African Green Energy and Korea-S.Africa Cooperation

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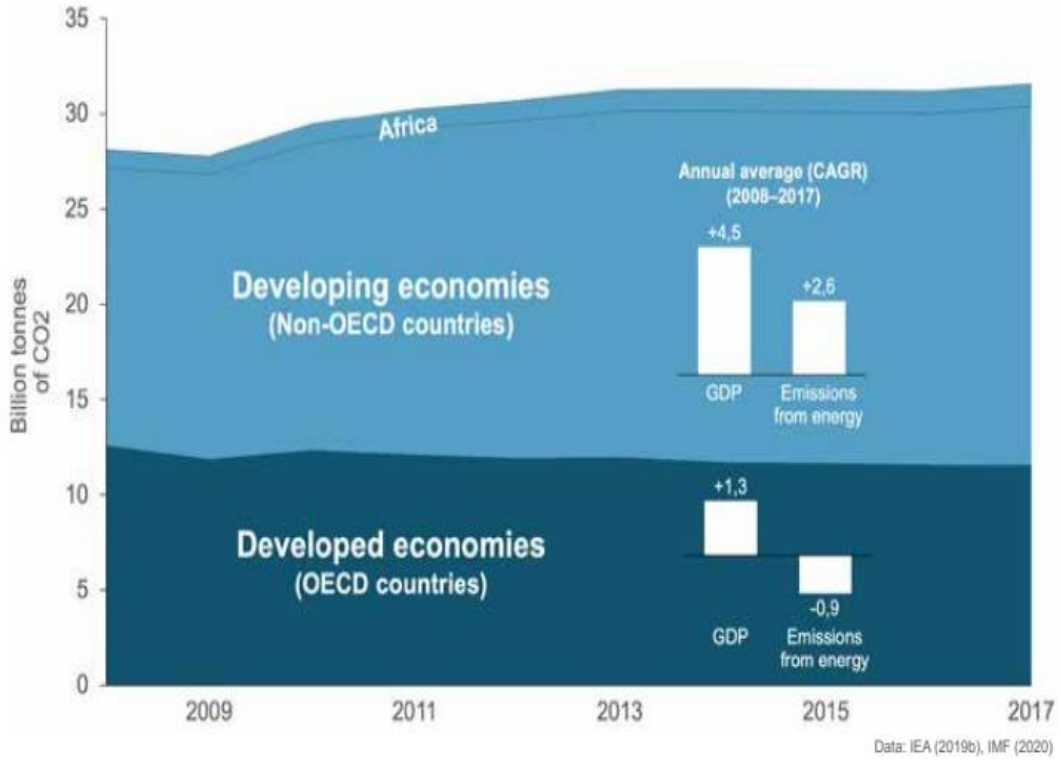
1. Decarbonization policies in major African countries

Africa is exposure to climate hazards, including rising sea levels, heat, water scarcity

- Africa's per capita CO_2 emissions were the lowest in the world at 800,000 tonnes in 2020
  - CO_2 emissions figures for the US and EU are approximately 15.2 million tonnes and 6.4 million tonnes
- Africa accounted for only 4% of global CO_2 emissions in 2020
  - Three-quarters of these occur in five countries: South Africa (33%), Egypt (17%), Algeria (12%), Nigeria (10%) and Morocco (5%)

Global CO_2 Emissions



Decarbonization policies in major African countries

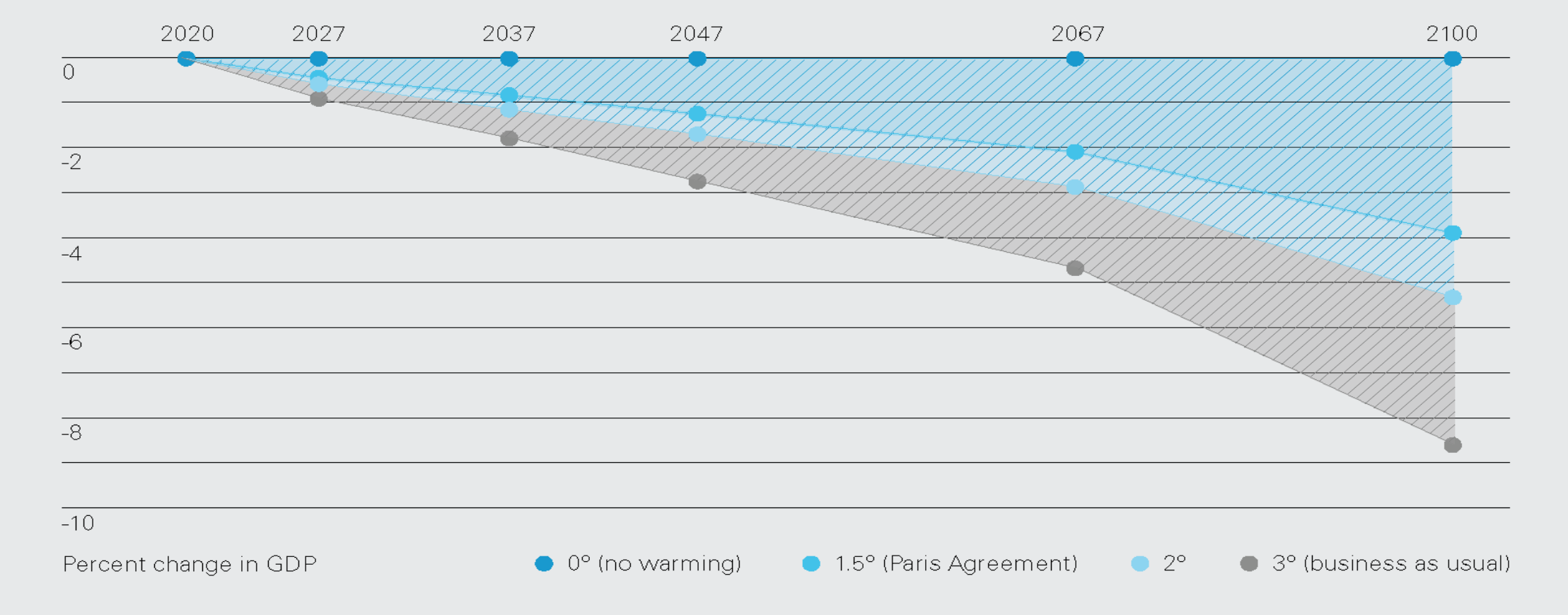
Country	Contents *National Development Plan
S.A	▪ Insert 'Environmental Sustainability and 'Equal transition to a low-carbon economy' in the NDP* formulated in 2021 - Present goals such as defossil fuels and renewable energy
Nigeria	▪ Declaration of achieving net zero by 2060 - Establishment of long-term GHG emission reduction strategy - 45% reduction in CO_2 conditionally by 2030
Egypt	▪ Announcement of countermeasures against climate change through 'Integrated Sustainable Energy Strategy 2035' - Target to increase the share of renewables in the energy mix to 42% by 2035
Morocco	▪ Morocco responds by setting up a national committee on climate change - Moroccan renewables targets are among the region's most ambitious
Kenya	▪ 32% reduction in GHG emissions by 2030 - Enactment of the Climate Change Act in 2016 - $62 billion required to achieve the target by 2030

1. Decarbonization policies in major African countries

Under the BaU scenario, Africa's GDP is expected to lose 8.5% in 2100

- If the current climate change continues, it will inevitably take a big hit on the African economy
  - Even if the Paris Agreement(1.5°) is maintained, the African economy will lose 4% of GDP in 2100 due to climate change

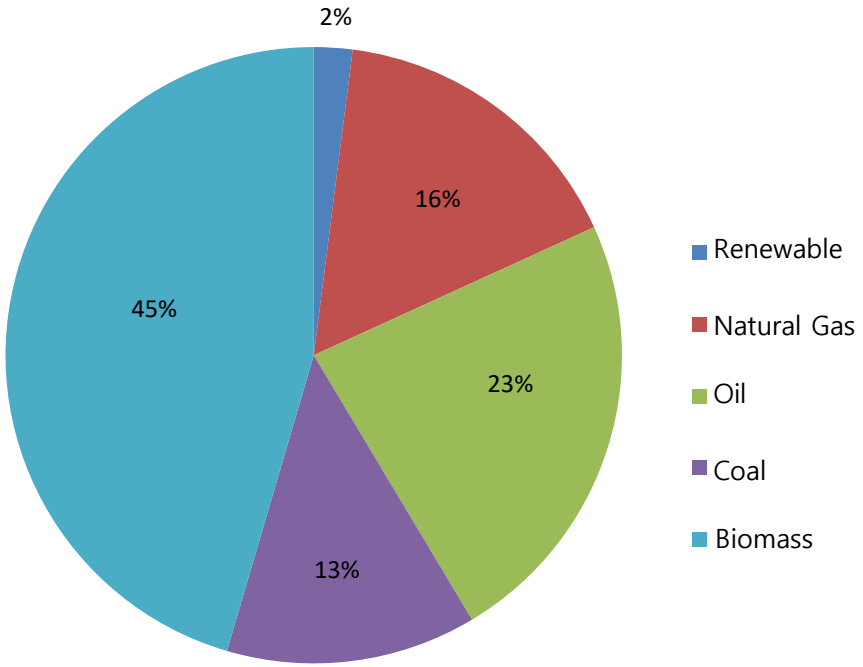
The impact of climate change on sub-Saharan Africa's GDP



Africa's largest energy source is biomass, accounting for 45%

- Most cooking energy sources use wood or charcoal
  - After that, fossil fuels such as crude oil, natural gas and coal account for the majority
  - Renewable energy is only 2%
- As for the energy source for power generation, natural gas ranks first with about 108,000 MW

Total primary energy supply in Africa, by sources(2021)



Sources :EIA, 2021

Electricity generation Mix(MW))

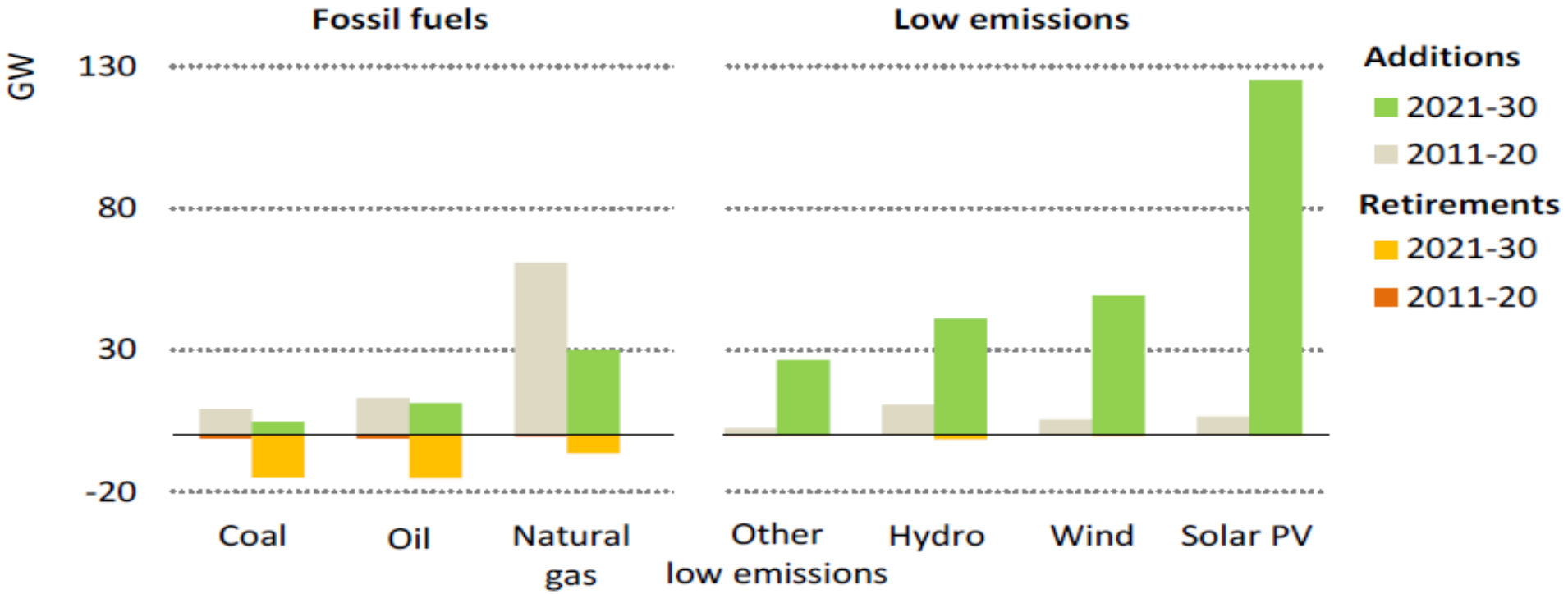
Energy Sources	electricity generation(MW)
Natural gas	107,928
Coal	48,289
Hydropower	35,754
Oil	22,668
Solar power	7,234
Wind power	5,753
Nuclear power	1,940
Bioenergy	1,626
Geothermal	830

Sources: World Bank, 2021

Renewables account for most of the generating capacity additions to 2030

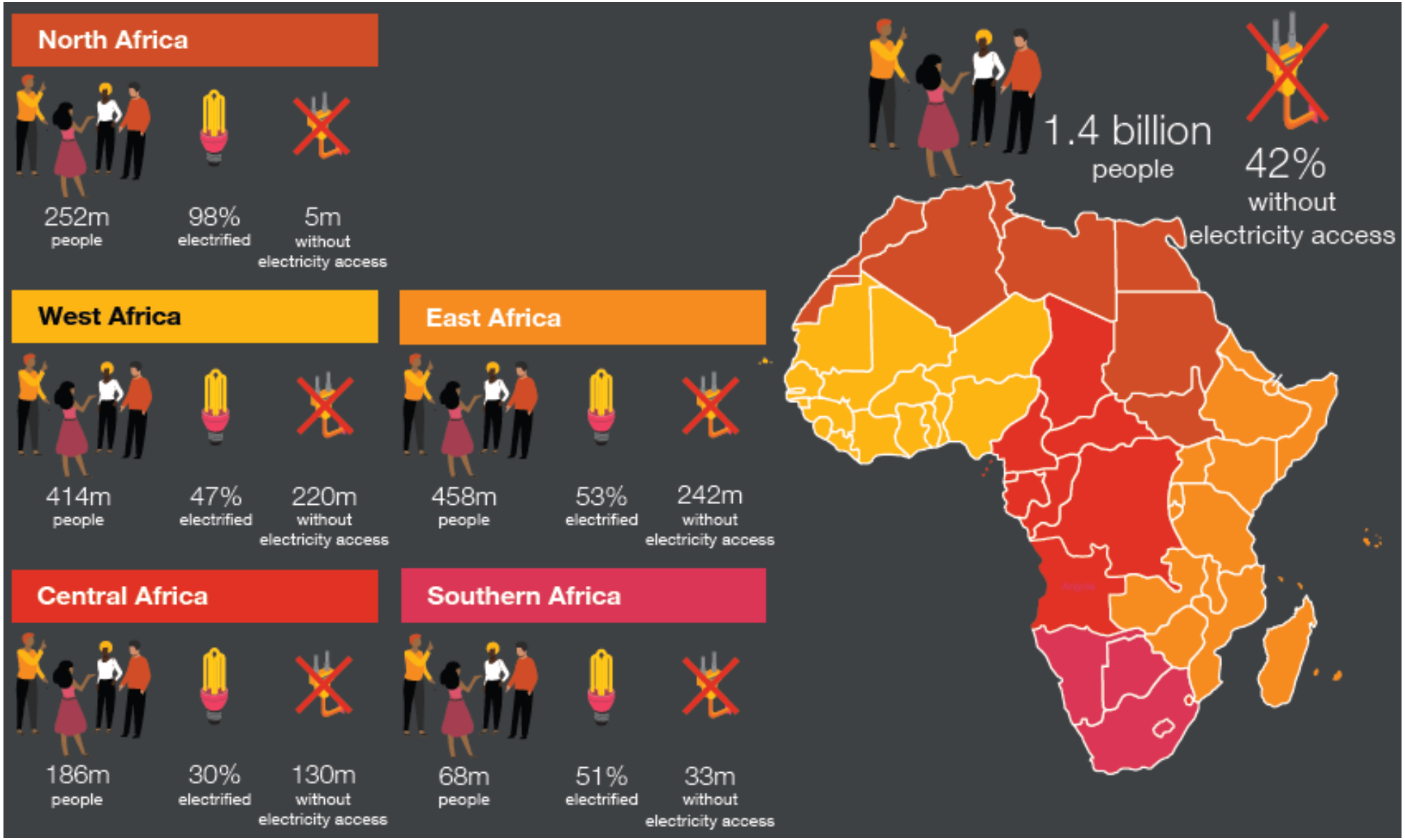
- Solar PV leads with 125 GW of capacity added between 2021 and 2030, over 40% of total capacity additions
  - Of the top 20% of solar sites globally, Africa is home to around 60% of them by land area
  - However, today, Africa holds only 1% of the world's installed solar PV capacity
  - The projected average rate of solar PV capacity additions is roughly equal to that of India in recent years
  - Wind power capacity also expands rapidly, especially in North and East Africa

Power generation capacity additions and retirements by source



※ Electrification rates in different regions

② African Electricity Access



Renewable capacity of more than 58GW(of which hydropower contributes 63%)

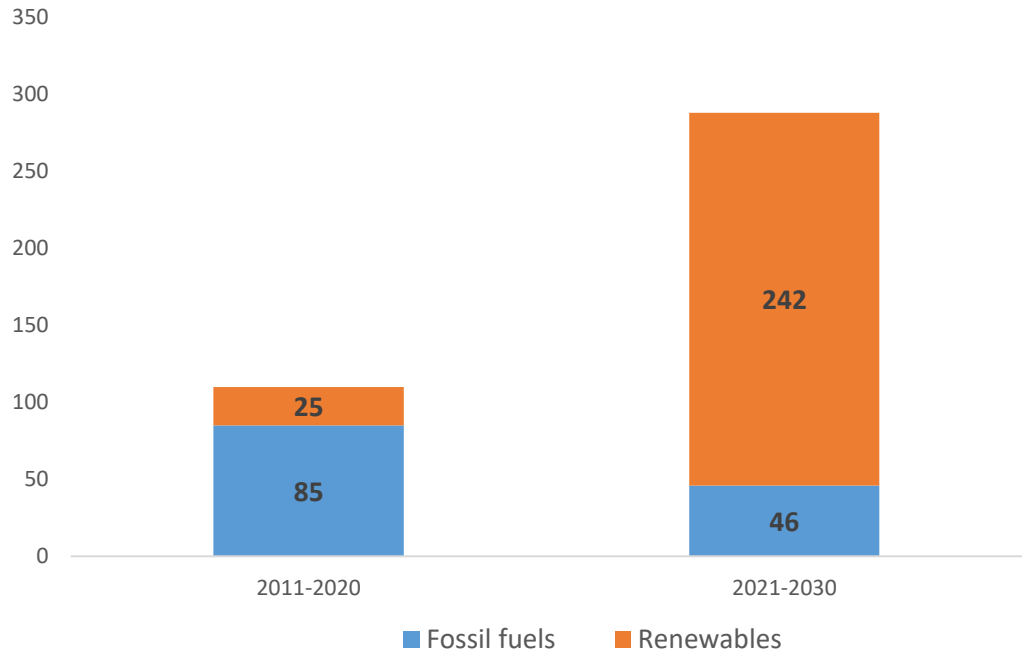
- Total electricity production in Africa was about 232GW in 2020
  - Among them, fossil fuels accounted for 181GW. Renewable energy accounts for 22%
  - Renewable energy is on a gradual rise across the continent with an annual growth rate of 21% between 2010 and 2020
  - Countries such as Egypt, Ethiopia, Kenya, Morocco, South Africa are leading the increase in renewable energy supply on the continent

Power generation by region(GW)

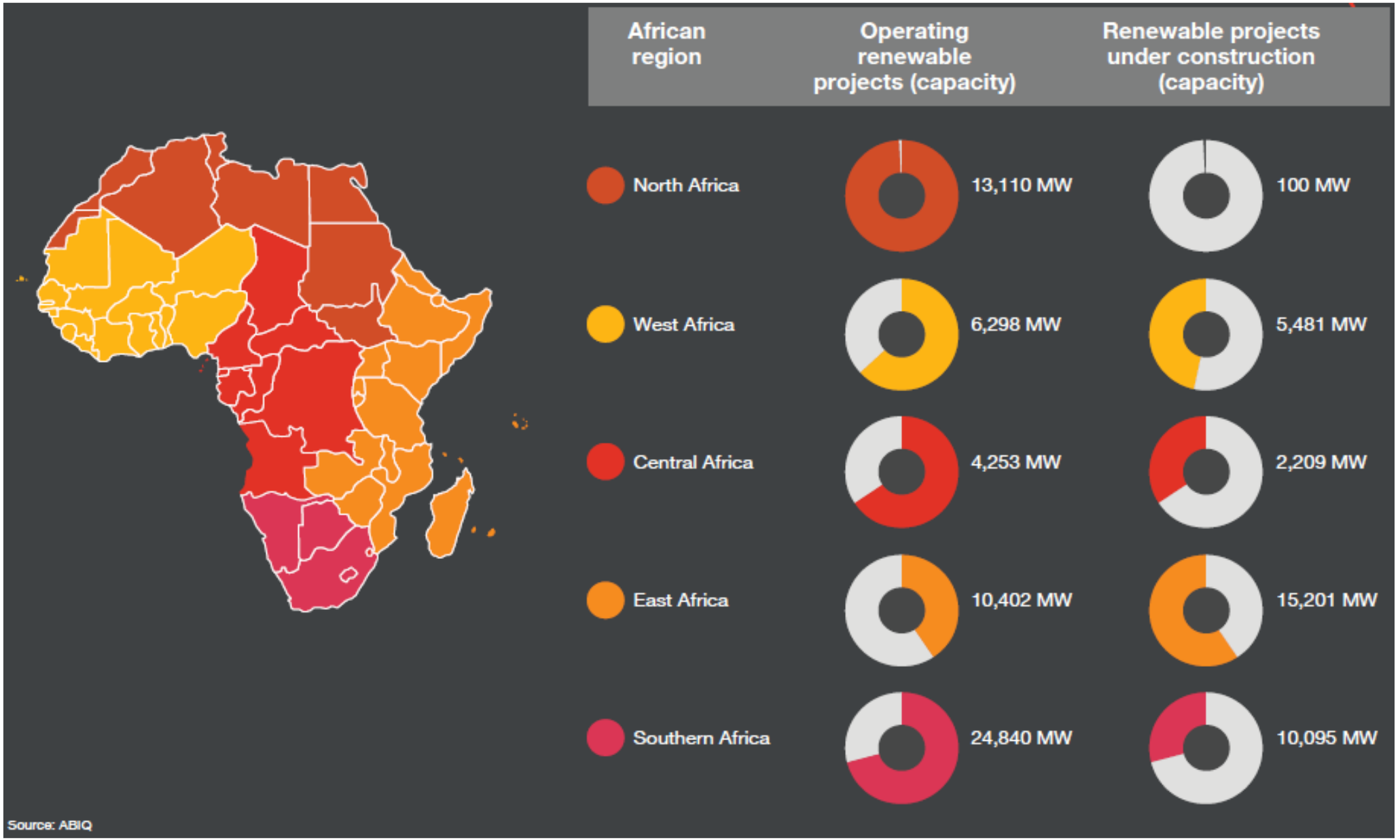
Area	Total (GW)	Renewable (GW)	Renewable Energy Share(%)
N. Africa	115	11	9%
E. Africa	15	11	71%
Central Africa	6	4	72%
W. Africa	24	6	25%
S. Africa	72	19	27%

자료 : IRENA, 2021

Power generation increase prospect(GW)



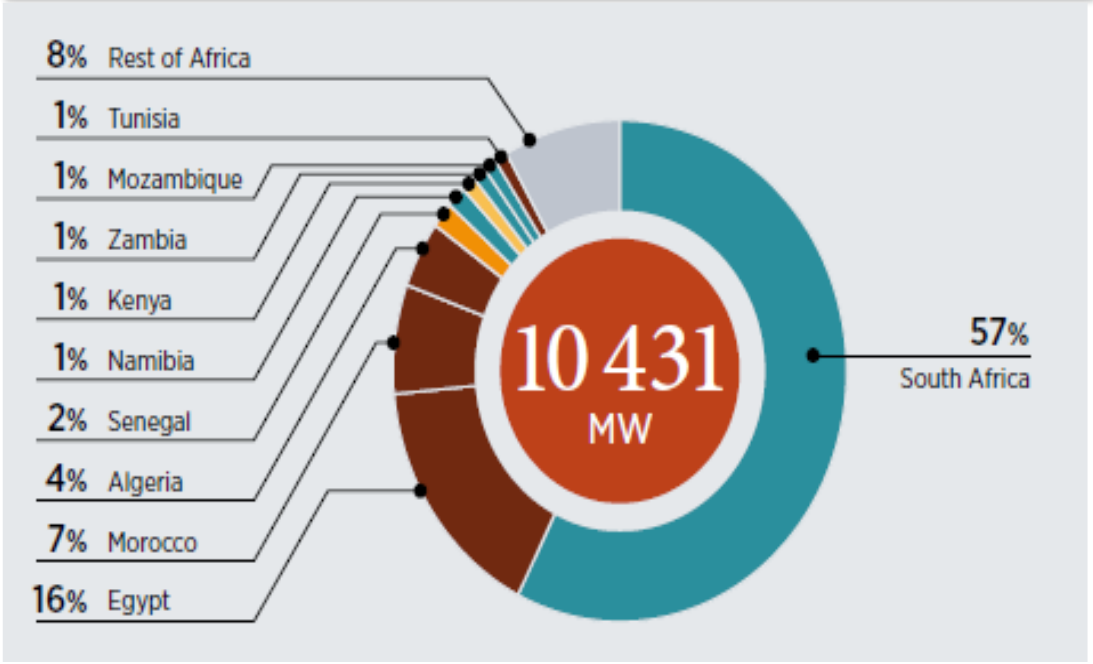
※ Renewable projects in Africa, 2021(MW)



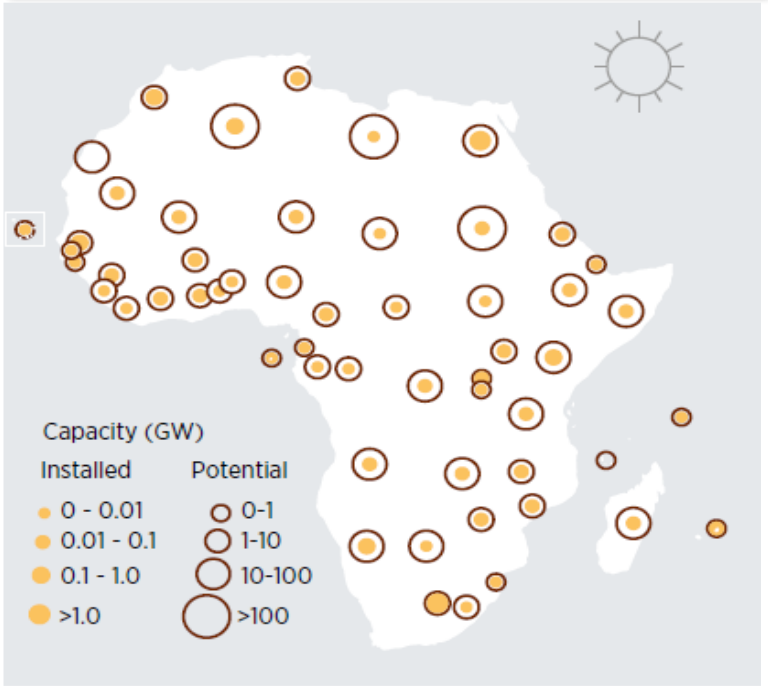
Africa has the largest solar power potential in the world

- The continent receives annual average solar irradiation of 2,119(kWh/m_2)
  - IRENA estimates the continent's solar technical potential at 7,900GW(assuming a 1% land-utilisation factor)
  - South Africa and Egypt are Africa's two largest solar producers, accounting for over three-quarters of installed solar capacity in 2020
- Between 2011 and 2020, solar PV capacity in Africa grew at a CAGR of 54%
  - Total solar added over the past decade amounted to 10.4 GW, with the largest addition in 2018 (2.9 GW)

Africa's installed solar generation capacity, 2020



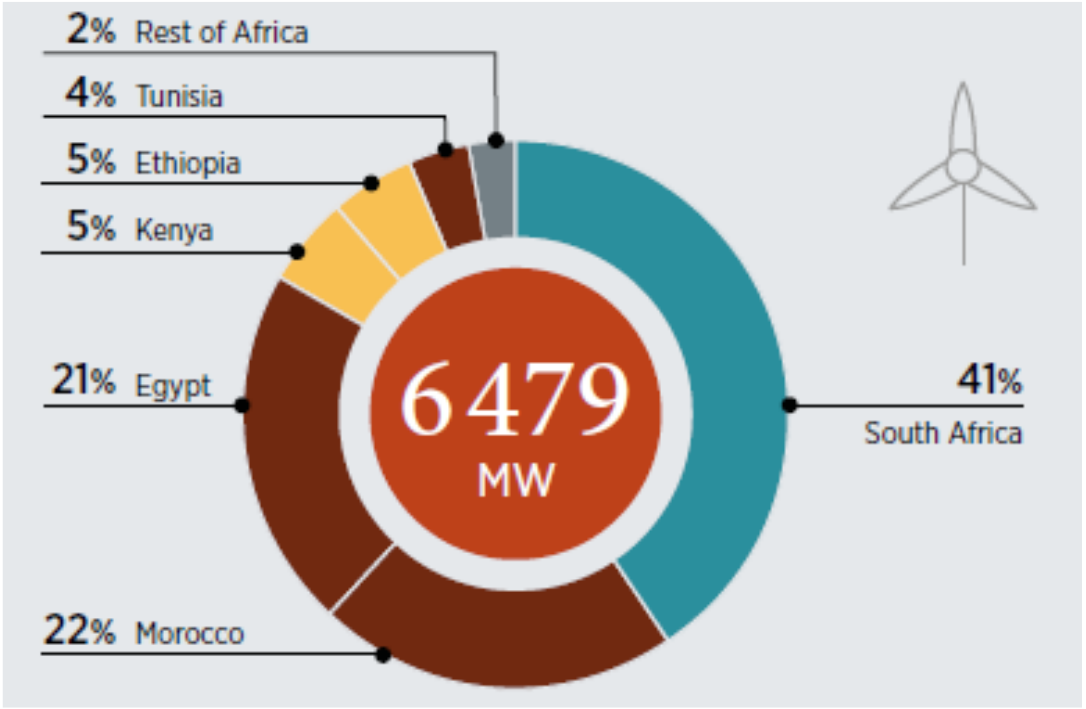
Solar potential and installed capacity



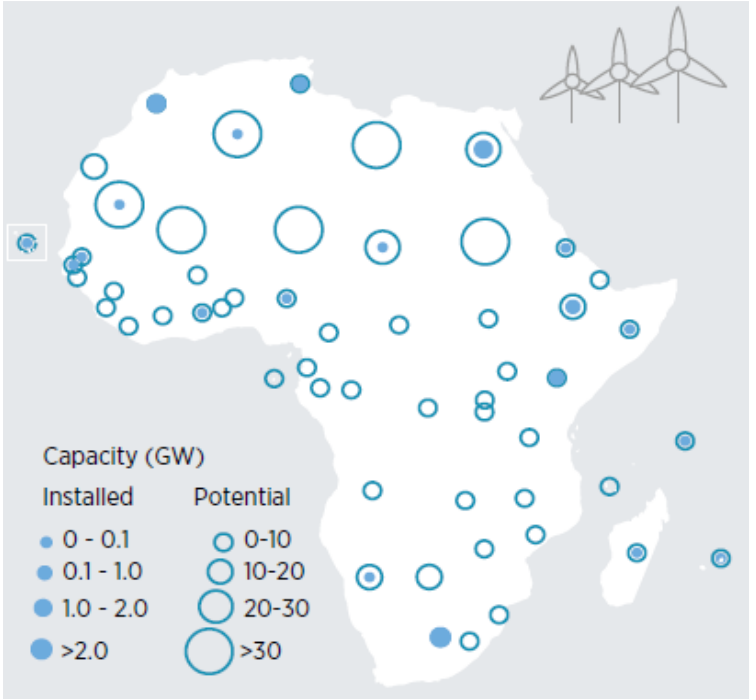
Wind power holds great potential in Algeria, Ethiopia, Namibia and Mauritania

- IRENA estimates the technical potential of wind power generation at an immense 461GW(assuming a 1% land-utilisation factor)
- Annual average wind speeds in North Africa and Southern Africa are high, reaching 7m/s
  - At the end of 2020, wind generation capacity in Africa amounted to 6.5 GW, of which some 0.7 GW was added in 2020
- Countries with significant generation capacity are South Africa, Morocco and Egypt, as well as Kenya, Ethiopia and Tunisia, which together account for over 95% of Africa's total wind generation capacity

Africa's installed wind generation capacity, 2020



Wind potential and installed capacity

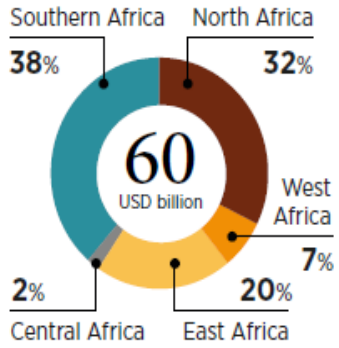


Between 2000-2020, Africa attracted almost U$60billion in investment in renewables

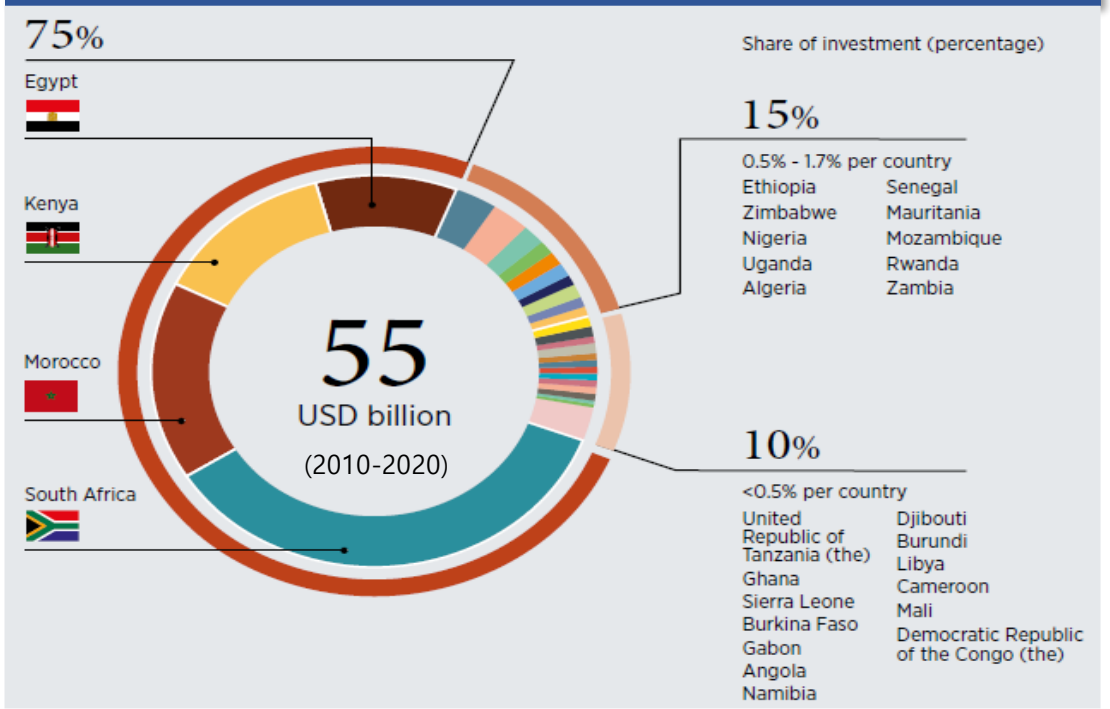
- Over 90% (some USD 55billion) was committed between 2010 and 2020
  - During this period, renewables investment in Africa grew at a remarkable average growth rate of 96% per year compared to 7% globally
- The period 2010-2020, 90% of all investments in renewables went to 14 of the 55 countries in Africa
  - Four countries alone attracted 75% of investments, namely South Africa, Morocco, Egypt and Kenya
  - This was mainly the result of enabling policies and financing mechanisms that were able to attract investments

Overall renewable energy investment in Africa and globally, '00-'20

	2000-2009	2010-2020	Cumulative 2000-20
Global	587 USD billion	2 254 USD billion	2 841 USD billion
Africa	4.8 USD billion (0.8% of global investment)	55 USD billion (2.4% of global investment)	60 USD billion (2% of global investment)
North Africa	1.9 USD billion	17.5 USD billion	
West Africa	0.5 USD billion	3.9 USD billion	
East Africa	2.0 USD billion	9.7 USD billion	
Central Africa	0	1.3 USD billion	
Southern Africa	0.3 USD billion	22.4 USD billion	



Top recipient countries of renewable energy investment



※ African power generation investment

Cumulative investment needs for African power generation(2015 to 2030)

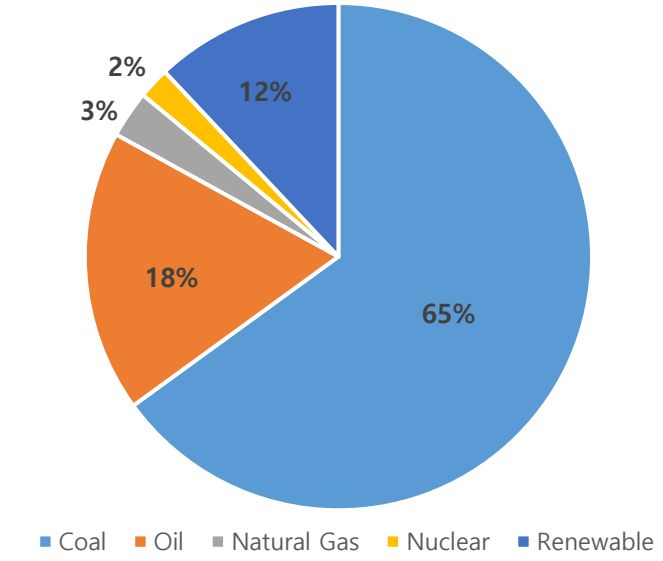
Region	Investment US$ billion (2015 –2030)			
	All generation	Large hydo	Other renewables	T&D
North Africa	342	2	218	186
West Africa	89	36	31	52
Central Africa	32	13	17	14
East Africa	72	36	21	49
Southern Africa	145	18	94	74
Total	**681**	**106**	**381**	**375**

Source: International Renewable Energy Agency (IRENA) (2015), Africa 2030: Roadmap for a Renewable Energy Future. IRENA, Abu Dhabi. www.irena.org/remap

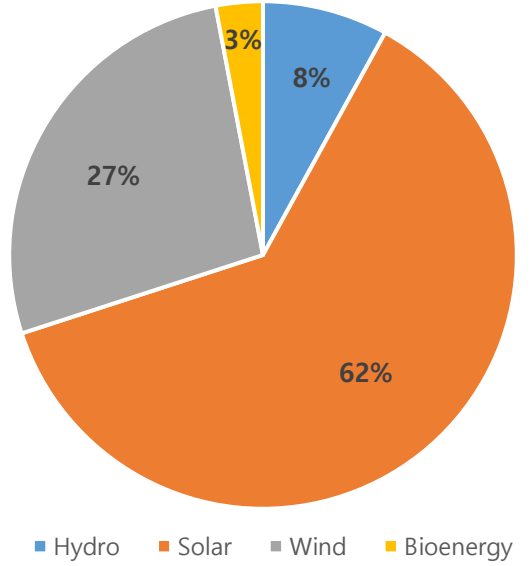
South Africa to reach 17,800MW of renewable energy by 2030

- South Africa has some of the best solar and wind resources in the world
  - Renewable Independent Power Producer Programme(REIPPP) is aimed at bringing additional megawatts onto the country's electricity system through private sector investment in wind, Solar, biomass and small hydro, among others
- Of the renewable energy supply capacity, solar power dominates with 62%, followed by wind with 27%
  - Favorable for solar power generation due to the average annual 2,500 hours of solar radiation
  - The annual 24-hour solar radiation average is about 220W/m_2 in South Africa, 150W/m_2 in the United States, and about 100W/m_2 in Europe and the United Kingdom

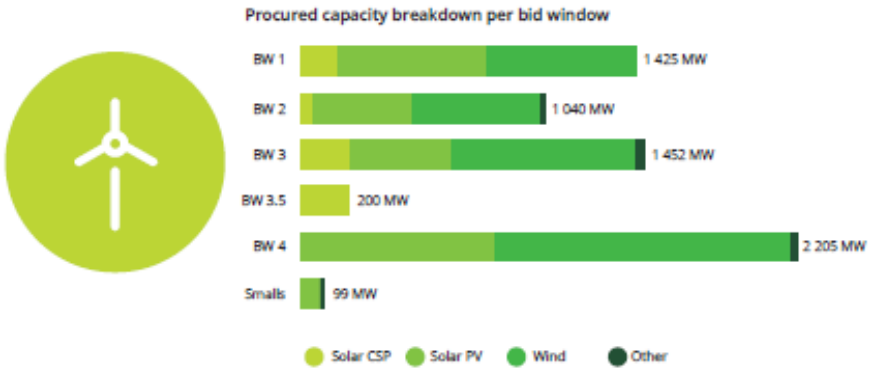
S. Africa Energy Sources(2021)

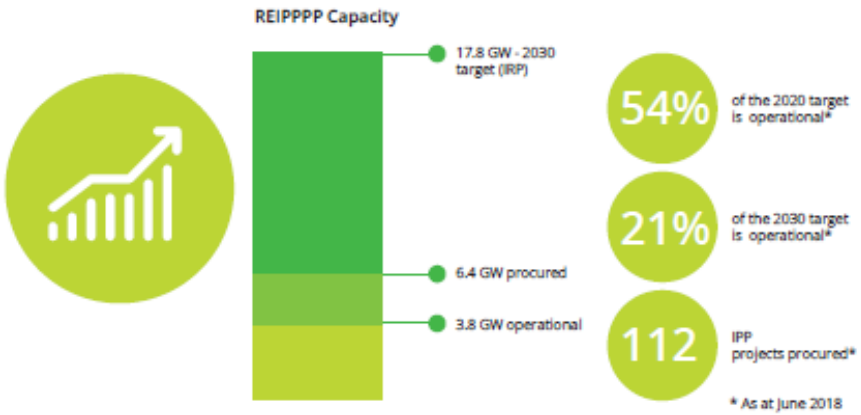


S. Africa Renewable Electricity Capacity(2021)

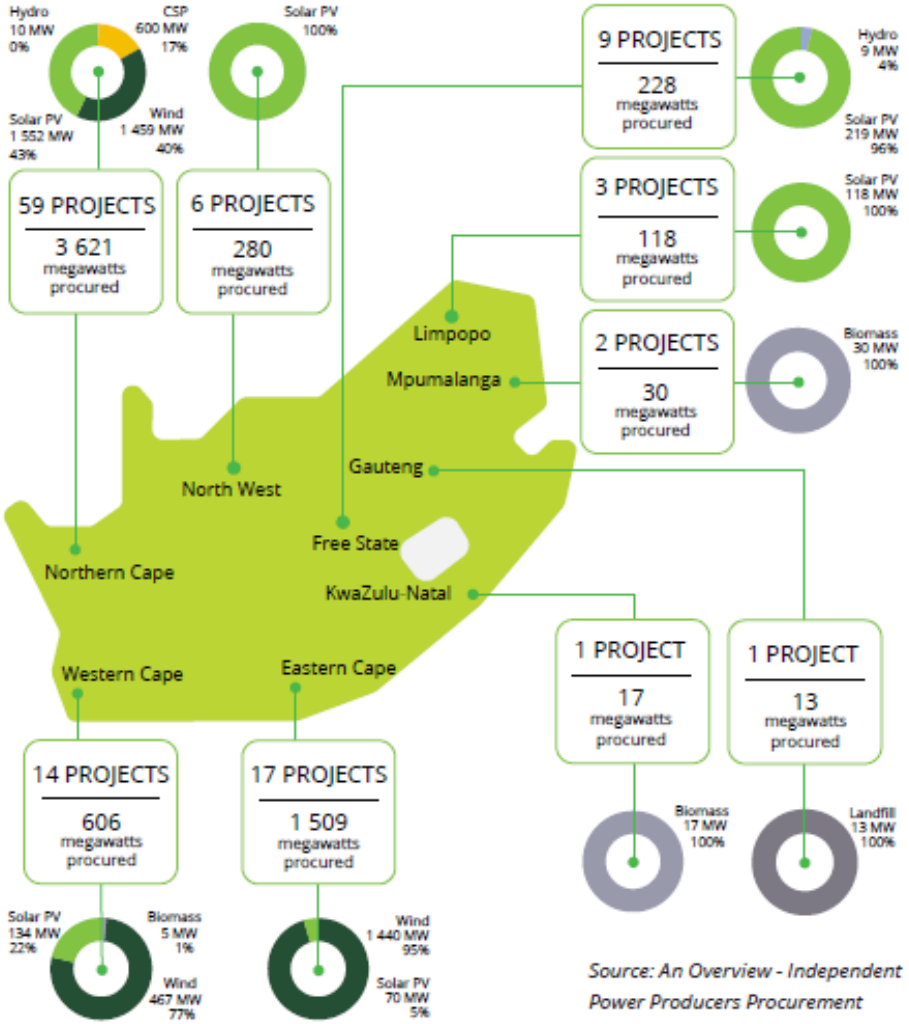


S. Africa Renewable Capacity





Source: An Overview - Independent Power Producers Procurement Programme (IPPPP) - As at 30 June 2018



Source: An Overview - Independent Power Producers Procurement Programme (IPPPP) - As at 30 June 2018

Green hydrogen production aims to occupy 4% of the global market share by 2050

- In February, the South African Hydrogen Society Roadmap(HSRM) was published by the South African government
  - Install 10 GW of electrolysis capacity in the Northern Cape by 2030 and aim to produce approximately 500,000 tons of green hydrogen
  - Expected to create 20,000 jobs annually by 2030 and 30,000 jobs by 2040
  - South Africa projected to produce green hydrogen at a cost of $1.60 per kg by 2030, making it globally competitive
- The German government will launch a new project for green hydrogen production in South Africa in 2021

South African Green Hydrogen Projects

Projects	Contents
Hydrogen corridor	▪ To build a 'hydrogen corridor' connecting the mines of Limpopo with the port of Durban - Facilitate the conversion of trucks from diesel to fuel cell trucks, increasing hydrogen demand by 80% by 2030
COALCO$_2$-X project	▪ Mpumalanga plans to use green hydrogen and coal power station flue gas pollutants to support the country's just energy transition to a decarbonized energy system, meet emission reduction goals and create value added products, such as fertilizer for export
Sustainable Aviation Fuels (SAF) project	▪ Sasol is also playing a leading role - SAF is key to GHG emission reductions, improved local air quality, reduced exposure to jet fuel supply and price volatility, and the decarbonization of aviation fuels
Boegoebaai Green Hydrogen Development Project	▪ Sasol is leading, the project has an established hydrogen production plant and is a designated Strategic Integrated Project (SIP) in the South African National Development Plan - It will consist of seven key facilities, including the construction of a deep water port, the use of 30 GW of wind and solar, and a battery park to power 10 GW of electrolyzers by 2030 - The project will also include the production of green ammonia linked to green hydrogen for export

BUILDING BLOCKS FOR A SOUTH AFRICAN HYDROGEN SOCIETY

2021-2024

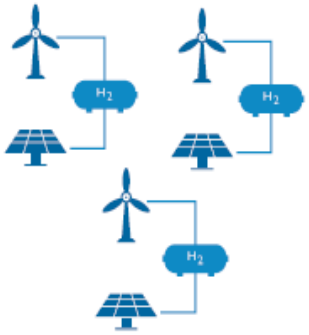
PRODUCTION
- Small scale electrolysis production
- At least 1MW GH2 production piloted

USE
- At least 100 buses and trucks powered by H2 by 2025
- At least 20 forklifts converted to fuel cell power by 2025
- At least 5 refueling stations deployed by 2025
- Demonstration in power generation and stationary fuel cells in public buildings
- Industry demonstration including SAFs

JOBS
- Upscaling of training and reskilling for new jobs

2025-2030

PRODUCTION
- 5GW electrolysis capacity under construction in NC
- 10GW electrolysis capacity deployed in NC by 2030
- 1.7GW electrolyser capacity deployed in H2 Valley by 2030
- At least 500kt H2 produced annually by 2030



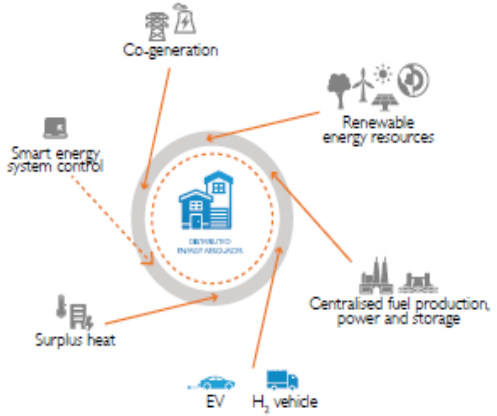
USE
- At least 500 buses and trucks powered by H2 by 2030
- Power generation in turbines using H2 and ammonia
- Sector coupling and use in transport, industry

JOBS
- At least 20 000 jobs created annually by 2030

2030-2040

PRODUCTION
- Increase electrolysis capacity to at least 15GW by 2040

USE
- Sector coupling and full use in transport, industry and power



JOBS
- At least 30 000 jobs created annually by 2040

Signed the Korea-Africa Energy Investment Framework (KAEIF) in June 2021

- **The Ministry of Strategy and Finance, the AfDB, and the Exim Bank of Korea signed the "Korea-Africa Energy Investment Framework (KAEIF)" with a limit of USD 600 million for 5 years on June 22, 2021**
  - KAEIF agreement has a particular focus on renewable energy
  - This includes generation, transmission, distribution, off-grid and mini-grid, policy reform and clean cooking
  - The support will run for five years

- **KAEIF will provide much needed additional funding, to supplement the Bank's financing, to support accelerated energy access and the continent's just transition to clean energy**

  -It would support new projects via co-financing the Economic Development Cooperation Fund(EDCF), the Economic Development Promotion Facility(EDPF) and AfDB

- **It expects that the facility will help African countries transition to green energy while simultaneously improving access to energy for people presently living without any**

- **The Korea-Egyptian Renewable Energy Cooperation Partnership Starts in January 2022**
  - South Korea had agreed to give Egypt a $1billion loan to fund a variety of projects, including efforts to bolster the Egypt's infrastructure for renewable energy
  - It is expected that Korean companies will be able to strengthen their business into Egypt through participation in eco-friendly infrastructure projects.

Need to build a network to promote South Africa's hydrogen economy

▪ There are many South African companies and initiatives in the green hydrogen space that Korean companies can engage with.

Potential project elements to consider




- Industrial park of electrolyzers
- Seawater desalination plant
- Green ammonia production plant
- Storage facility
- Solar/Wind and Battery Industrial Park
- Industrial park for common parts suppliers
- Gigafactory for advanced manufacturing of electrolyzers

S. Africa's Most Promising Hydrogen Applications

- Industry - Converting existing industries and grids to green hydrogen fuel based operations.
- Mining & Transportation - Manufacture heavy vehicles and minibuses using hydrogen-based pgm catalytic fuel cells.
- Exports - Green hydrogen is produced in large quantities and exported, while some is consumed domestically

Korea-South African business cooperation

In terms of transportation, mobile fuel cells, FCEV vehicles (with fuel cells on vehicles in bus rapid transit systems) and the use of FCEVs in commercial vehicles are leading the market on a global scale, and South Africa is competitive in this market.

- The following industries have great potential.

– Green hydrogen chemical products

– Development of CCU technology to support blue hydrogen production and decarbonization of each sector

– Development of off-grid energy solutions

- Green ammonia and green hydrogen fertilizers
- Green Steel

※ Hydrogen Export Potential by Country

Hydrogen Export Potential by Country