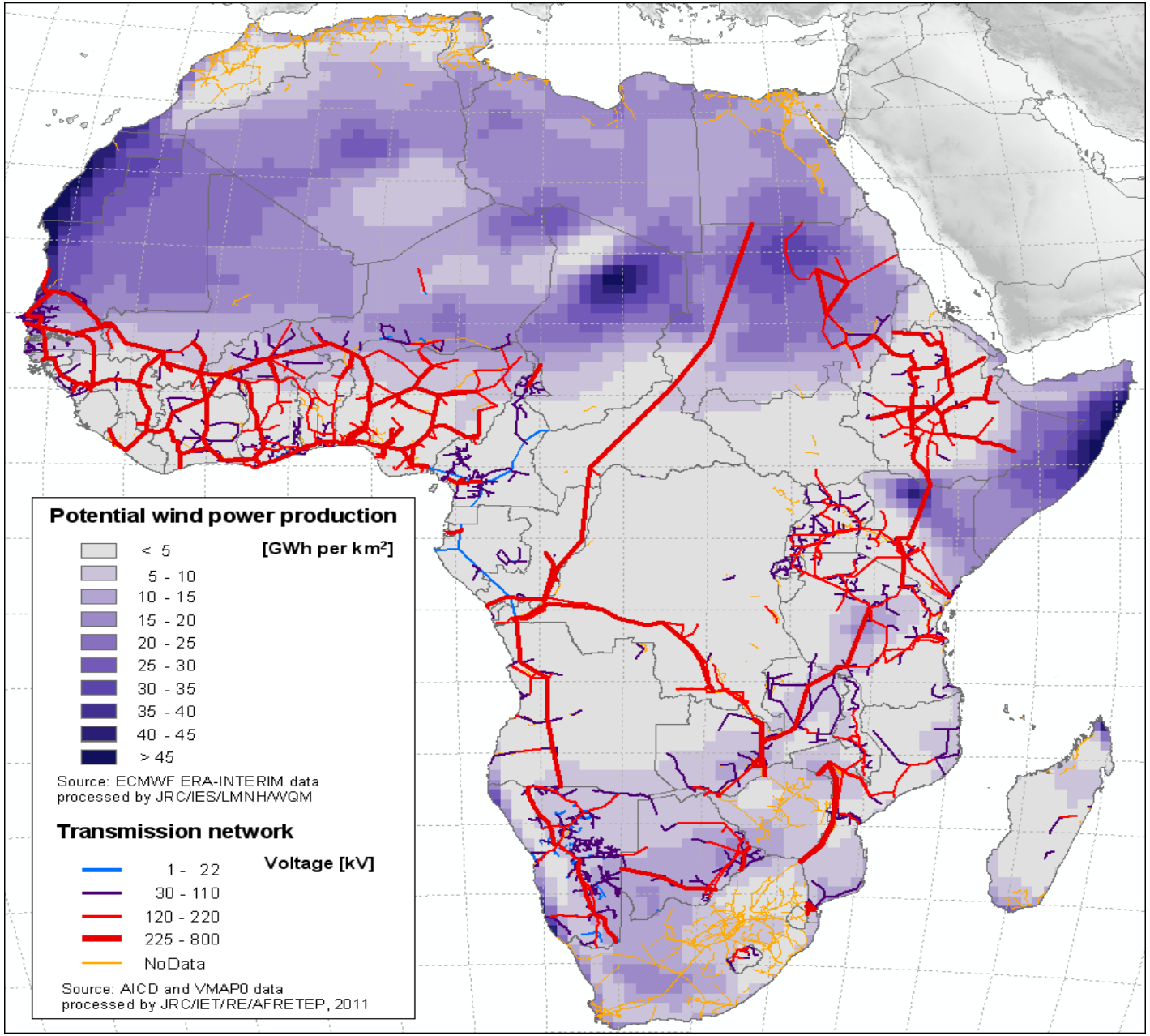
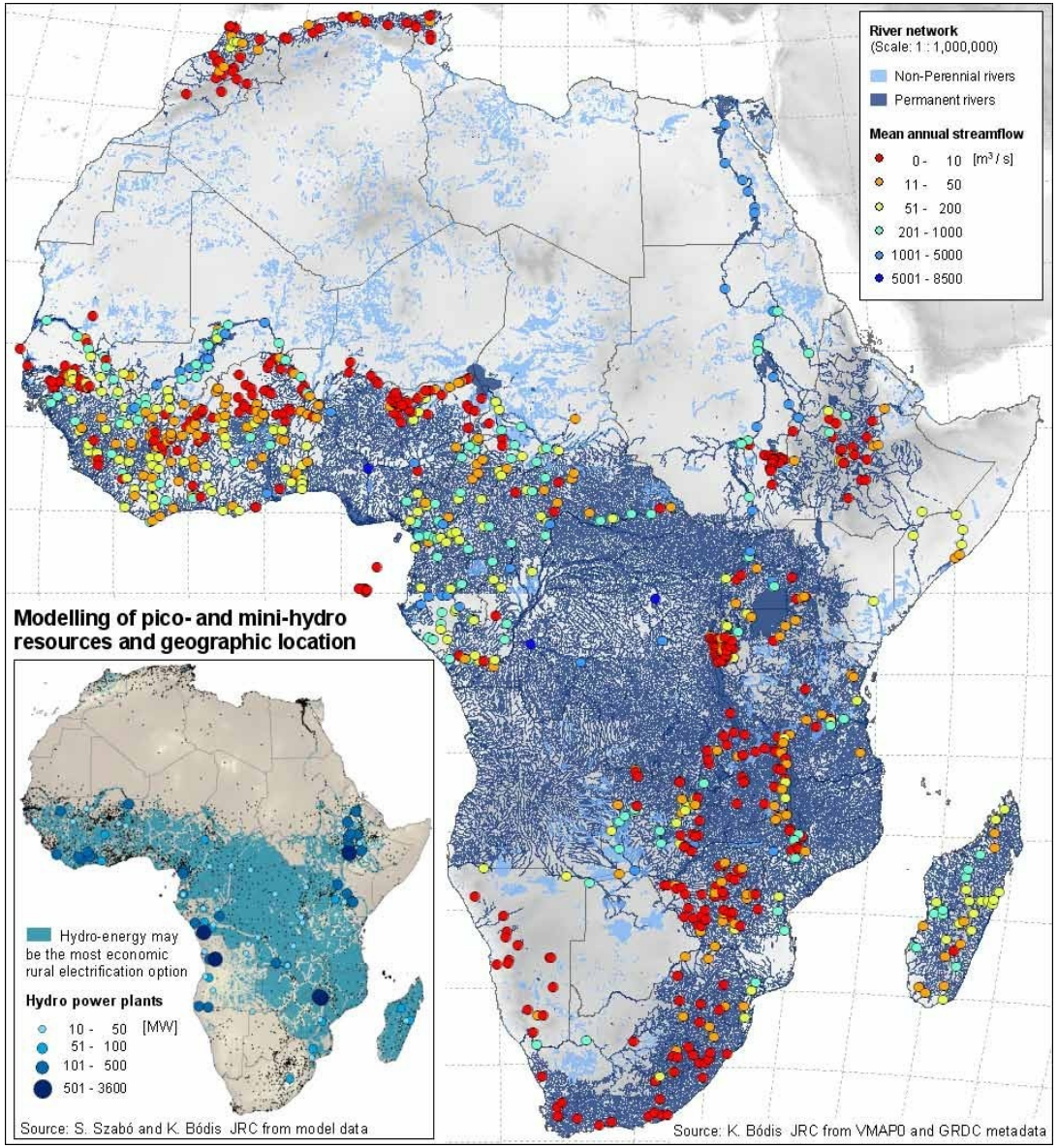


Table 1 **Wind generation installations during 2014**

| Country | End 2013 | New 2014 | Total (End 2014) |
|---|---|---|---|
| Morocco | 487 | 300 | 787 |
| South Africa | 10 | 560 | 570 |
| Egypt | 550 | 60 | 610 |
| Tunisia | 200 | 55 | 255 |
| Ethiopia | 171 | 0 | 171 |
| Cabo Verde | 24 | 0 | 24 |
| Other | 21 | 10 | 31 |
| **Total** | **1 463** | **999** | **2 462** |

*Source: IRENA (2015b)*

# HYDROPOWER GENERATION POTENTIAL IN AFRICA



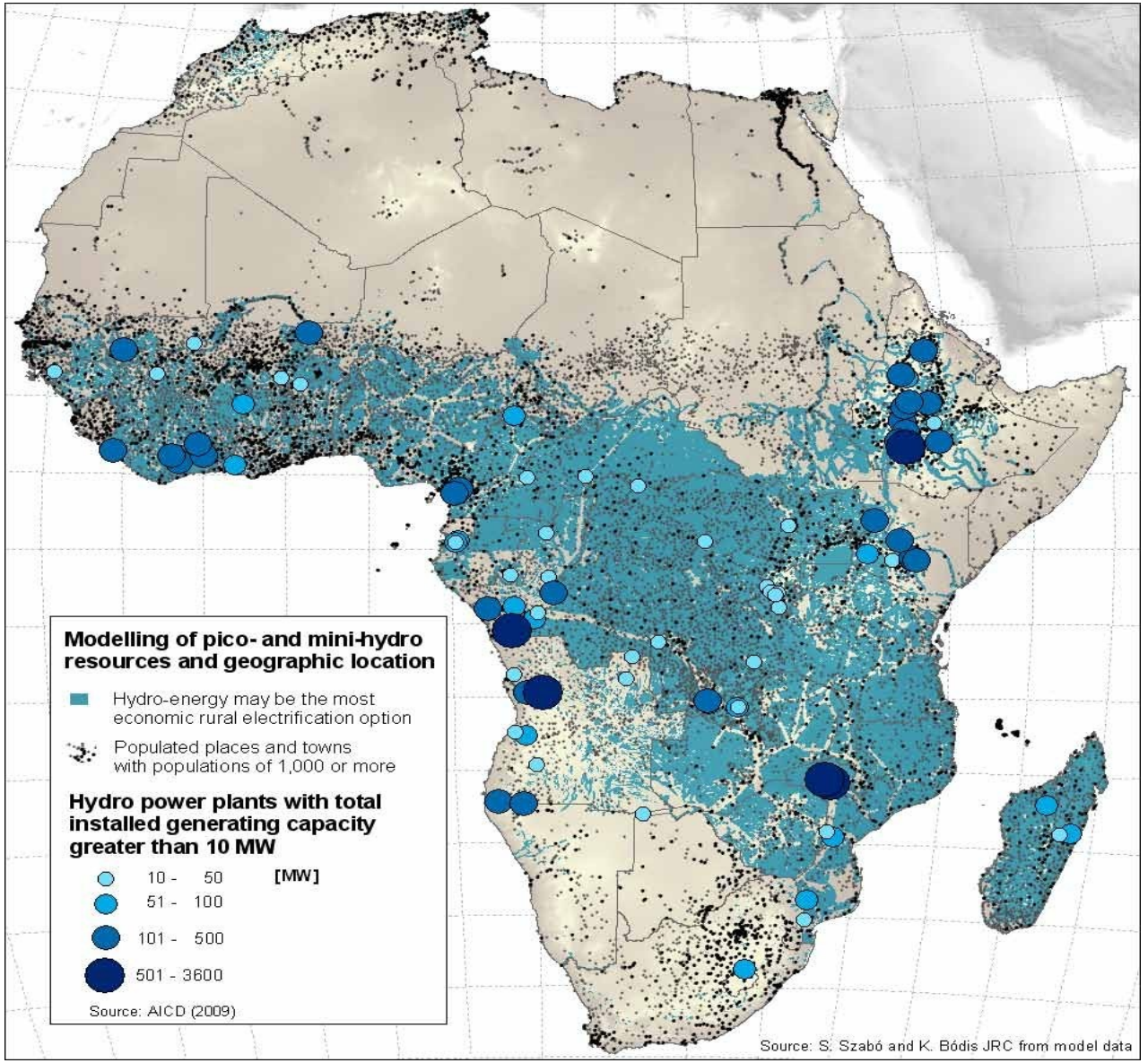



Table 2 **Hydropower generation and technical potential**

*Source: Hydropower and Dams (2014)*

| | Region | Hydro generation in 2013 or most recent/average (GWh/yr) | Technically feasible hydropower potential (GWh/yr) | Ratio between hydro generation and technically feasible hydropower potential |
|---|---|---|---|---|
| N | North Africa | 16 728 | 59 693 | 28% |
| W | West Africa | 19 445 | 101 492 | 19% |
| C | Central Africa | 14 614 | 570 730 | 3% |
| E | East Africa | 26 215 | 334 600 | 8% |
| S | Southern Africa | 44 896 | 415 857 | 11% |
| | **Total** | **122 538** | **1 584 670** | **8%** |

Table 3 **Renewable energy use in 2013 and REmap Options for 2030***

| | 2013 (in PJ/yr) | 2030 (in PJ/yr) | 2030 *(in physical units)* |
|---|---|---|---|
| **INDUSTRY SECTOR** | | | |
| Firewood for boiler | 721 | 608 | *220 000 average systems* |
| Solar thermal | 3 | 244 | *90 million m² area* |
| Biodiesel | 0 | 7 | *200 million litres* |
| Bagasse CHP (heat for own use in sugar sector) | 43 | 104 | *4 600 $MW_{th}$* |
| Biogas digester (heat for own use in dairy sector) | 1 | 4 | *1100 average systems* |
| Boiler with industrial residue (heat for own use in coffee, pulp and sawn wood sectors) | 74 | 276 | *20 000 average systems* |
| Industry residue based power | 18 | 63 | *17 TWh* |
| Other renewable energy fuelled power (on-grid/off-grid) | 155 | 1557 | *430 TWh* |
| Share of renewables | 29% | 30% | |
| **Share of modern renewables** | **8%** | **23%** | |
| **BUILDING SECTOR** | | | |
| Firewood used in traditional cookstove | 10 270 | 3 115 | *50 million stoves* |
| Firewood used in efficient cookstove | 571 | 3 851 | *180 million stoves* |
| Charcoal used in traditional cookstove | 846 | 330 | *5 million stoves* |
| Charcoal used in efficient cookstove | 47 | 408 | *19 million stoves* |
| Briquettes used in cookstove | 15 | 152 | *3 million stoves* |
| Ethanol used in cookstove | 13 | 82 | *2 million stoves* |
| Solar water heating | 7 | 326 | *120 million m² area* |
| Biogas digester | 0 | 0.1 | *8 million households* |
| Renewable energy fuelled power (on-grid/off-grid) | 199 | 1701 | *470 TWh* |
| Share of renewables | 80% | 54% | |
| **Share of modern renewables** | **5%** | **33%** | |
| **TRANSPORT SECTOR** | | | |
| Biodiesel | 0 | 93 | *2 800 million litres* |
| Ethanol | 0 | 123 | *5 800 million litres* |
| **Share of modern renewables** | **0%** | **2%** | |
| **POWER TRANSFORMATION SECTOR (GENERATION IN TWh)** | | | |
| Hydropower | 97 | 402 | *101 GW* |
| Solar PV | 0 | 70 | *31 GW* |
| CSP | 1 | 160 | *38 GW* |
| Wind | 2 | 304 | *101 GW* |
| Geothermal | 2 | 21 | *3 GW* |
| Distributed solar PV | 0 | 46 | *24 GW* |
| Biomass | 5 | 37 | *8 GW* |
| Biomass industrial residues (own production) | 5 | 17 | *4 GW* |
| Share of renewables except hydropower | 2% | 30% | |
| **Share of all renewables** | **17%** | **49%** | |
| **TOTAL FINAL ENERGY CONSUMPTION** | | | |
| Share of renewables | 56% | 32% | |
| **Share of modern renewables** | **5%** | **22%** | |

Figure 5 **Modern renewable energy use in 2013 (above) and 2030 (below)**

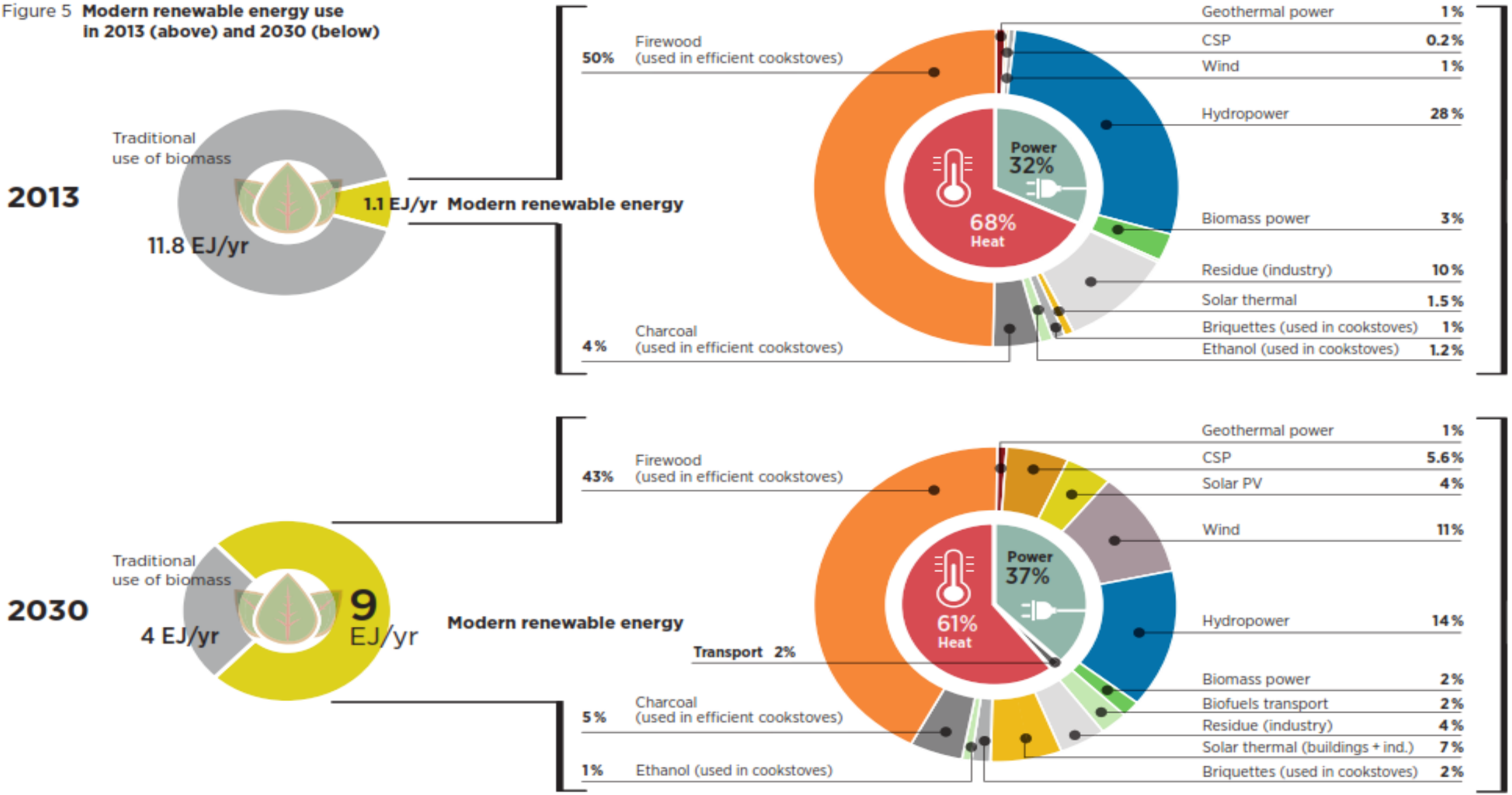
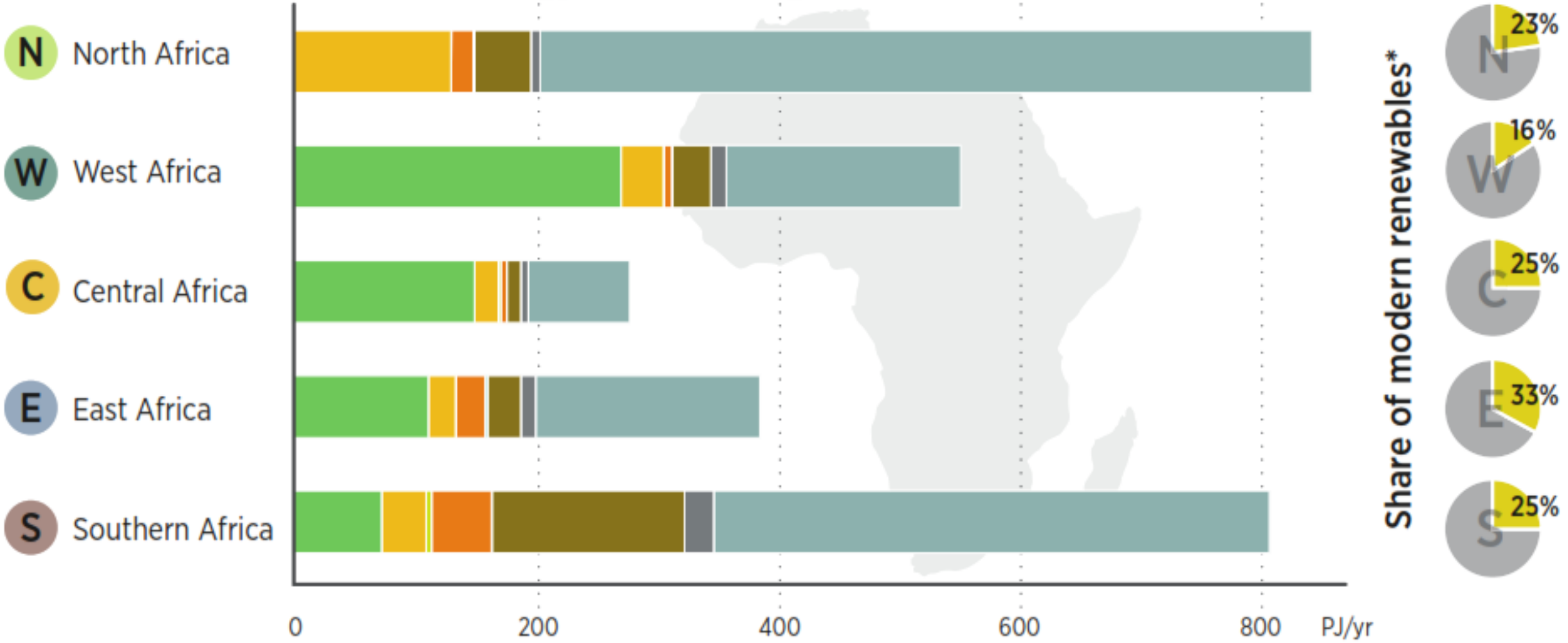


Figure 7 **Final renewable energy use in the industry sector in 2013 and the share of modern renewable energy use in each region**




*Source: IRENA*

Figure 6 **Total final energy consumption (left) and electricity demand (right) in the industry sector**

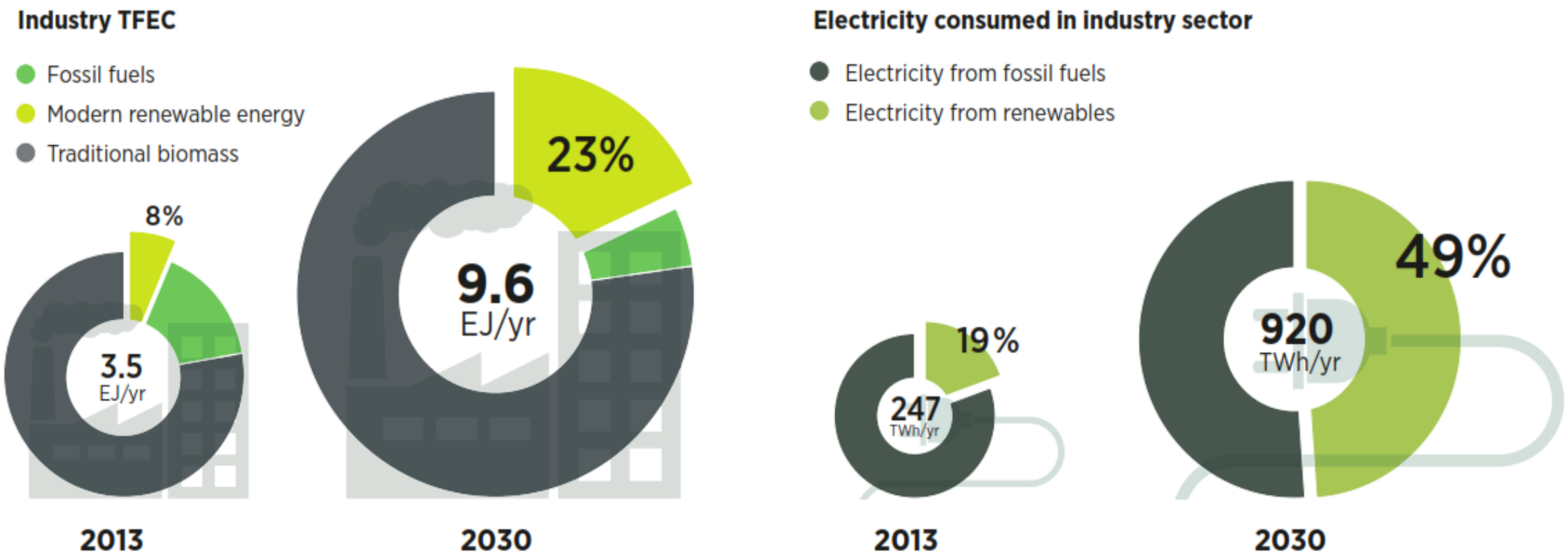
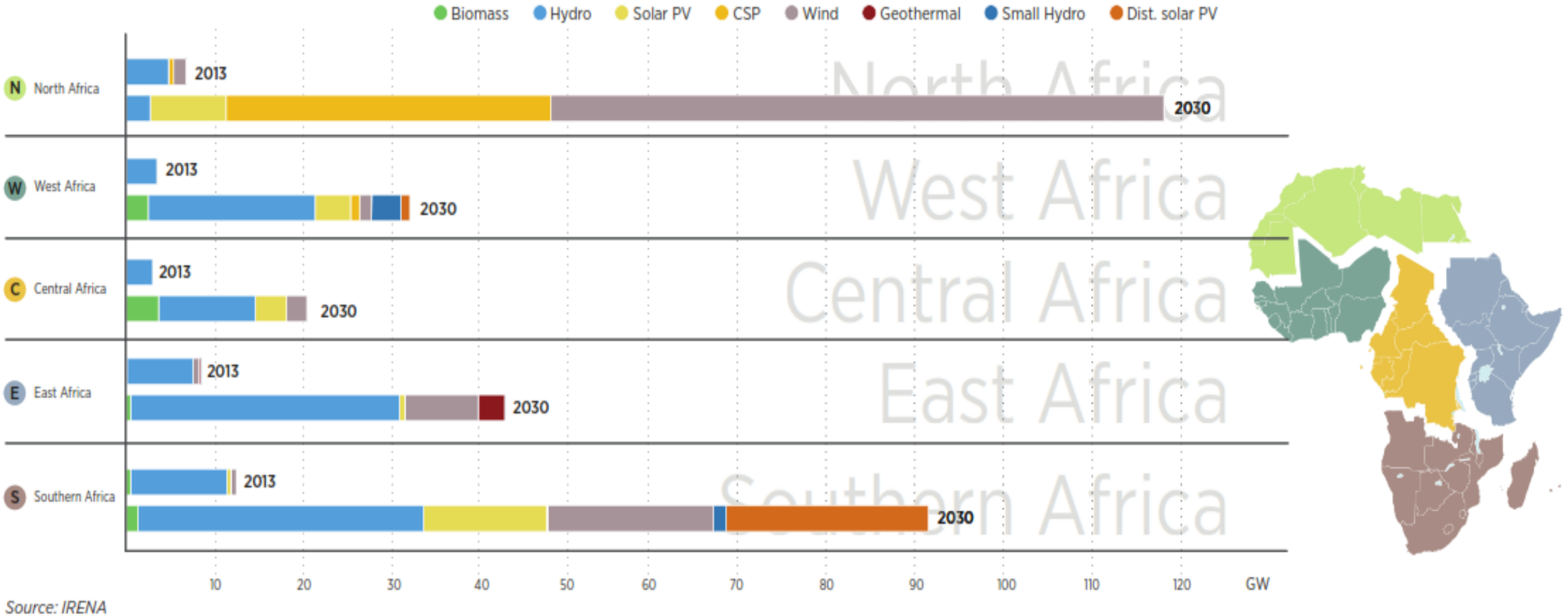


Figure 8 **Capacity development of REmap Options in 2030**

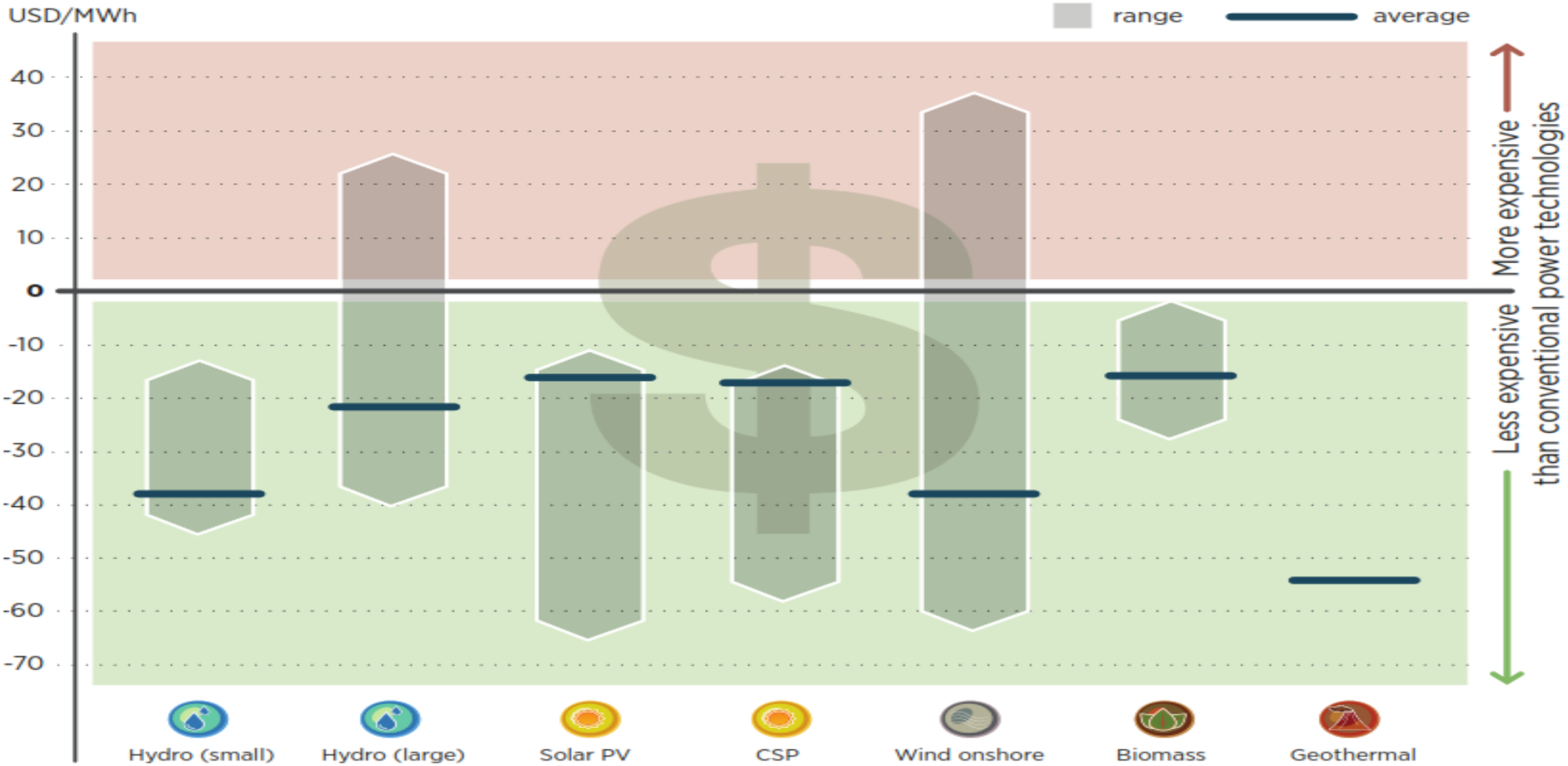



*Source: IRENA*

Table 4 **Cumulative investment needs between 2015 and 2030**

| Region | | Investment billion USD (2015 – 2030) | | | |
|---|---|---|---|---|---|
| | | All generation | Large hydro | Other renewables | T&D |
| N | North Africa | 342 | 2 | 218 | 186 |
| W | West Africa | 89 | 36 | 31 | 52 |
| C | Central Africa | 32 | 13 | 17 | 14 |
| E | East Africa | 72 | 36 | 21 | 49 |
| S | Southern Africa | 145 | 18 | 94 | 74 |
| | **Total** | **681** | **106** | **381** | **375** |

Figure 9 **Average regional substitution cost of REmap Options in 2030**




*Source: IRENA*

Figure 10 **Share of modern renewable energy use in building and transport sectors**

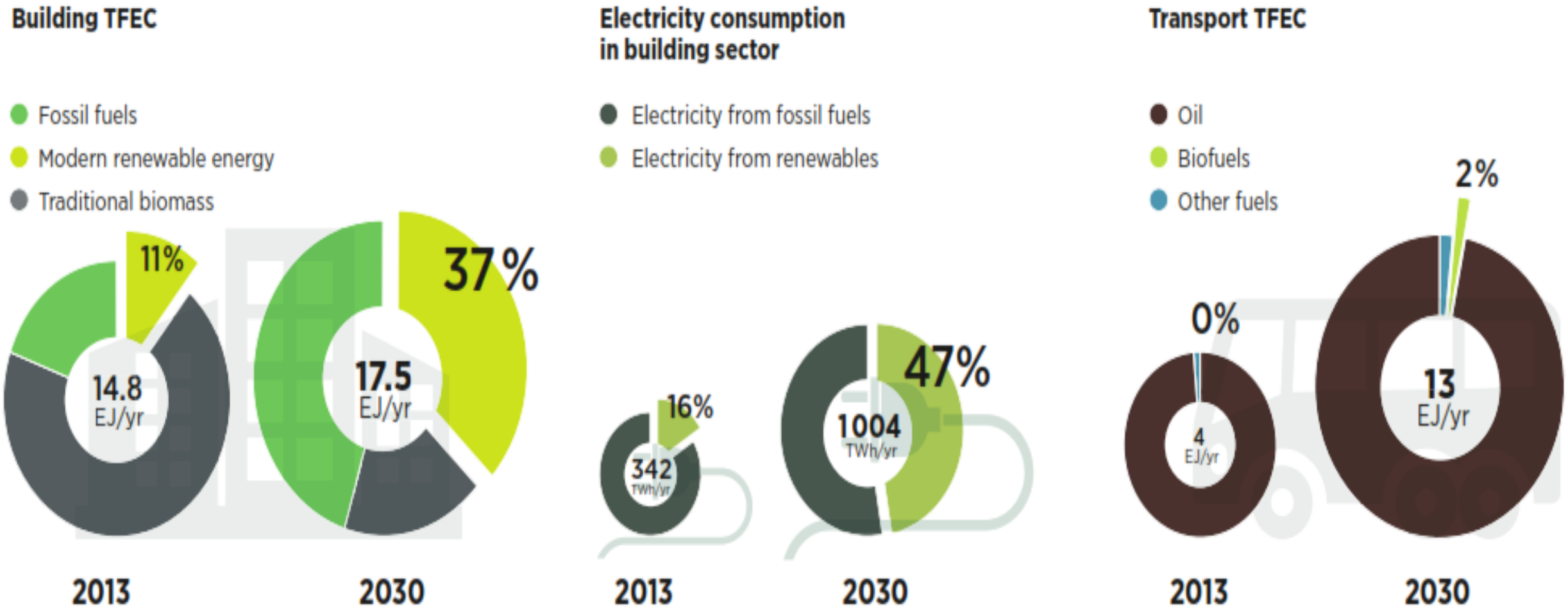


Figure 11 **REmap Options for the building sector by 2030, contribution to TFEC**

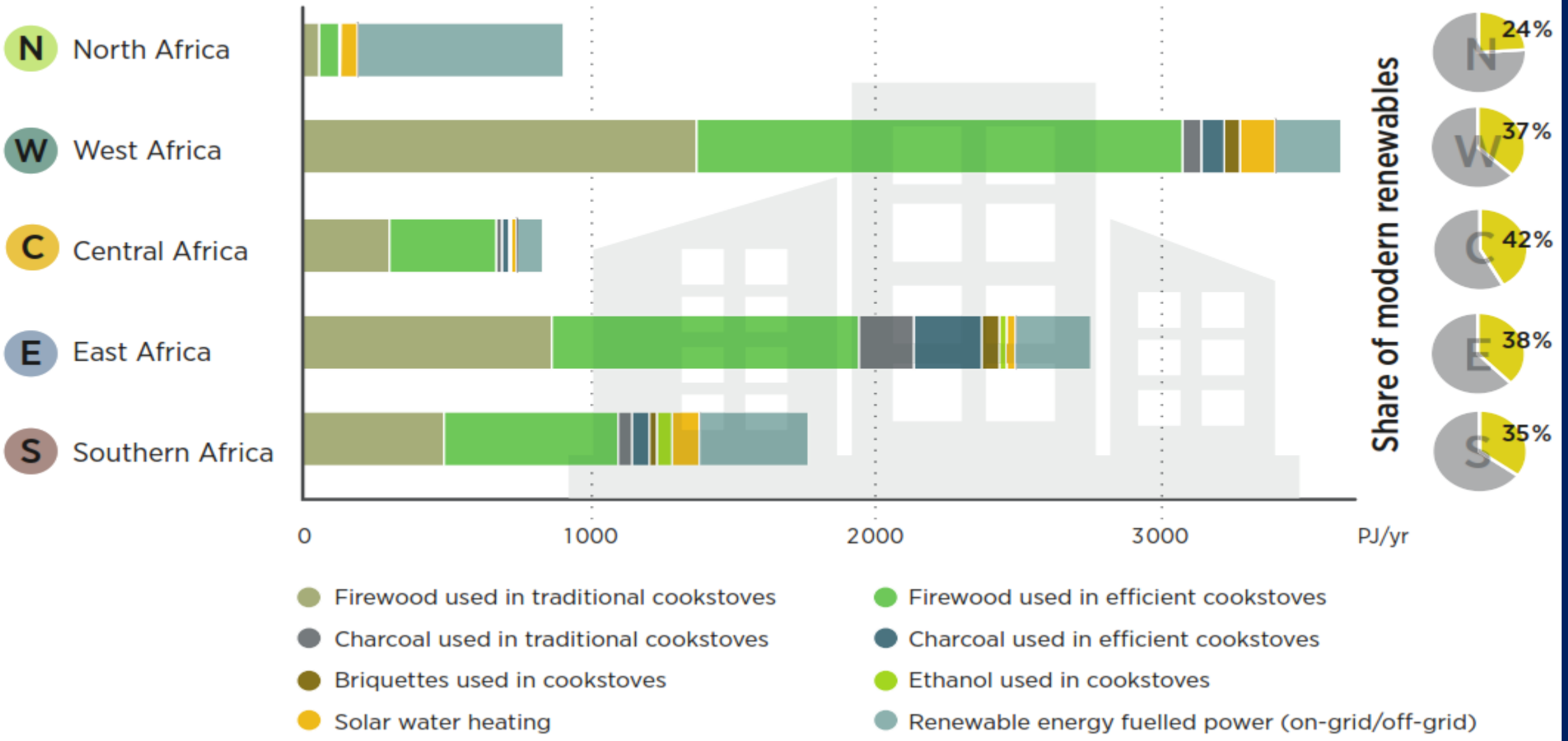


Figure 12 **Ethanol and biodiesel use in 2030**

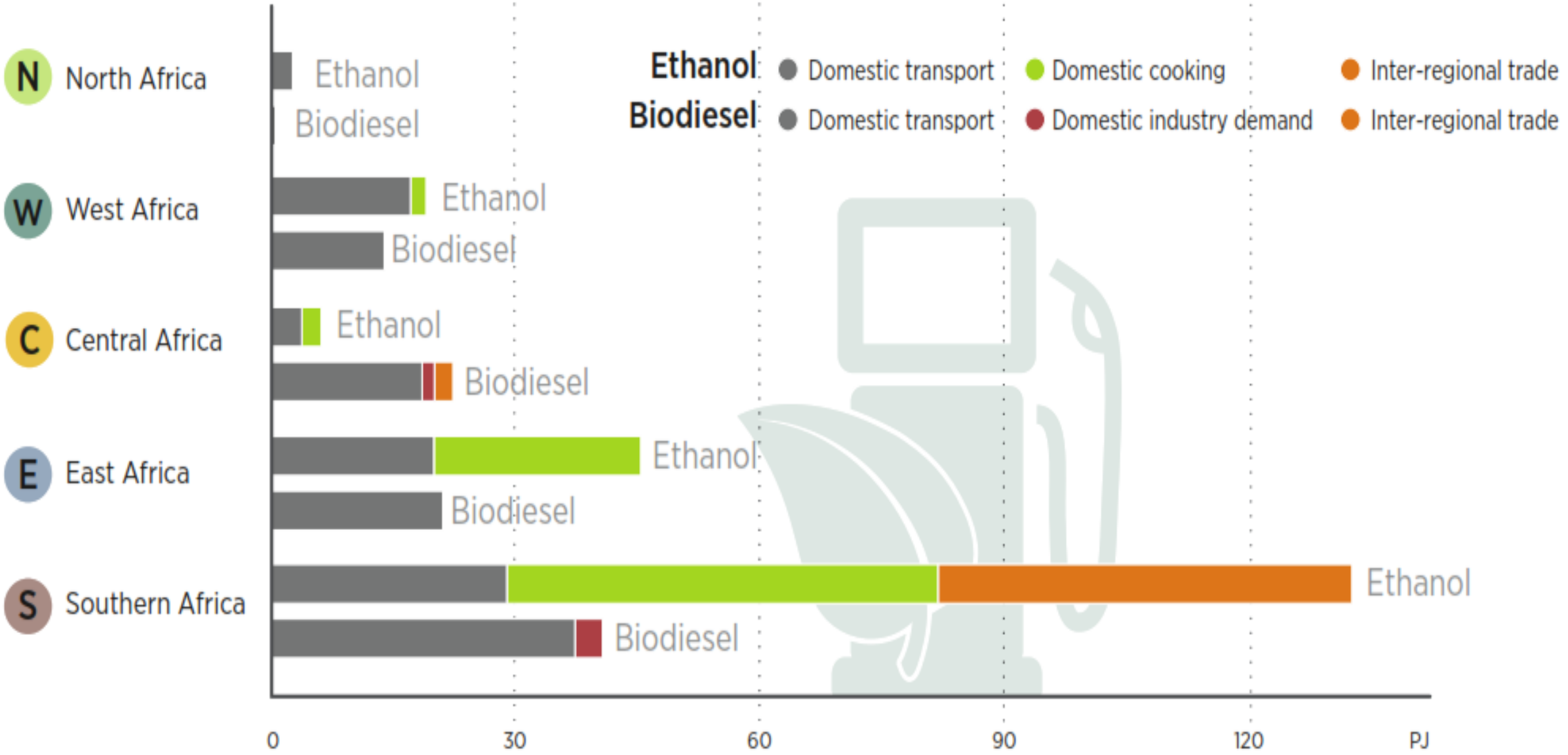


Table 5 **Renewable energy targets of African countries**

| | Share of total energy | Share of electricity | Planned capacity | Target year |
|---|---|---|---|---|
| Algeria | 40 | | | 2030 |
| Benin | | | | 2025 |
| Burundi | 2.1 | | | 2020 |
| Cabo Verde | | 50 | | 2020 |
| Côte d' Ivoire | 5, 15, 20 | | | 2015, 2020, 2030 |
| Djibouti | 30 | | | 2017 |
| Egypt | 14 | | | 2020 |
| Eritrea | | 50 | | n.d. |
| Ethiopia | | | 6 810 MW | 2013 |
| Gabon | 80 | | | 2020 |
| Ghana | | 10 | | 2020 |
| Guinea | | 8 | | 2025 |
| Guinea-Bissau | 2 | | | 2015 |
| Kenya | | | 5 000 MW geothermal | 2030 |

| | | | | |
|---|---|---|---|---|
| Lesotho | | 35 | | 2020 |
| Libya | 10 | | | 2020 |
| Madagascar | 54 | | | 2020 |
| Malawi | 7 | | | 2020 |
| Mali | 15 | | | 2020 |
| Mauritania | 20 | | | 2020 |
| Mauritius | | 35 | | 2025 |
| Morocco | | 42 | | 2020 |
| Mozambique | | | 6 000 MW and others | na |
| Namibia | | | 40 MW | 2011 |
| Niger | 10 | | | 2020 |
| Nigeria | | 20 | | 2030 |
| Rwanda | | 90 | | 2012 |
| Senegal | 15 | | | 2025 |
| Seychelles | | 15 | | 2030 |
| South Africa | | 13 | | 2020 |
| Swaziland | | | | 2014 |
| Tunisia | | 25 | | 2030 |
| Uganda | | 61 | | 2017 |
| Zimbabwe | | 10 | | 2015 |

Table 7 **Programmes to support renewable energy technologies for heating in rural Africa**

| Application | Country | Programme | Socio-economic impacts |
|---|---|---|---|
| **Solar thermal refrigeration** | Kenya | The ISAAC solar powered icemaker | • Produces up to 50 kg of ice per sunny day that is capable of chilling up to 100 litres of milk<br>• Induced businesses for milk production, milk collection, packaging and sale for cooperatives, and the production of yogurt and mala that are sold at a higher price, generating additional profits |
| **Improved cookstoves** (ICS) | Kenya<br>Uganda<br>Tanzania | Developing Energy Enterprise Programme (DEEP) to support the deployment of ICS | • As of the end of June 2012, DEEP was supporting a total of 975 businesses across East Africa, 492 of which in the cookstove sector. Out of these, 257 are led by women.<br>• Total revenue generated by ICS businesses in DEEP during January to June 2012 was USD 693 506.<br>• As of June 2012, 1305 people were employed in ICS businesses through DEEP (GVEP, 2012) |
| **Solar dryers** | Ghana | Solar dryer at Silwood Farms | • The dryer reduces moisture content in up to 600 kg of maize from approximately 20% to 10% within 6 days at 35° – 38°C.<br>• Similar results can be achieved with other locally grown crops such as cassava, pepper, okra and pineapple. |

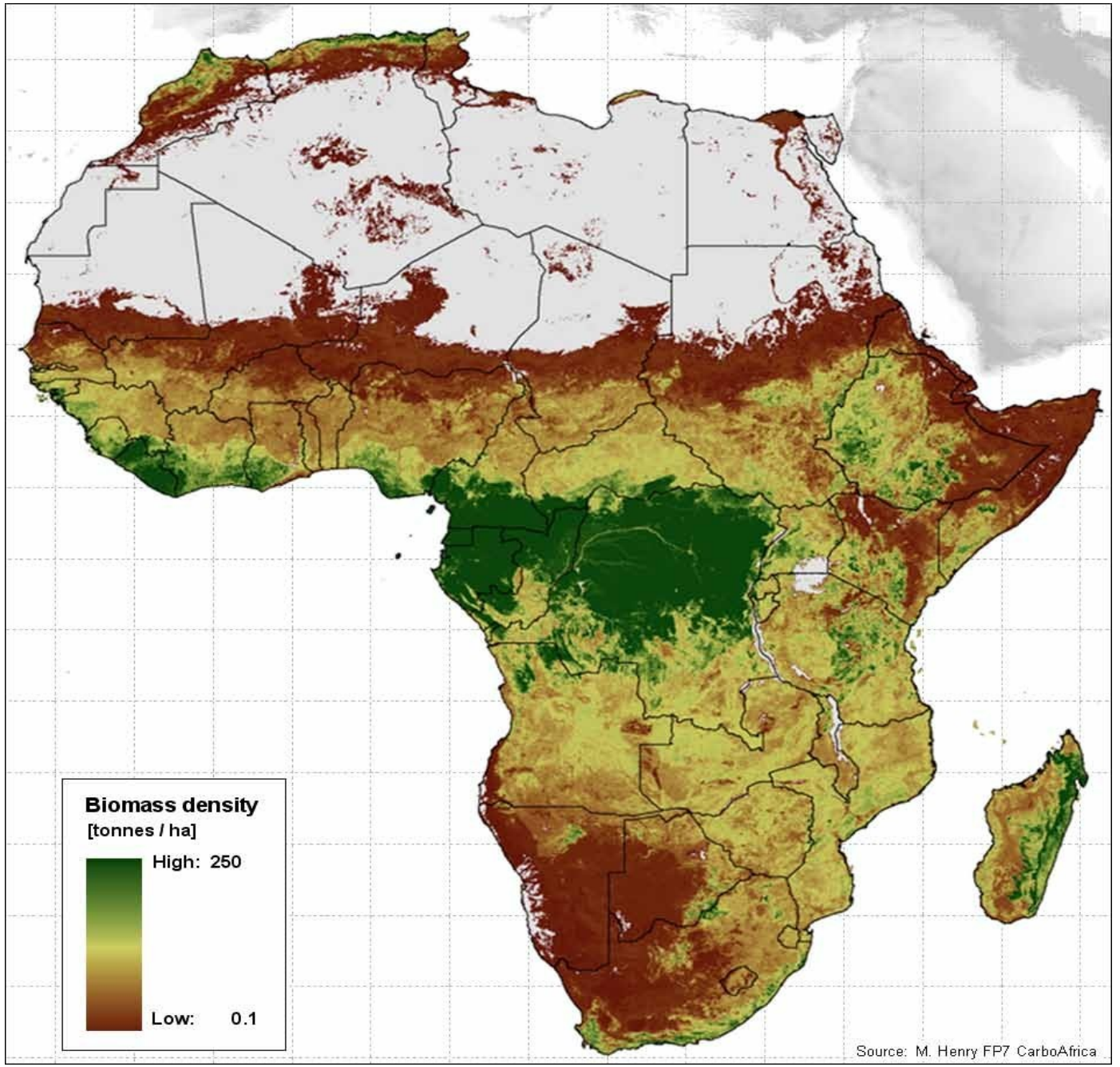
# Nuclear Energy

South Africa is the only African country with commercial nuclear energy plants. Presently SA is heavily dependent on coal

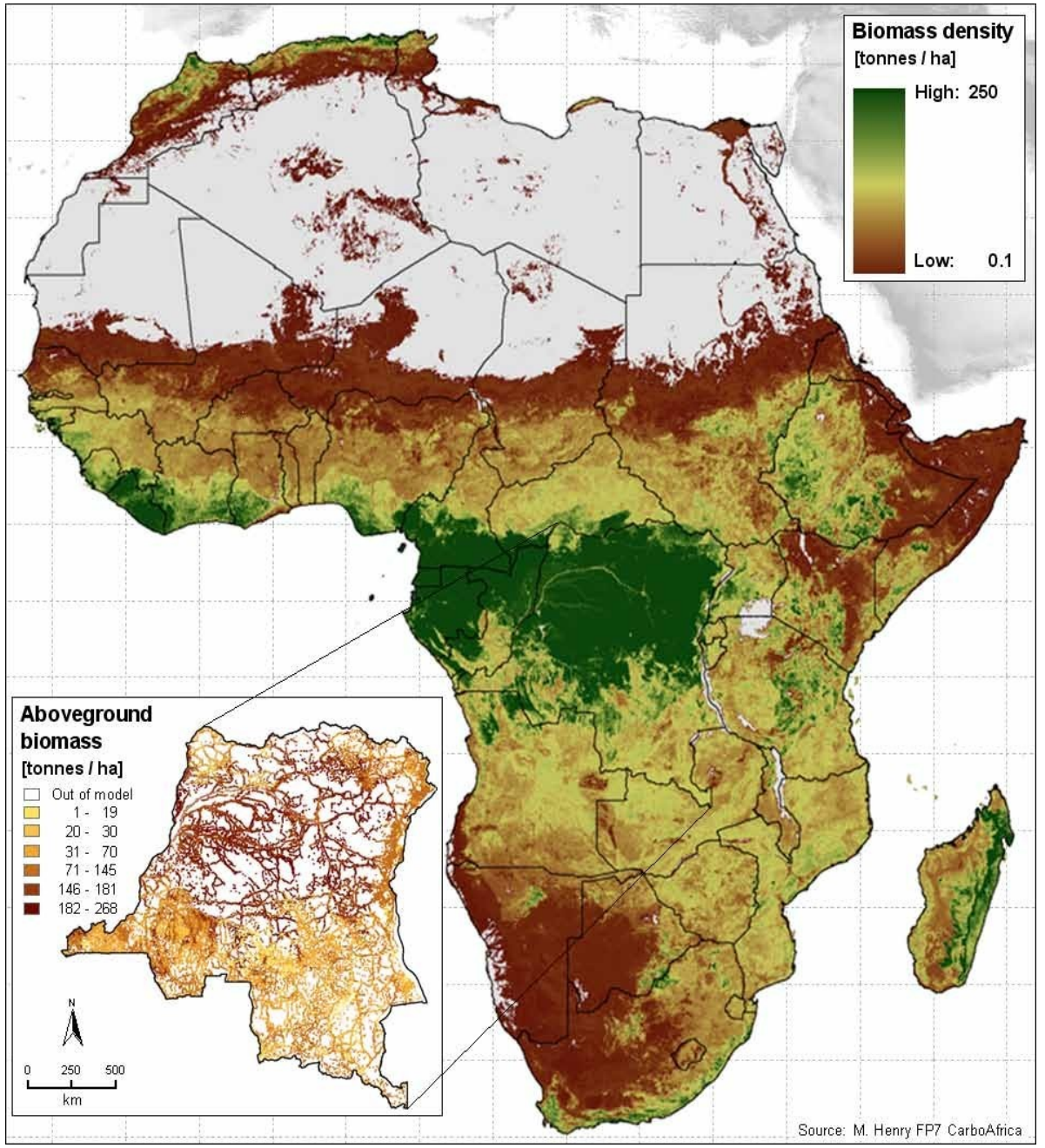
Two nuclear reactors provide 5% of electricity production

Government is planning increase of 1300 MWe

# Biomass Electricity Potential In Africa

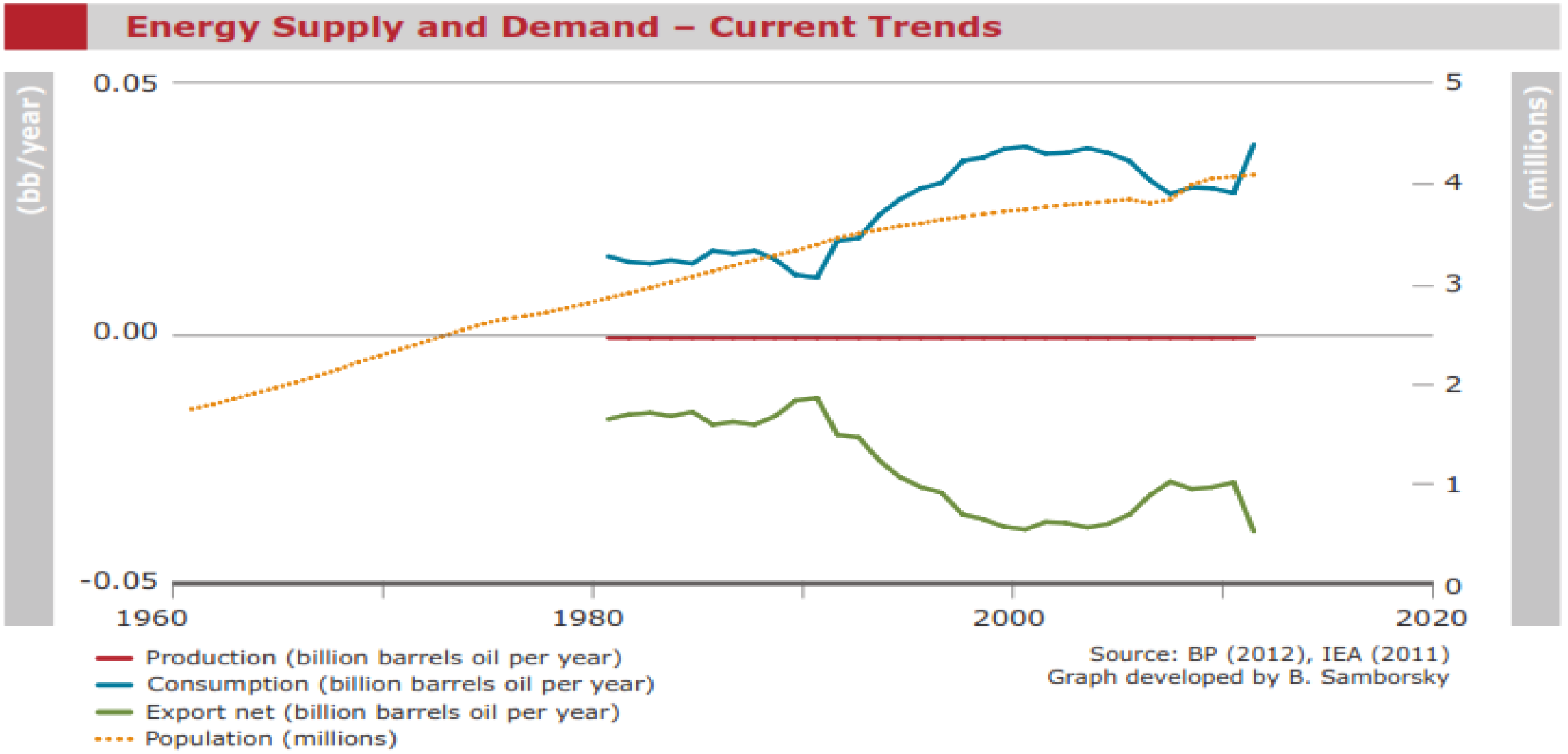


***Biomass density in Africa [ton/ha] and biomass density in the area closest than 5 km from a road in Democratic Republic of Congo***

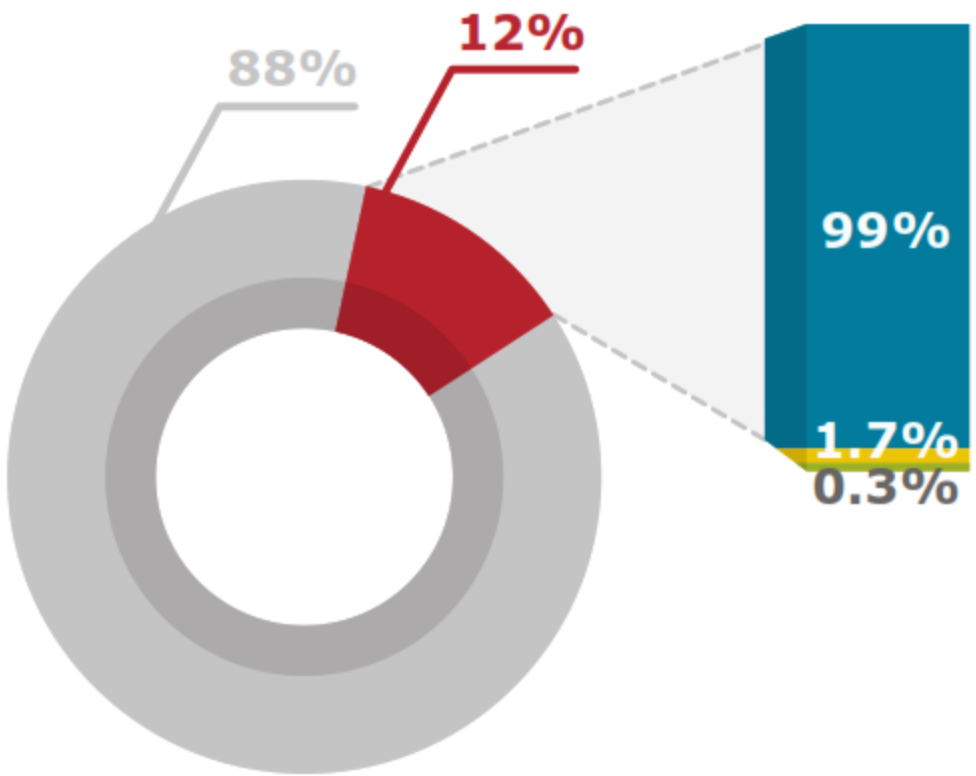


# The MENA Region

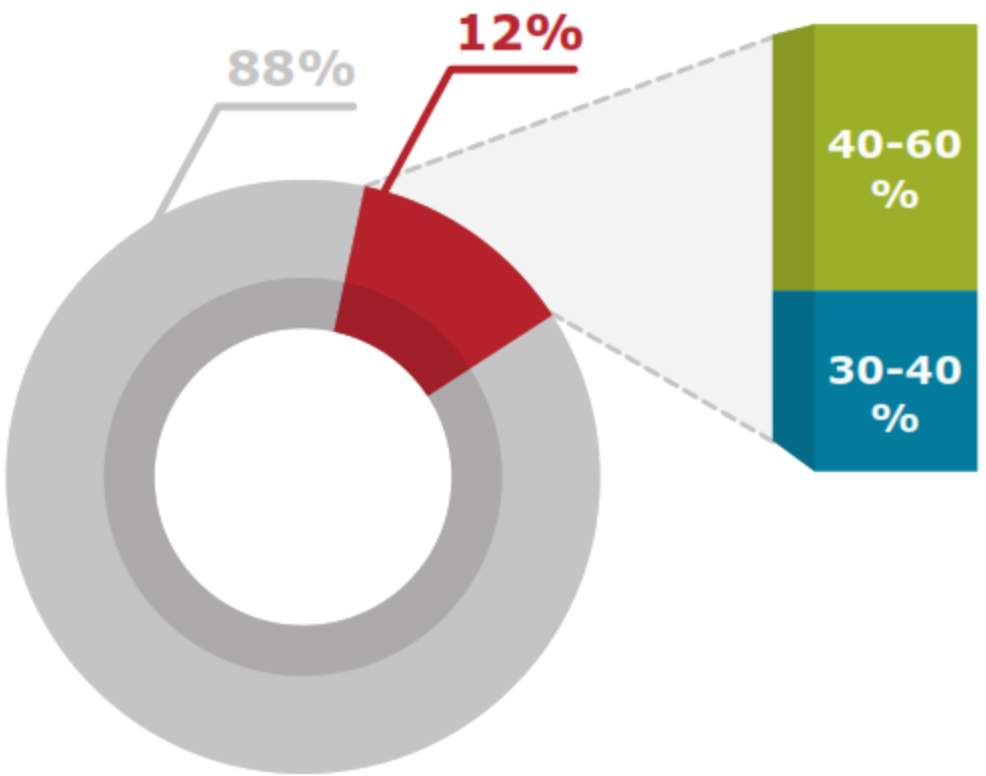
# LEBANON


Energy Supply and Demand – Current Trends
(bb/year)
0.05
0.00
-0.05
5
4
3
2
1
0
(millions)
1960
1980
2000
2020
Production (billion barrels oil per year)
Consumption (billion barrels oil per year)
Export net (billion barrels oil per year)
Population (millions)
Source: BP (2012), IEA (2011)
Graph developed by B. Samborsky

## Current Installed Capacity




## RE Targets - Year 2030

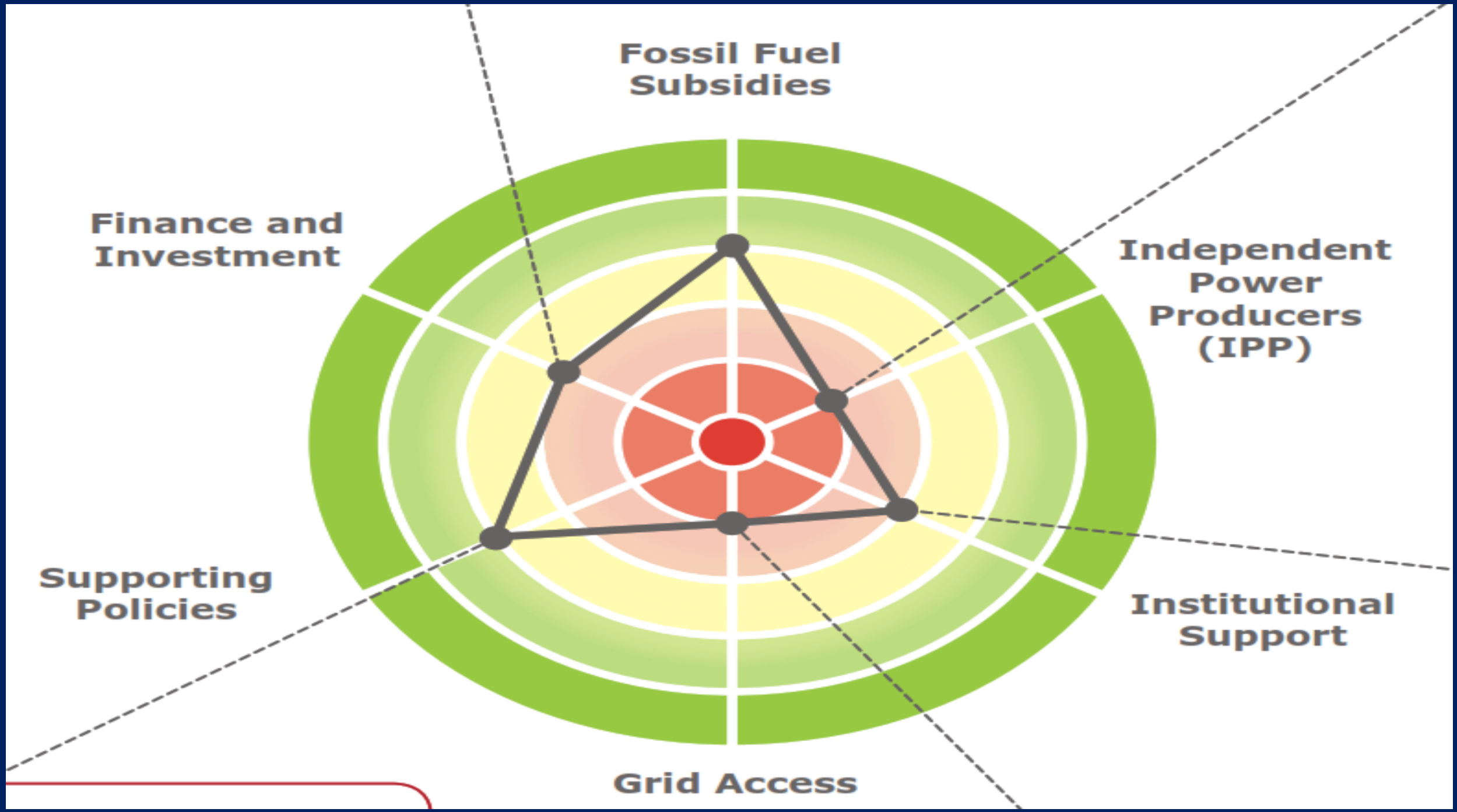



Fossil fuel | RE | Wind | PV | CSP | Hydro

| | Wind | PV | CSP | Hydro | Total RE | Total all Energy |
|---|---|---|---|---|---|---|
| MW | ~0.5 | 1 | 0 | *282 | 283.1 | 2313 |

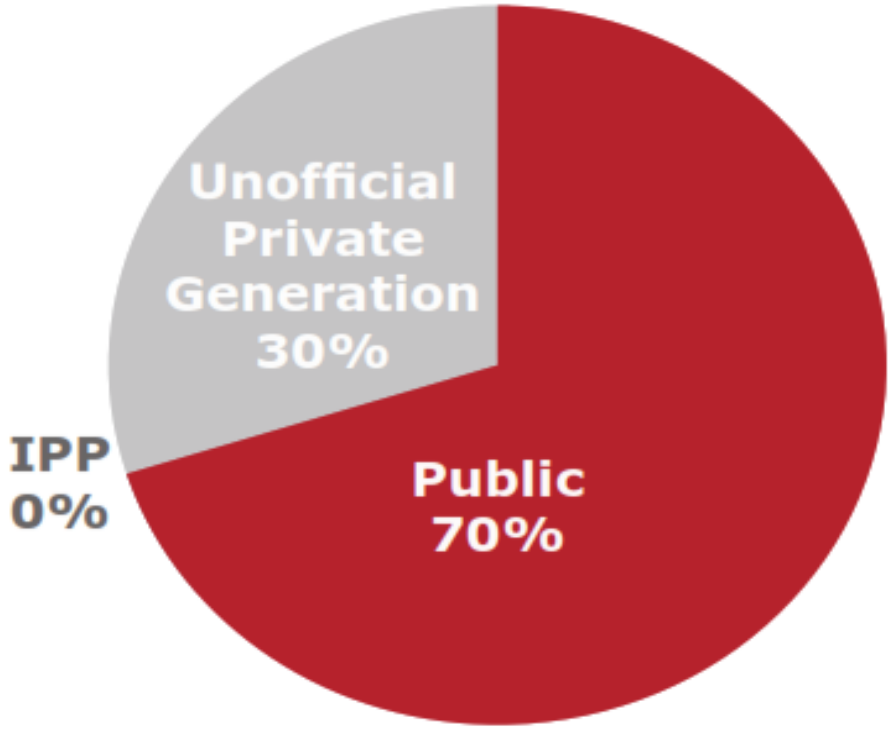
| | Wind | Hydro | Waste to Energy | Total | Target Date |
|---|---|---|---|---|---|
| MW | 60-100 | 40 | 15-25 | 115-165 | 2015 |

* Total operating capacity is around 150 MW.

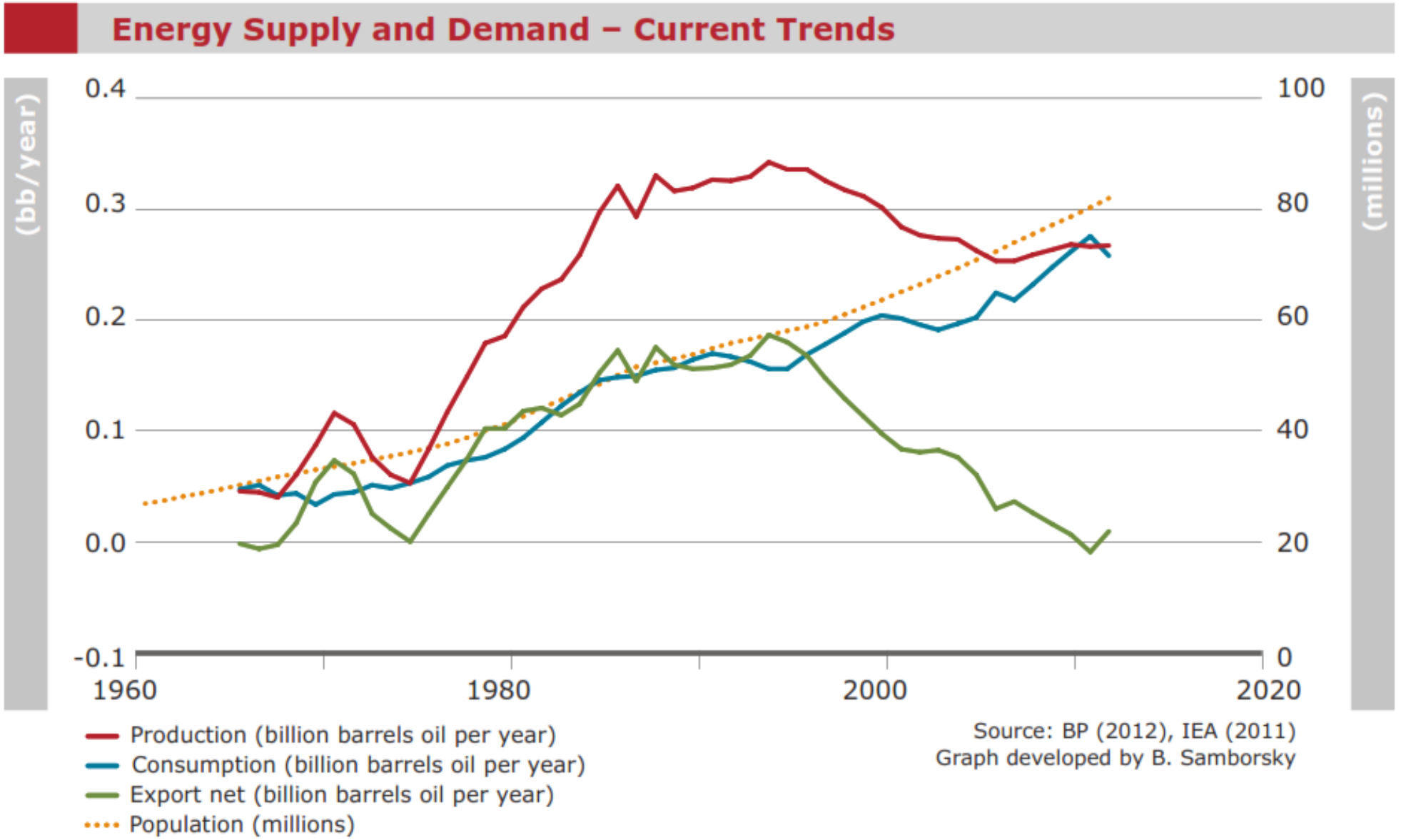

Fossil Fuel Subsidies
Independent Power Producers (IPP)
Institutional Support
Grid Access
Supporting Policies
Finance and Investment

## Independent Power Producers (IPP)

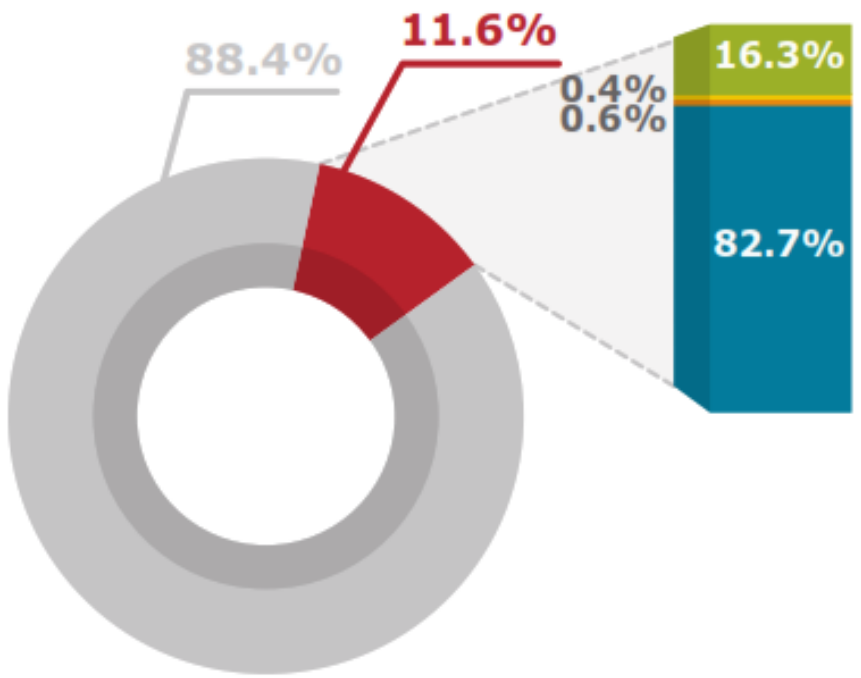
- In 2002, Lebanon adopted law No 462 authorizing electricity generation by private companies.To this day, the law remains unenforced as there is no regulator existing to issue licenses for electricity generation.
- Formally, all electricity is supplied by Electricite du Liban (EDL). About 30% of power is supplied by unofficial private standalone generating sets in times of power shortage in the country.
- The legal framework of Lebanon allows private self-generation of RE (auto-producers) with the possibility of feeding surplus electricity to the grid. According to the decision of the Board of EDL, surplus electricity is deducted from bills received by the end of the next month. Extra credit is kept for the following period, and is set to zero by the end of the year.
- No RE auto-producers in practice.



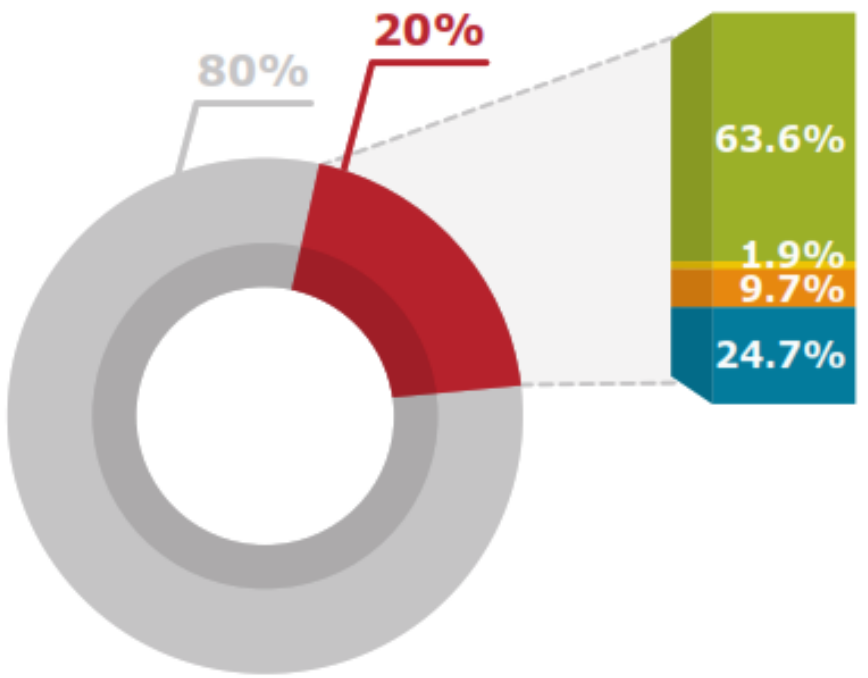
# EGYPT


Energy Supply and Demand – Current Trends
(bb/year)
(millions)
0.4
0.3
0.2
0.1
0.0
-0.1
100
80
60
40
20
0
1960
1980
2000
2020
Production (billion barrels oil per year)
Consumption (billion barrels oil per year)
Export net (billion barrels oil per year)
Population (millions)
Source: BP (2012), IEA (2011)
Graph developed by B. Samborsky

## Current Installed Capacity




## RE Targets - Year 2020



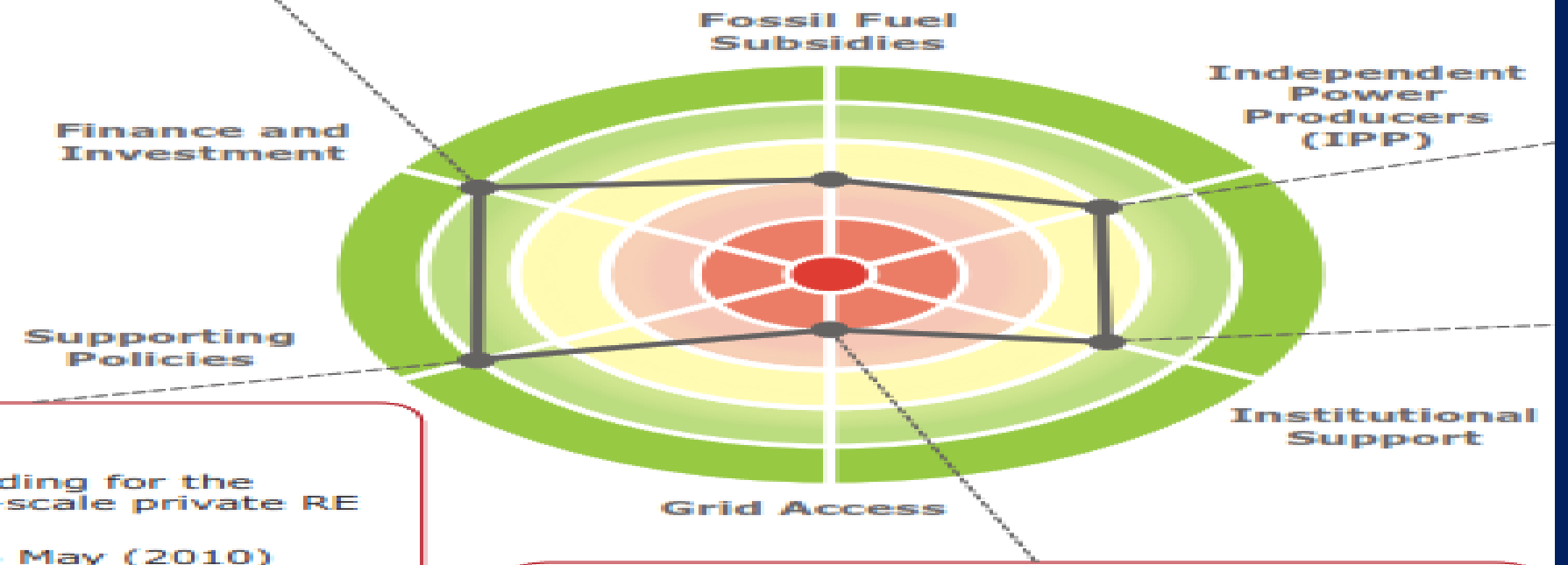

Fossil fuel RE Wind PV CSP Hydro

| | Wind | PV | CSP | Hydro | Total RE | Total all Installed Capacities |
|---|---|---|---|---|---|---|
| MW | 550 | 15 | 20 | 2800 | 3385 | 29076 |

| Wind | PV | CSP | Hydro | Total | Target Date |
|---|---|---|---|---|---|
| 7200 | 220 | 1100 | 2800 | 11320 | 2020 |

## Finance and Investment

- In June 2012, the cabinet approved establishing RE fund for financing RE projects. Clear determination of sources of financing and procedures for disbursement of funds to RE projects are still under discussions.
- On 26 July 2009, the Supreme Council of Energy approved a policy to obtain financial guarantee to secure payments under power purchase agreements.
- According to the decision of cabinet of 26 May 2010, RE projects enjoy customs duty exemption. Investors have to apply to NREA with the list of equipment that needs to be imported. NREA certifies equipment as eligible for customs duty exemption.
- No internal tax benefits are provided to RE projects.

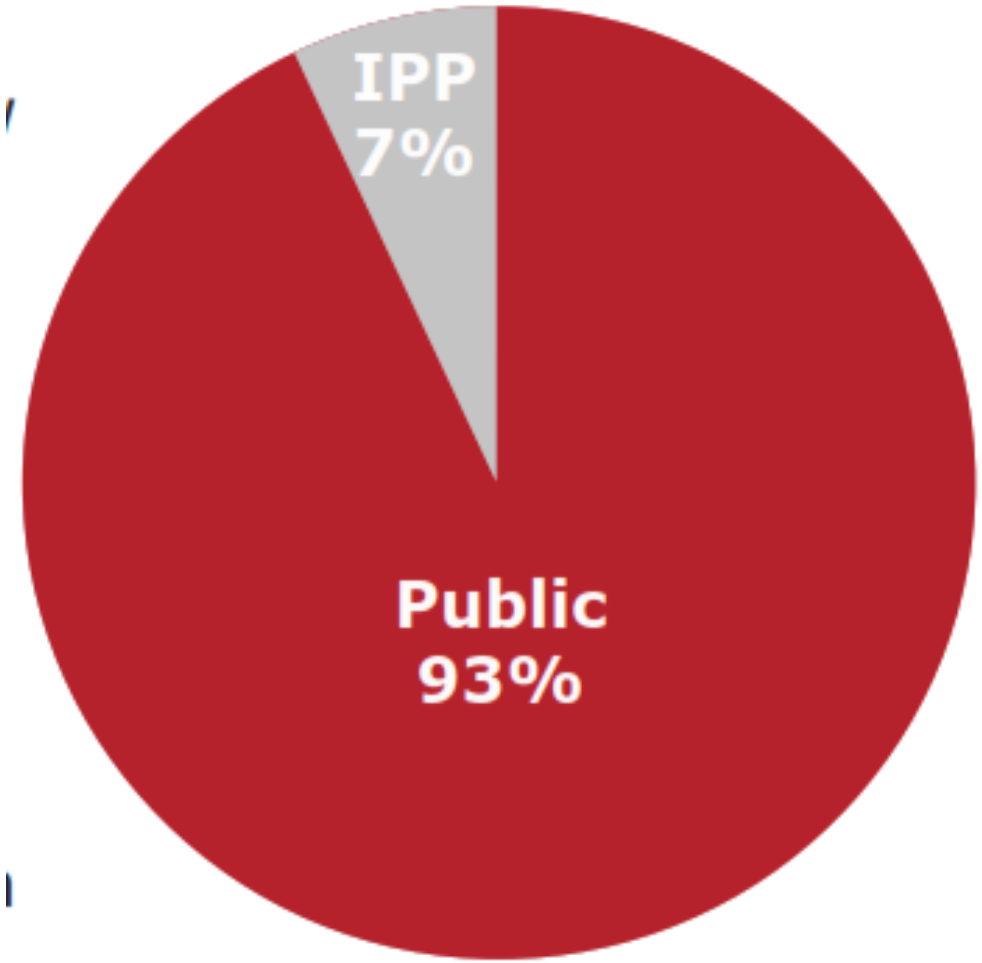



## Supporting Policies

- Public competitive bidding for the development of large-scale private RE projects (2500 MW).
- Cabinet decision of 26 May (2010) ensures signing long-term (20-25 years) power purchase agreements.
- Feed-in Tariffs are under preparation.
- Net-metering policy for small-scale grid connected RE projects: In January 2013, EgyptERA adopted a net-metering policy that allows small-scale RE projects to feed in electricity to the grid. Generated surplus electricity will be discounted from the balance through the net-metering process.

## Grid Access

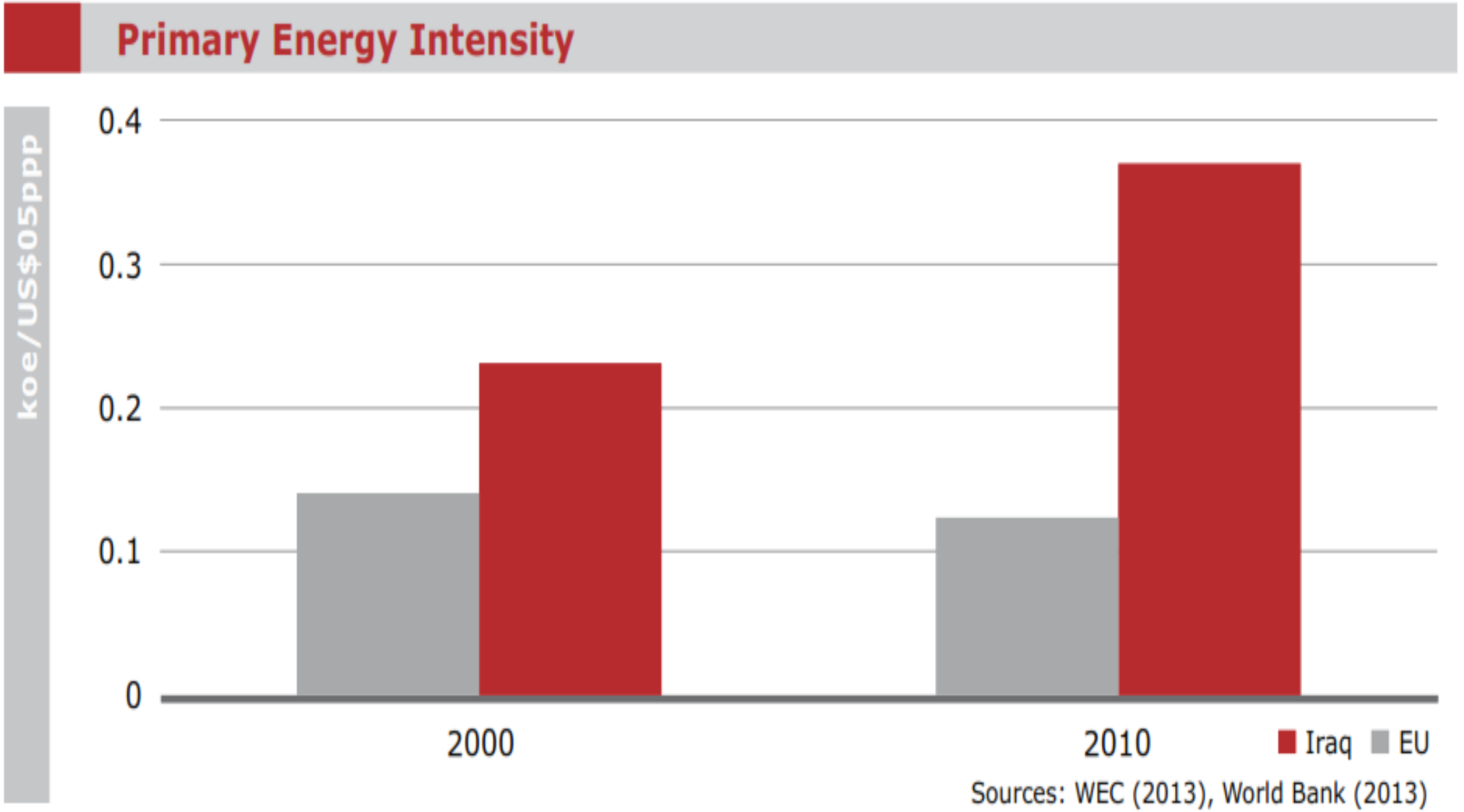
- No priority access to RE is granted by law, however the Egyptian Electricity Transmission Company (EETC) purchases all existing RE currently.
- Renewable energy grid code is under preparation.
- No detailed grid map for designated renewable energy sites.


IPP
7%
Public
93%

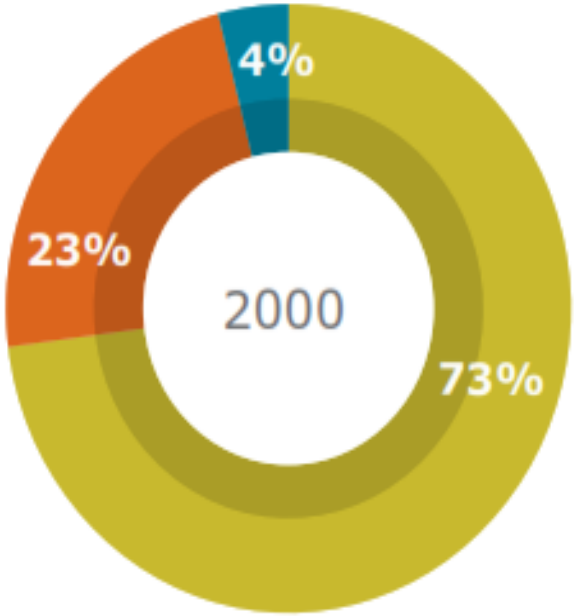
## Grid Interconnections

| Country | Length (km) | Voltage (KV) | Capacity (MW) | Status |
|---|---|---|---|---|
| Jordan | 13 | 400 | 550 | In operation |
| Lebanon | | 400 | 100 | In operation |
| Libya | 180 | 220 | 240 | In operation |

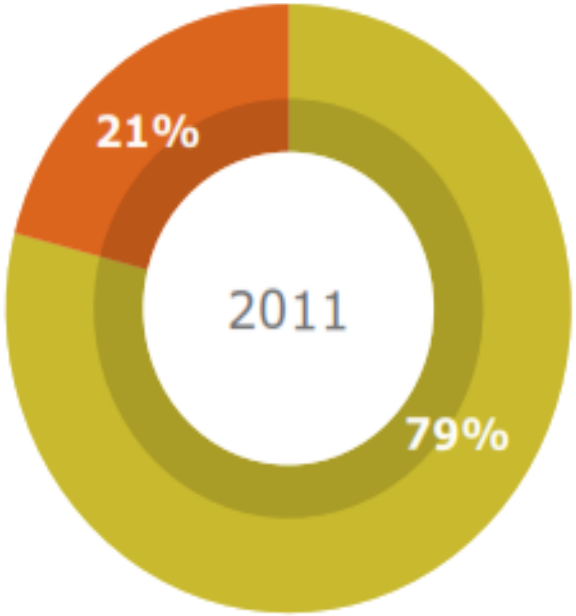
# IRAQ


Primary Energy Intensity
koe/US$05ppp
0.4
0.3
0.2
0.1
0
2000
2010
Iraq
EU
Sources: WEC (2013), World Bank (2013)

# Primary Energy Consumption




527 Thousand boe/day



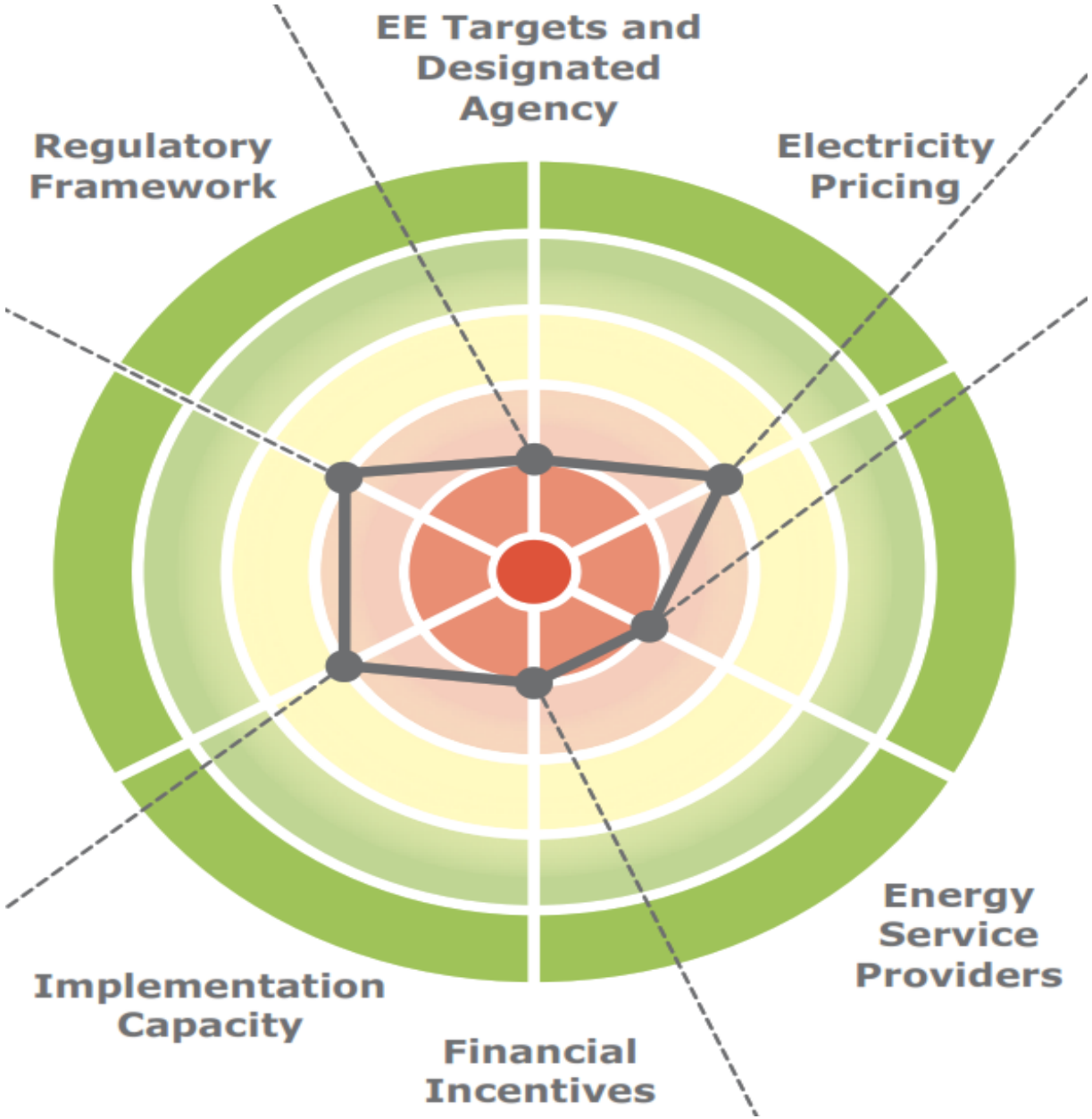

745.1 Thousand boe/day

Hydroelectricity
Natural gas
Oil

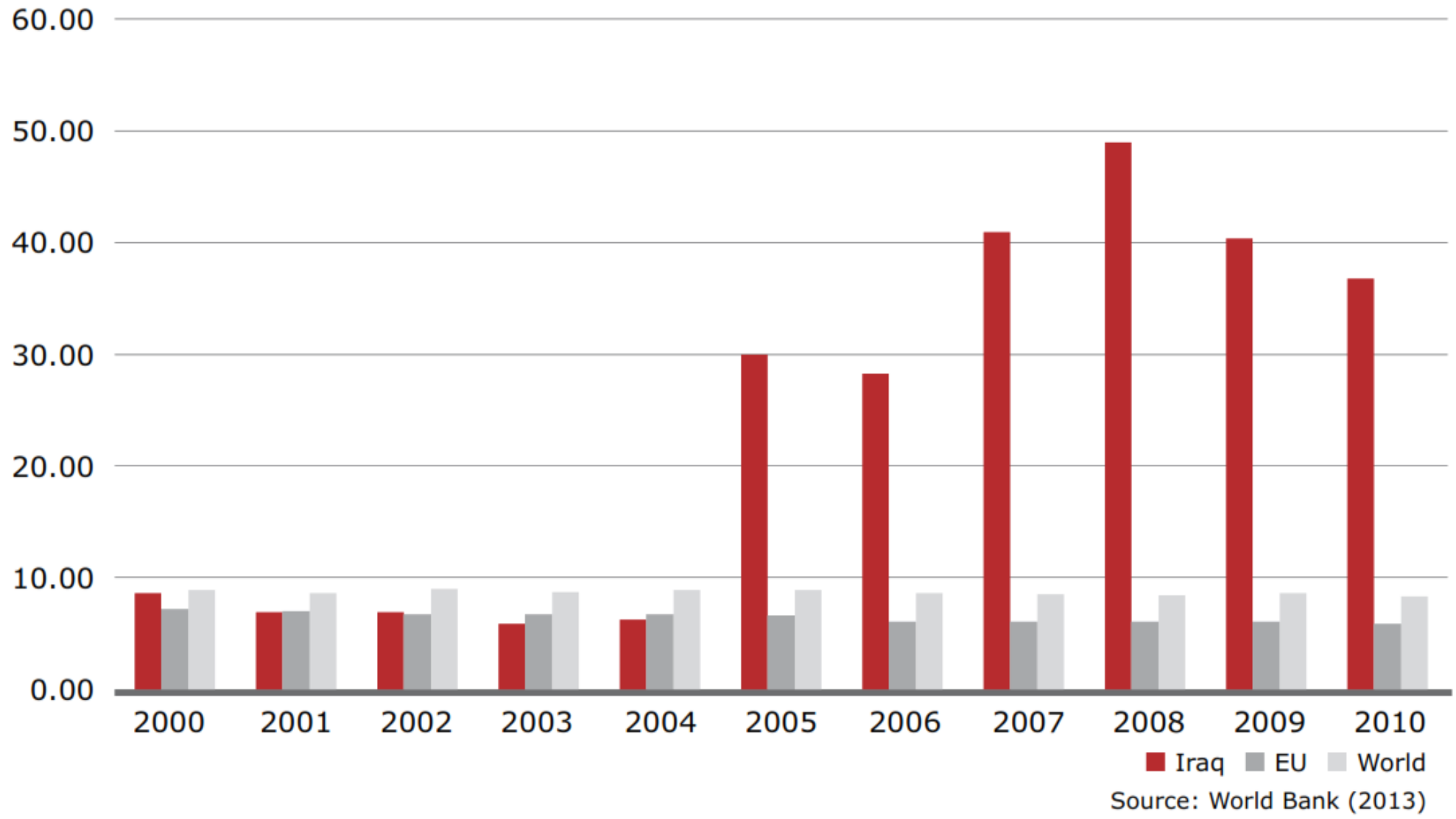
Source: OAPEC (2005, 2012)

# Final Energy Consumption - 2009


Source: IEA (2009)

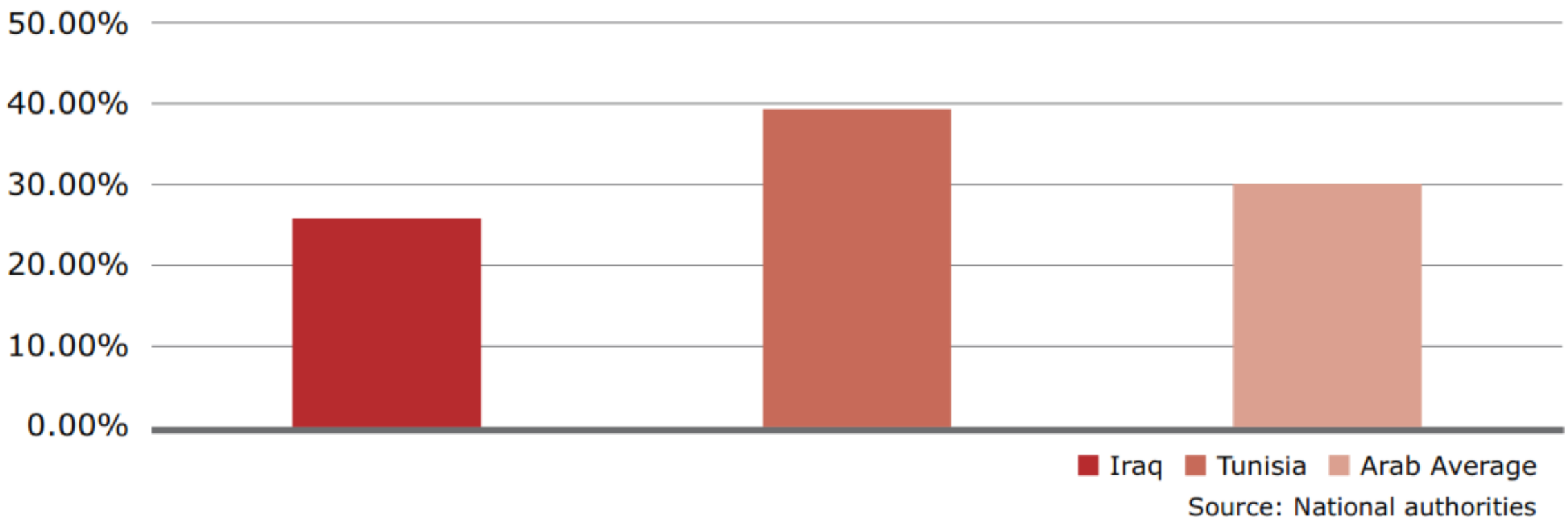

EE Targets and Designated Agency
Electricity Pricing
Energy Service Providers
Financial Incentives
Implementation Capacity
Regulatory Framework

## Power Transmission and Distribution Losses (in Percentage) - 2010




Source: World Bank (2013)

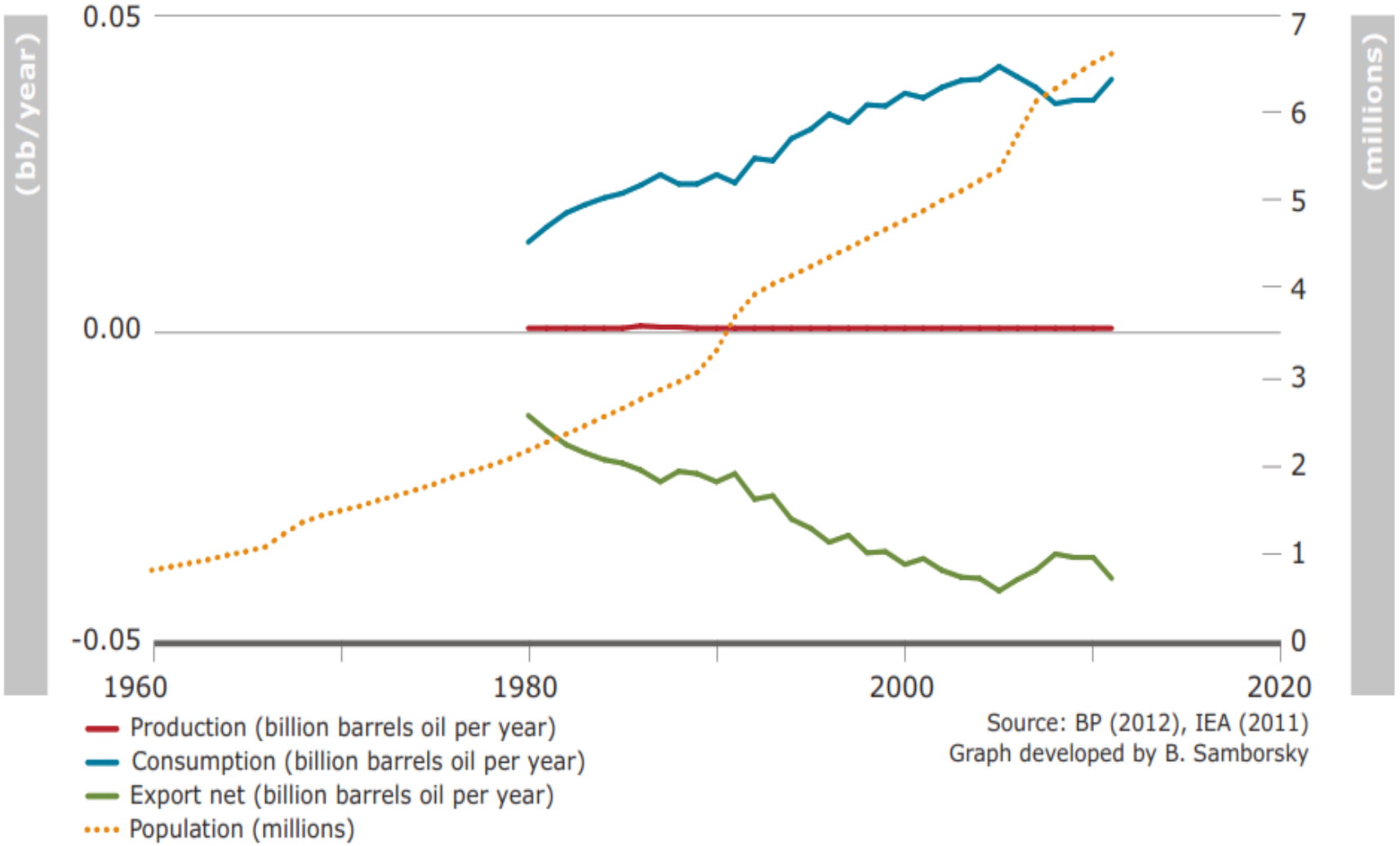
## Power Generation Efficiency - 2009




Source: National authorities

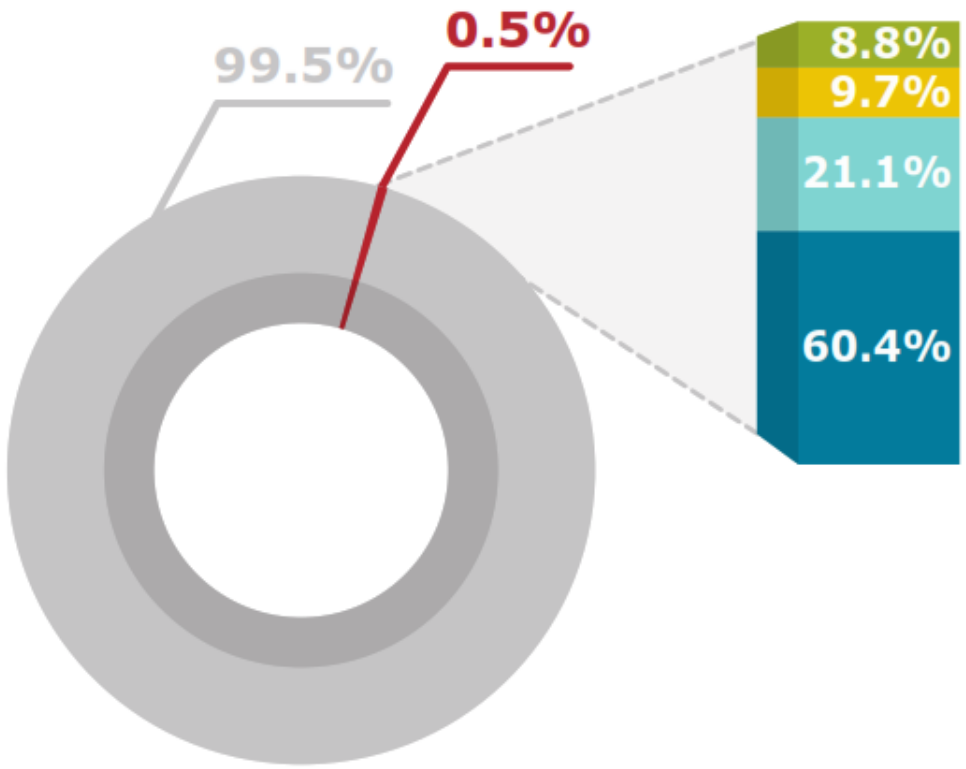
# JORDAN

## Energy Supply and Demand – Current Trends

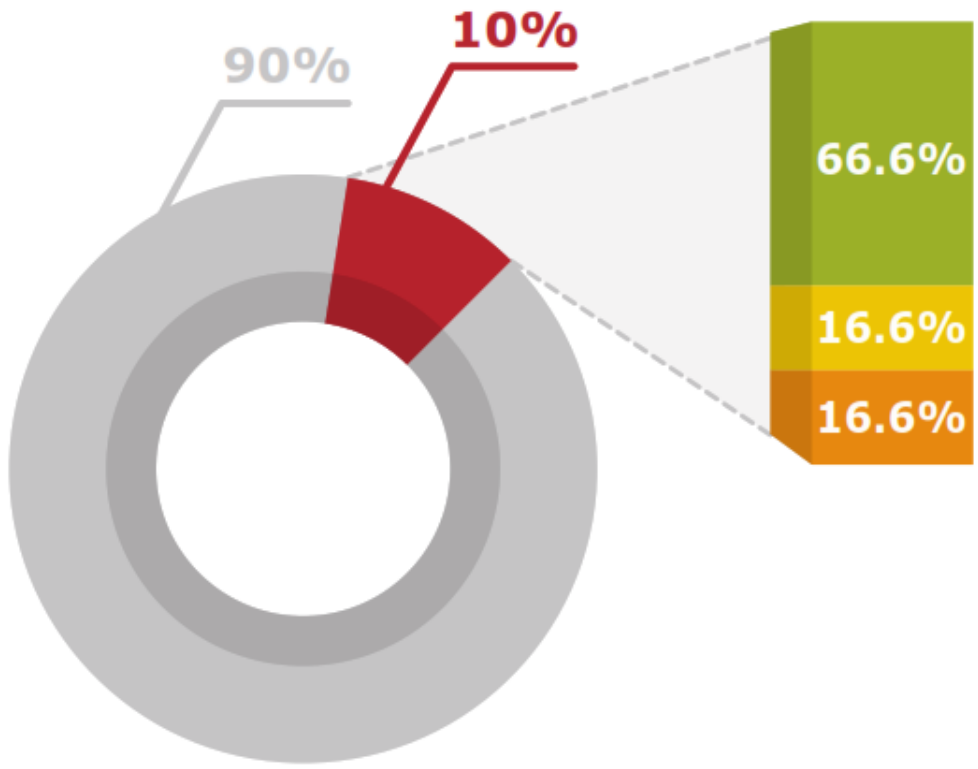



Source: BP (2012), IEA (2011)
Graph developed by B. Samborsky

## Current Installed Capacity



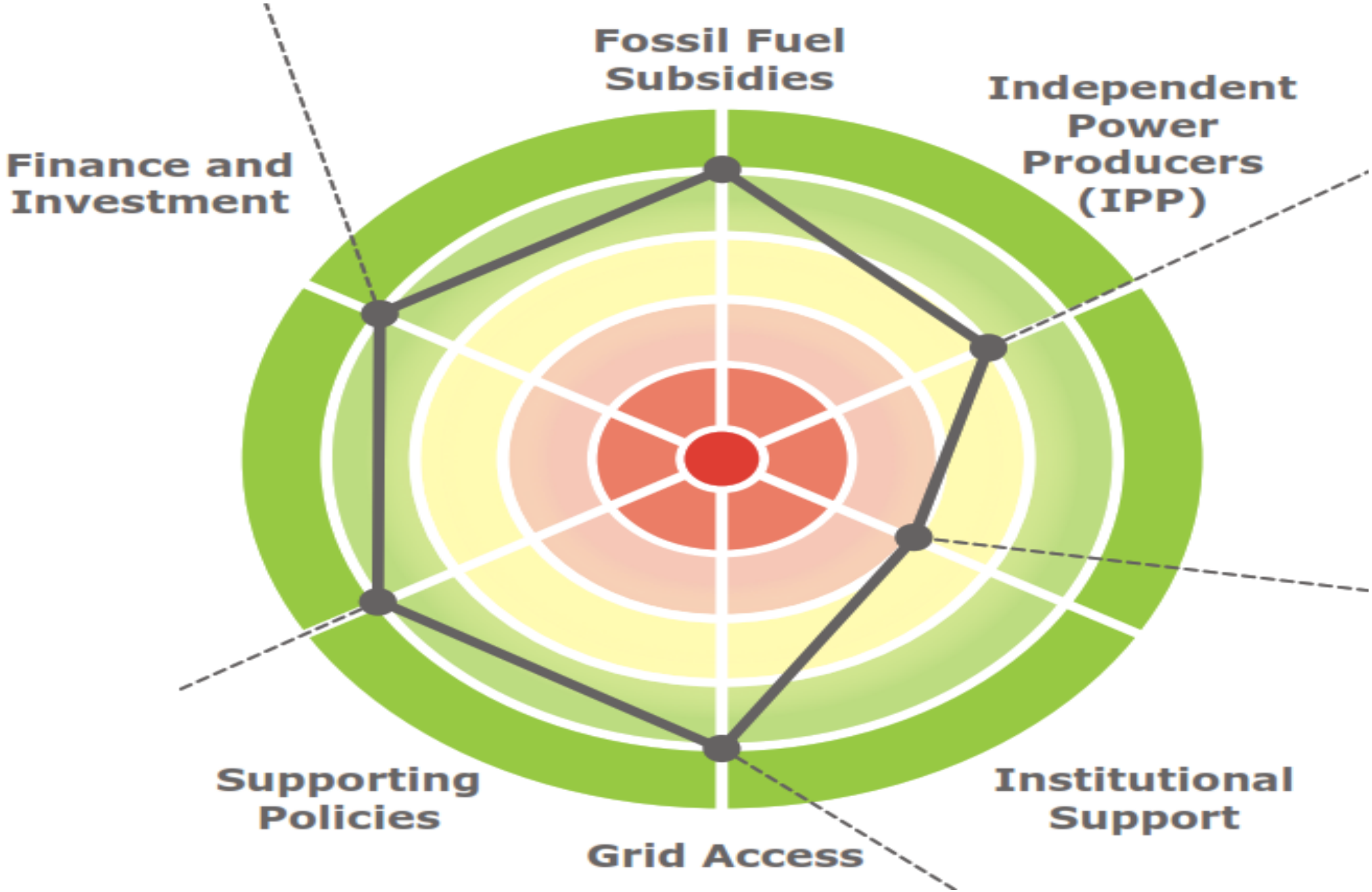

## RE Targets - Year 2020




Fossil fuel | RE | Wind | PV | Biomass | CSP | Hydro

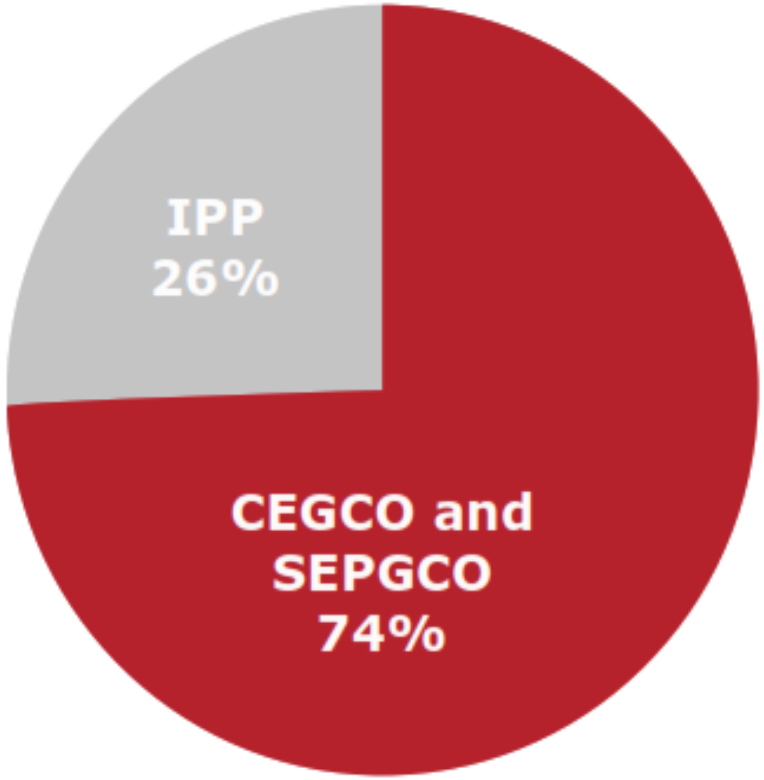
| | Wind | PV | Biomass | Hydro | Total RE | Total all Energy |
|---|---|---|---|---|---|---|
| MW | 1.445 | 1.6 | 3.5 | 10 | 16.545 | 3100 |

| | Wind | PV | CSP | Total | Target Date |
|---|---|---|---|---|---|
| MW | 1200 | 300 | 300 | 1800 | 2020 |


Fossil Fuel Subsidies
Independent Power Producers (IPP)
Institutional Support
Grid Access
Supporting Policies
Finance and Investment

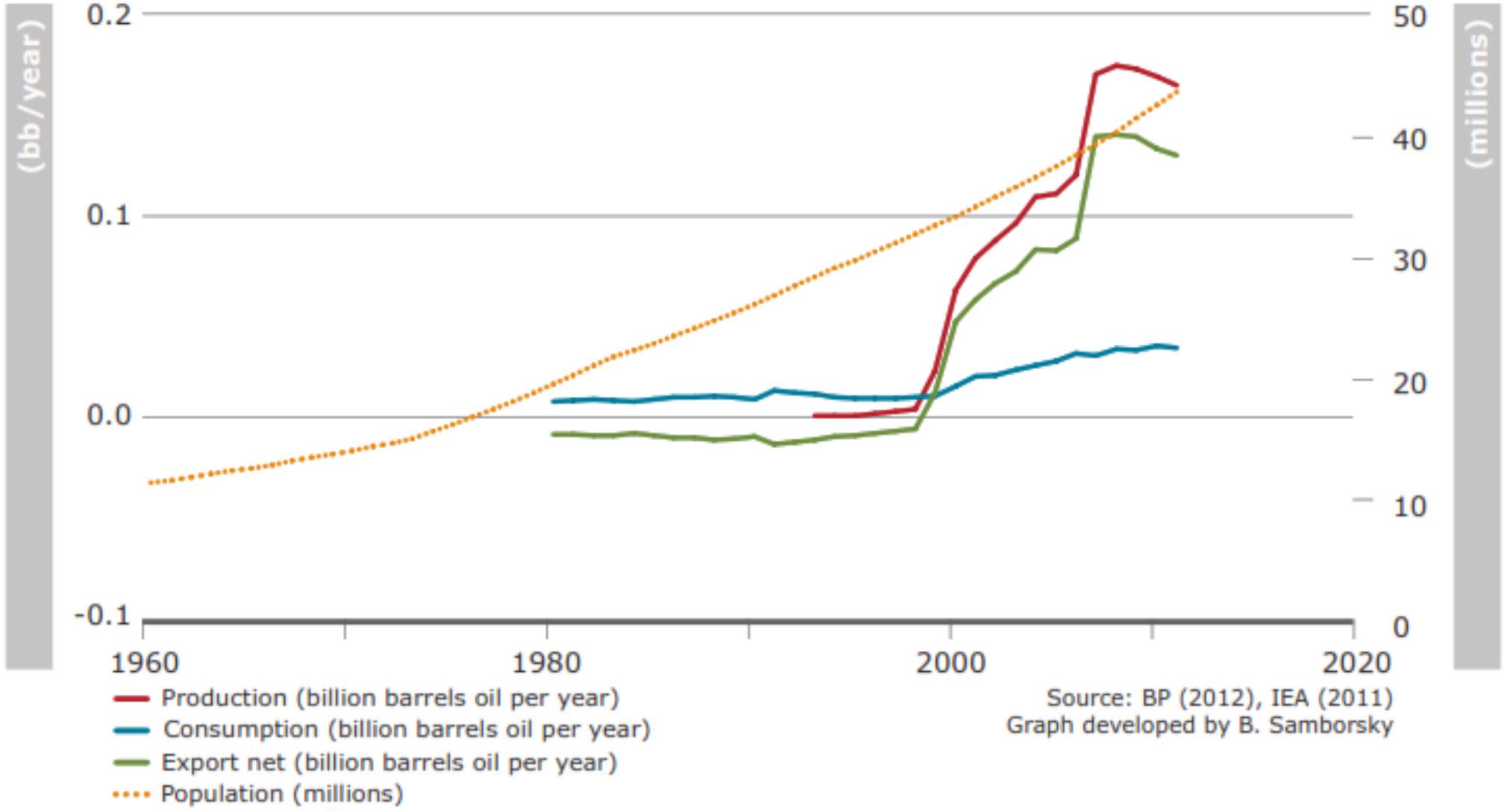
## Independent Power Producers (IPP)

- Private generation of electricity has been authorized by law No 64 (2002). Today, total generation capacity of conventional electricity by IPPs constitutes 740 MW.
- No IPPs producing RE exist yet. The first RE private projects are currently under bidding processes.
- Legal framework of Jordan allows private self-generation of RE (auto-producers). Excess electricity is purchased at the following tariffs: 120 J.Fils/kWh (17 US¢/kWh) for Solar Energy, 95 J.Fils/kWh (13.4 US¢/kWh) for Hybrid RE and 85 J.Fils/kWh (12 US¢/kWh) for other sources of RE.
- User is awarded an incentive of 15% on these tariff prices for installed RE systems of Jordanian origin.
- No RE auto-producers in practice.



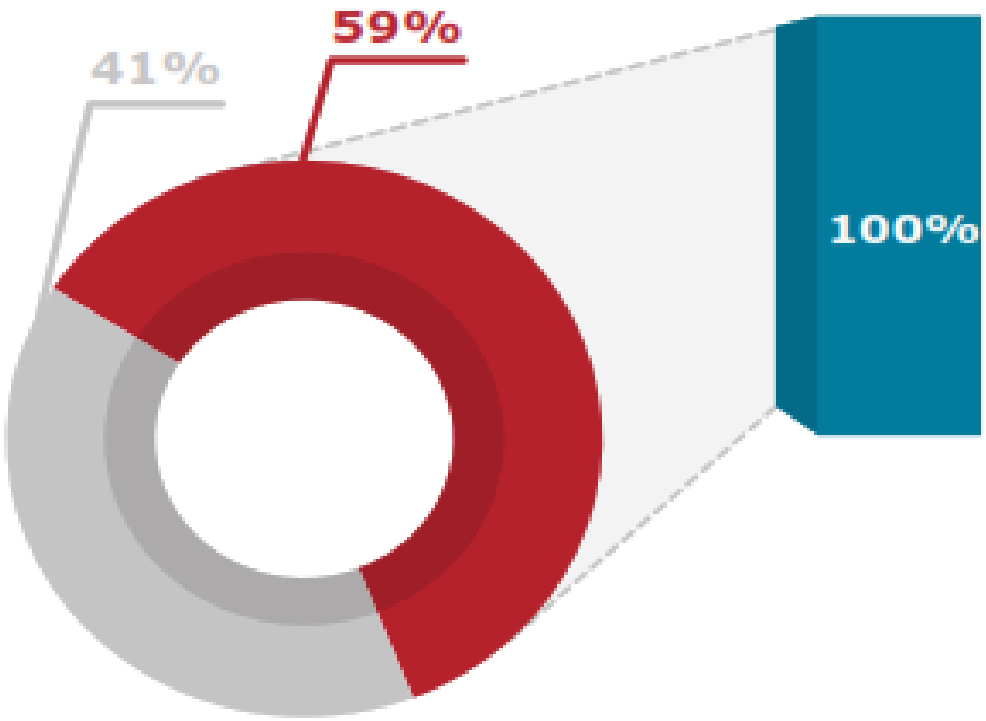
# SUDAN

## Energy Supply and Demand – Current Trends



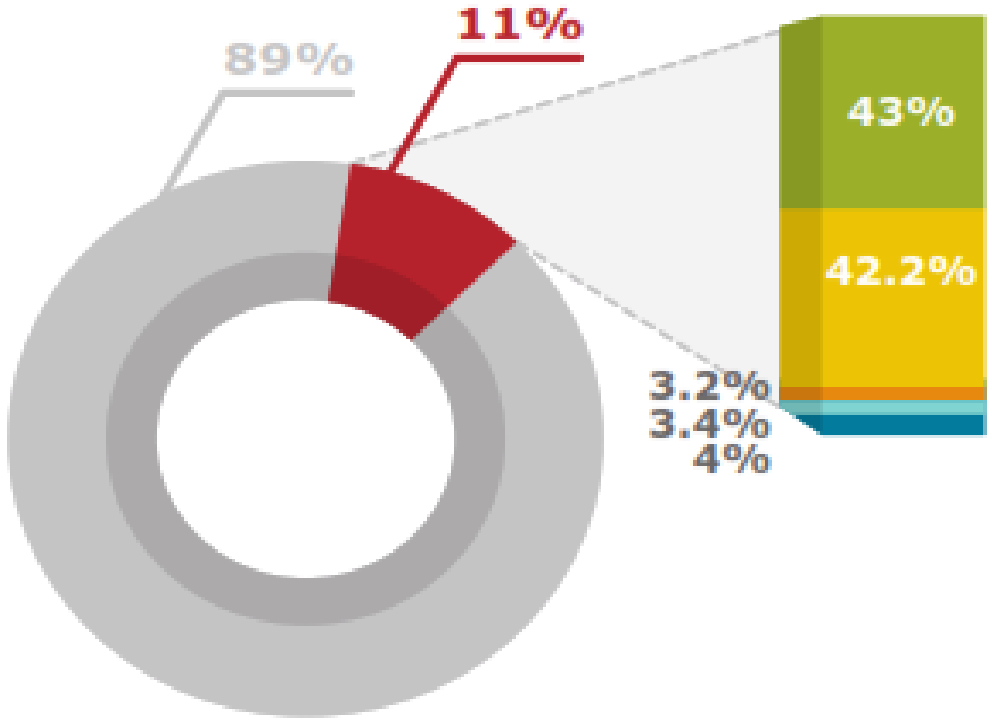

Source: BP (2012), IEA (2011)
Graph developed by B. Samborsky

## Current Installed Capacity



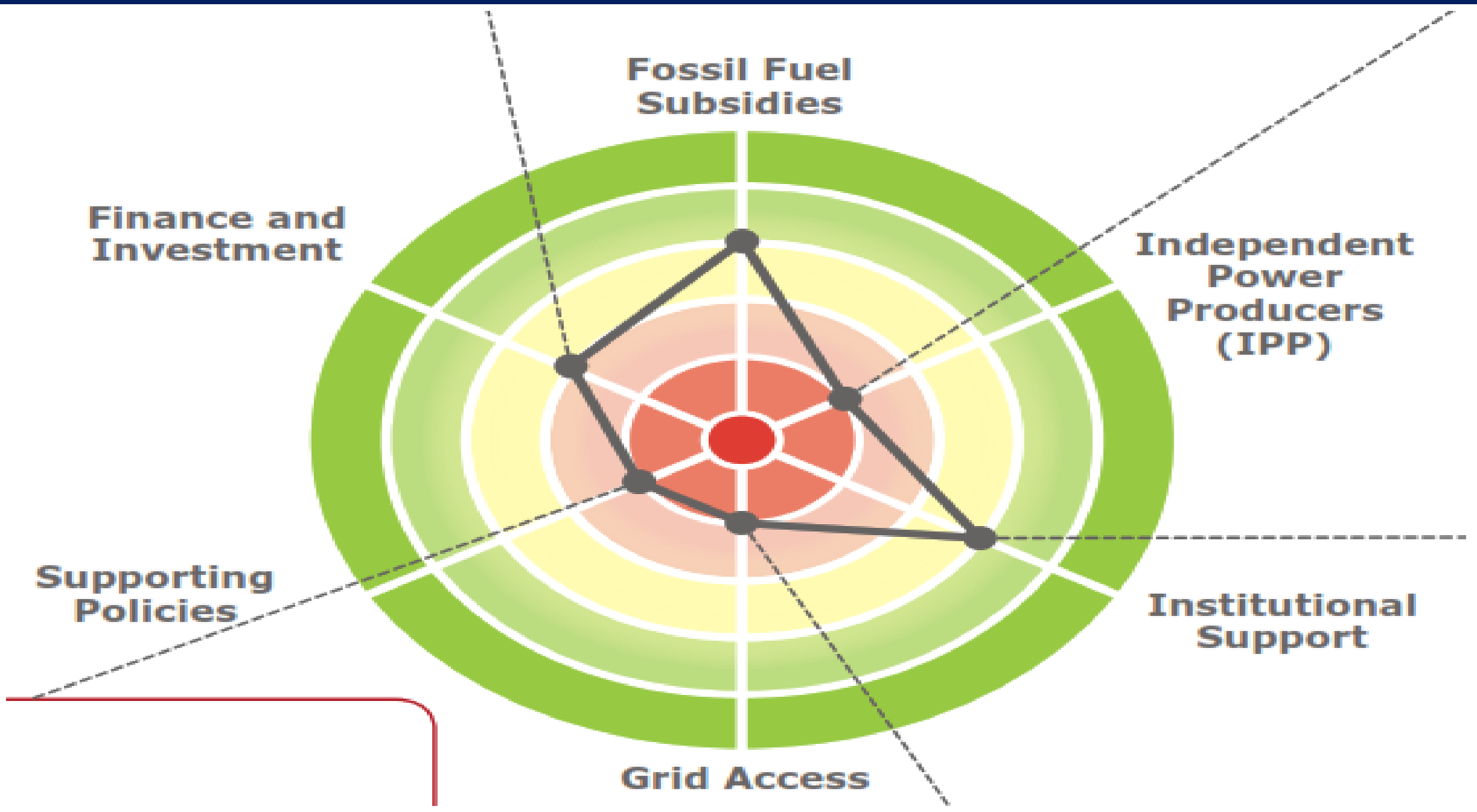

| | Wind | PV | CSP | Hydro | Total RE | Total all installed capacity |
|---|---|---|---|---|---|---|
| MW | 0 | 0 | 0 | 1590 | 1590 | 2723 |

## RE Targets - Year 2031 (excluding hydro)



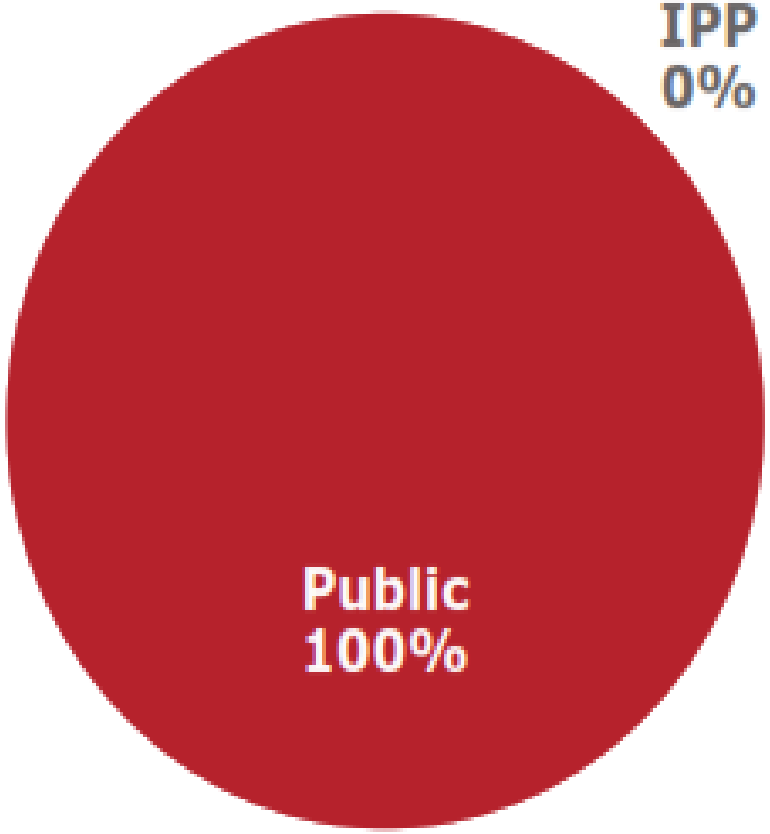

Fossil fuel | RE | Wind | PV | Biomass | CSP | Hydro

| RE Targets (MW Installed Capacity) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wind | PV | CSP | Biomass | Small-Scale Hydro | Waste to Energy | Total | Target Date |
| 680 | 667 | 50 | 54 | 63 | 68 | 1582 | 2031 |


Fossil Fuel Subsidies
Independent Power Producers (IPP)
Institutional Support
Grid Access
Supporting Policies
Finance and Investment

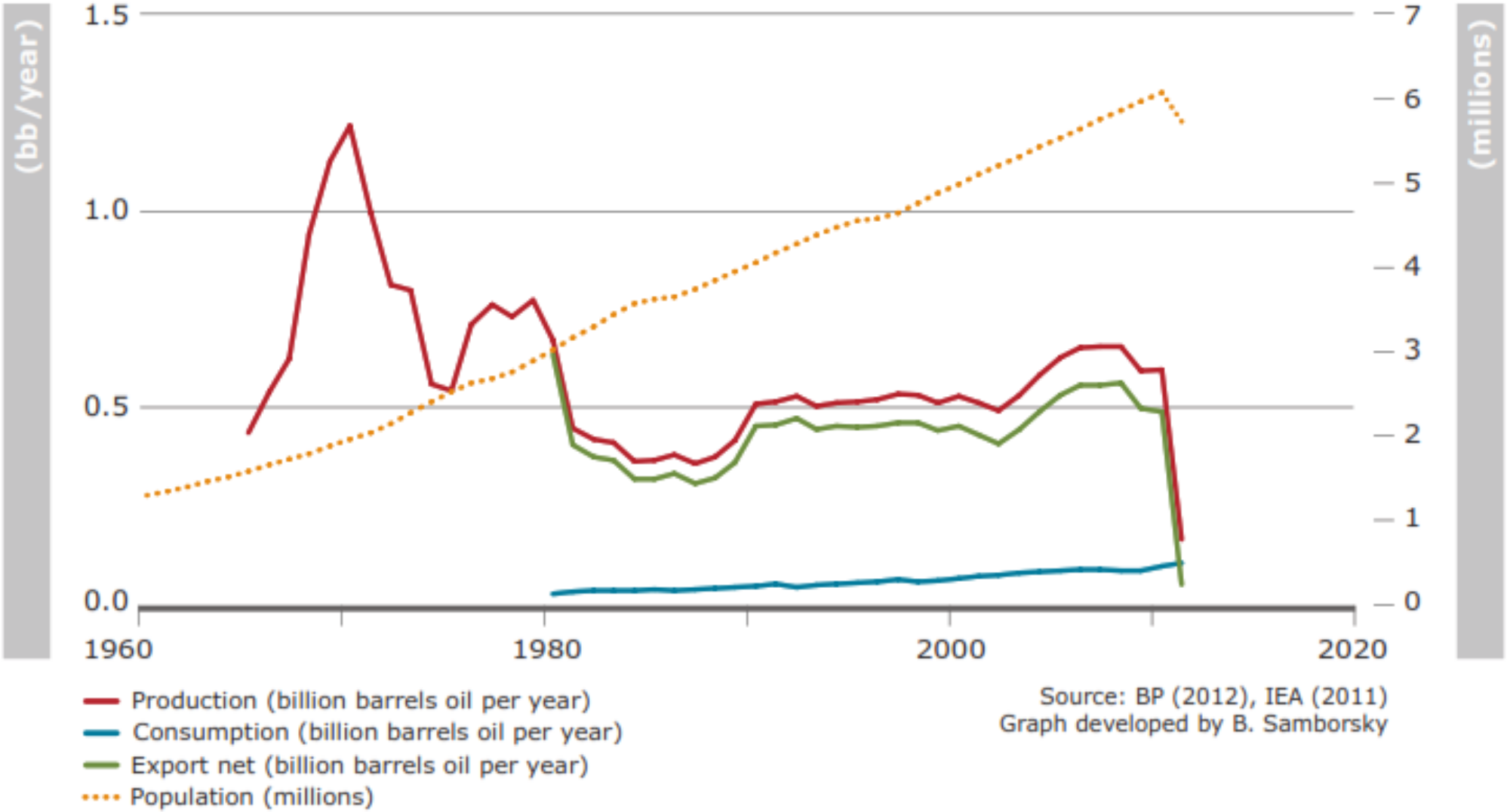
## Independent Power Producers (IPP)

- All power producers in Sudan remain state-owned. The Ministry of Water and Electricity is the main body responsible for regulating electricity generation, transmission, and distribution.
- In 2001, Sudan adopted a new electricity law authorizing private sector power generation, but to this day no IPPs exist in practice.
- Currently, Sudan's legal framework does not allow private self-generation of RE (auto-producers) with the possibility of feeding surplus electricity to the grid.
- No RE auto-producers in practice.



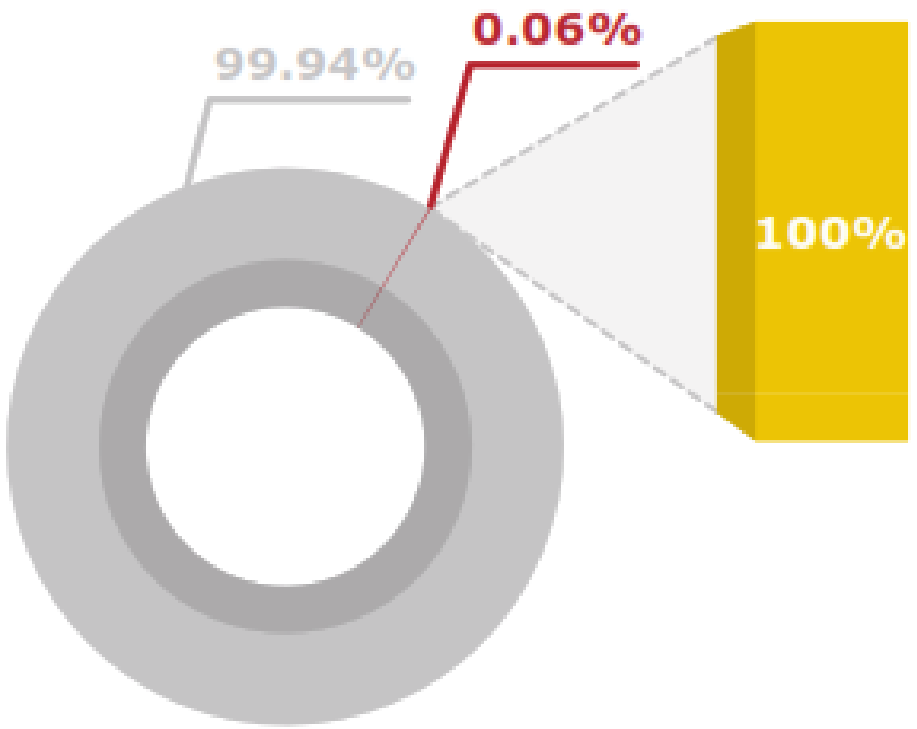
# LIBYA

## Energy Supply and Demand – Current Trends



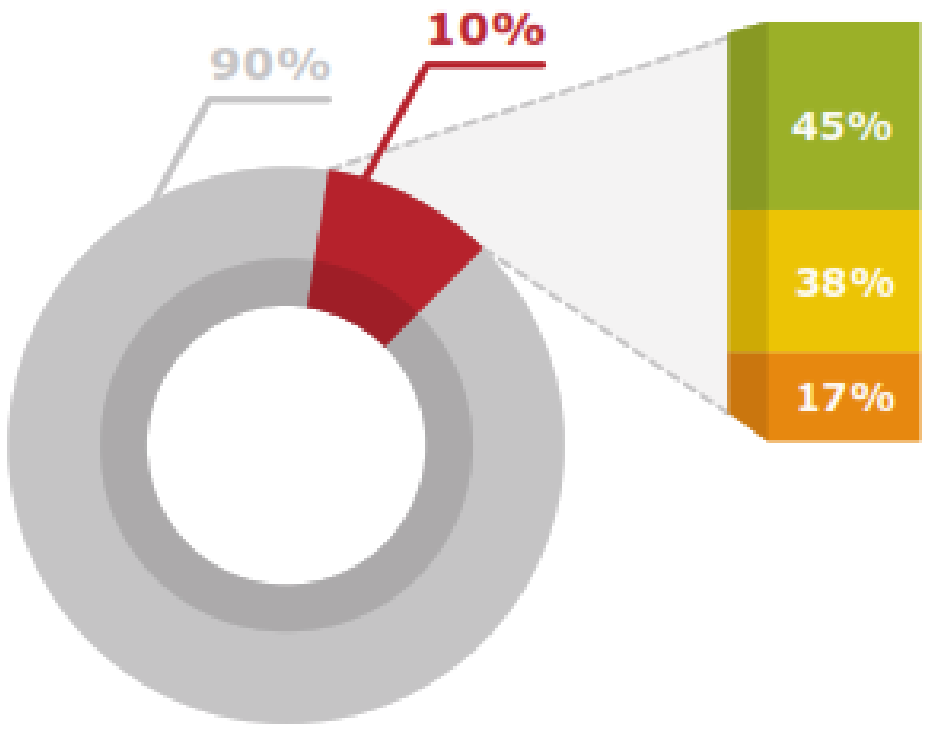

Source: BP (2012), IEA (2011)
Graph developed by B. Samborsky

## Current Installed Capacity



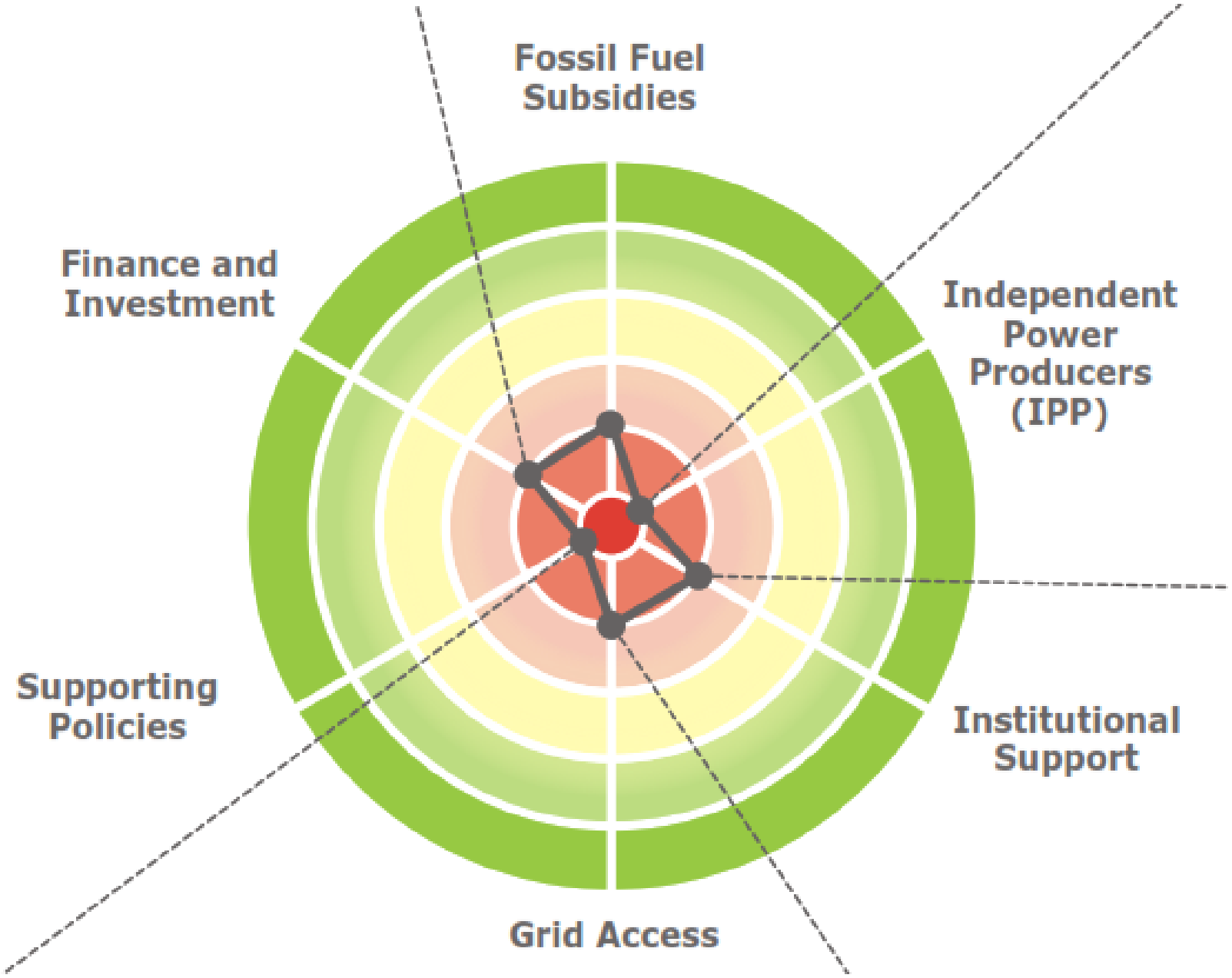

| | Wind | PV | CSP | Hydro | Total RE | Total all Energy |
|---|---|---|---|---|---|---|
| MW | 0 | 5 | 0 | 0 | 0 | 8907 |

## RE Targets - Year 2025



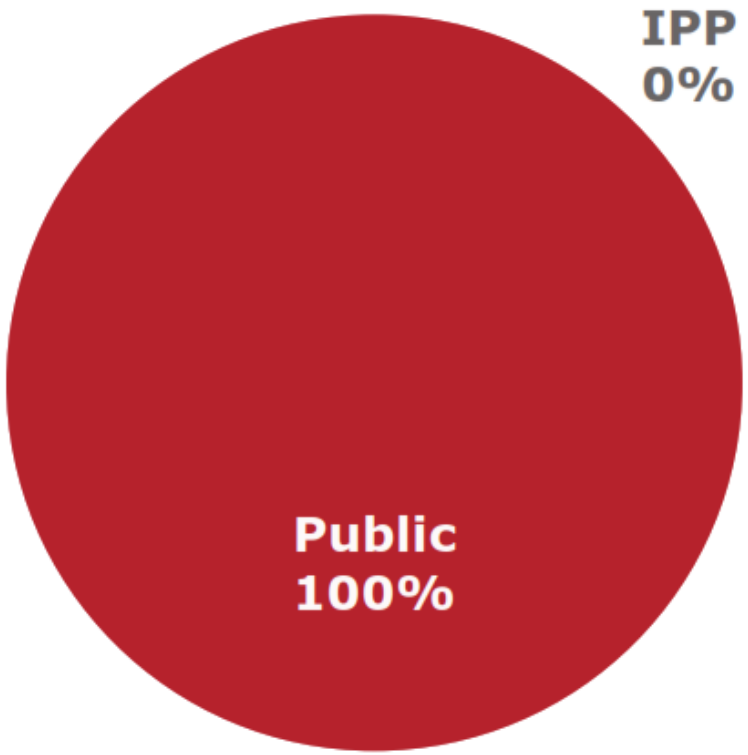

Fossil fuel RE Wind PV CSP Hydro

| Wind | PV | CSP | Total | Target Date |
|---|---|---|---|---|
| 260 | 129 | 0 | 389 | 2015 |
| 600 | 344 | 125 | 1069 | 2020 |
| 1000 | 844 | 375 | 2219 | 2025 |


Fossil Fuel Subsidies
Independent Power Producers (IPP)
Institutional Support
Grid Access
Supporting Policies
Finance and Investment

## Independent Power Producers (IPP)

- All power companies in Libya remain state-owned. The power generation market is still closed for private investors.
- Currently, there is a new electricity law under preparation that will allow private sector companies to generate electricity.
- Libyan's legal framework does not allow private sector self-generation of RE (auto-producers) with the possibility of feeding surplus electricity to the grid.
- Besides small-scale scattered PV projects, there are no RE auto-producers in practice.



# Successful Projects in Africa and the MENA Region

# KENYA

a)Solar home systems (SHS) (10-100 Wp)
b)Stand-alone institutional PV systems (50-500 Wp)
c)Mini-grids (e.g. hybrid PV-diesel or Wind) (5 kW-1 MWp)
d)Improved cook stoves
e)Wind energy large & small applications

# MOROCCO

**Noor Project:** largest in the World
**Phase I:** 80MW
**Phases I, II & III :**160MW

**Wind energy programs:** 750 MW (2014)

By 2020 share of wind & solar each expected to be 14% of the installed capacity.

# South Africa

The wind farms : currently 159 MW; 296 by 2018

Solar concentrators: currently 300 MW; 600MW by 2018

# EGYPT

**The largest wind farm in the World with capacity: 200MW,**

**The farm produces 800GW/yr., enough for 5000 households**

# SUDAN

Applied for the followings; Solar dryers; Solar pumps; SHS; Solar Fridges; street lights; schools; health centers in 300 villages

Solar Evaporators

**Abandoning traditional fossil fuel energy sources is not a viable option. Shifting to new technologies hampered by :**

- **High capital and operating costs,**
- **Lack of finance, & Lack of expertise,**
- **Policy constraints, such as subsidies for traditional technologies**
- **Institutional barriers, such as problems related to monitoring and enforcement,**
- **Environmental regulations, & Information shortage**

# Conclusions and Recommendations

- ***African countries support renewable technologies and are seen as the most economic option.***

- ***Africa is rich in renewable energy sources, such as solar, wind, biomass, hydro and geothermal.***

- ***Africa 2030 renewable energy program is part of IRENA' outlines a roadmap to double the share of renewables in the world's energy mix by 2030.***

# Nuclear Energy Technologies Application

- Construction, operation and maintenance of nuclear reactors requires massive investments.
- Saudi Arabia: planned nuclear power reactors come at an estimated cost of $80 billion.
- The UAE's has an estimated cost of $20 billion.
- Egypt, Jordan, and Morocco are planning nuclear reactors nuclear plants.

# Nuclear Energy

- Construction, operation and maintenance of nuclear reactors requires massive investments.
- Decommissioning: IEA estimates that 200 reactors currently operating will be retired by 2040, at a cost exceeding $100 billion.

# To improve energy situation in Africa we recommend following multi-pronged strategy:

A short-term programme (1-5years) that would aim to implement low- risk and low-cost near term initiative

A long-term programme (10-15) years) that is built around major renewable energy sector initiatives

# The Short-term Program Wou

- Biomass-based co-generation
- Geothermal energy
- Small-scale renewables (improved cook stoves and kilns, solar dyers, solar water heaters, wind pumps, small hydro)

# The Long -Term Programme

- Medium and Large-scale wind power projects
- Medium and Large-scale solar projects
- Large scale urban waste-to-energy projects
- Long-term capacity building & training, policy and financing programs.

# Thank You