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Towards universal electricity access in Sub-Saharan Africa – Technology & investment requirements

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Content

Introduction — Why?

Methodology — How?

Results

What?

Discussion and conclusion

Introduction

Energy- enabler for basic human needs

Correlation between HDI, electricity consumption, and electricity access

Energy features prominently in international goals and agreements

Sustainable Development Goals

Agenda 2063

Paris Climate Agreement

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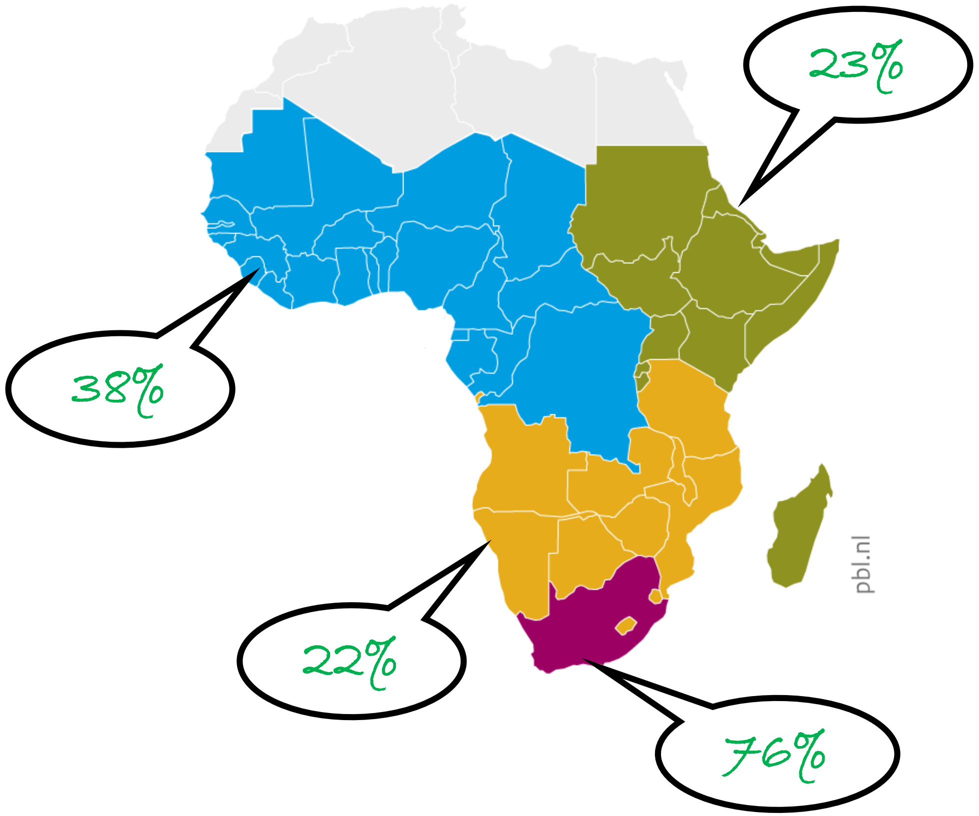
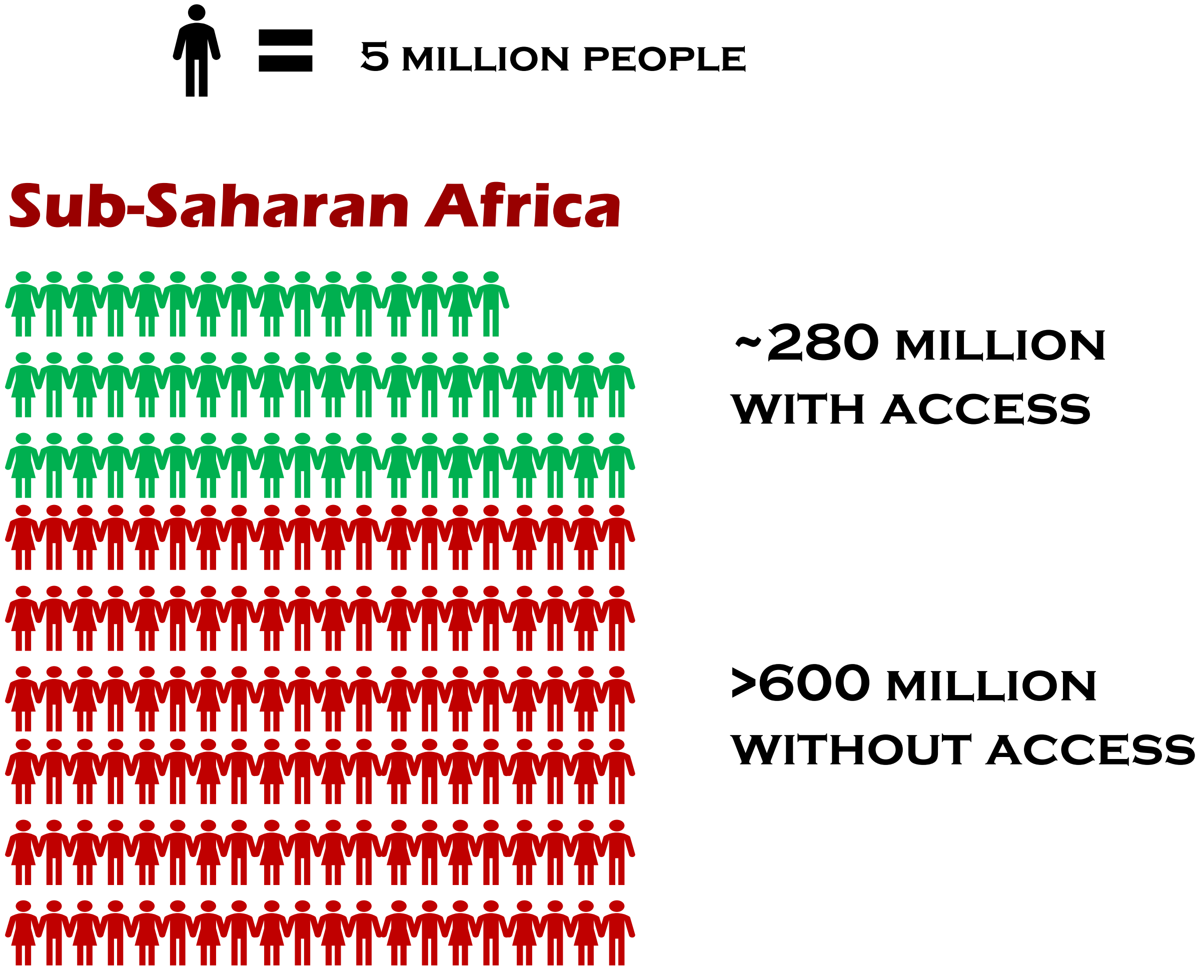
Electricity access 2010





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Electricity access 2010

5 million people

63% Urban
has access

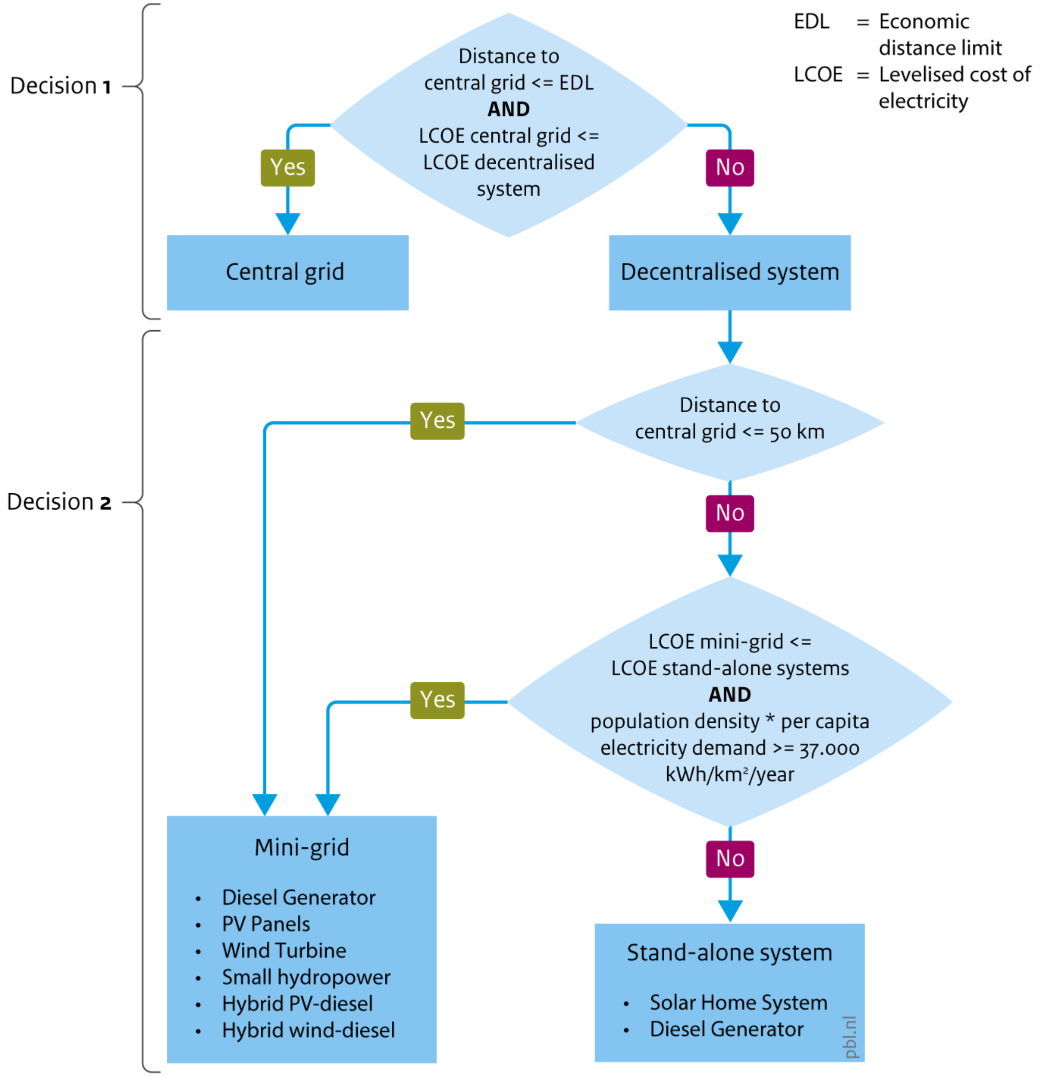
14% Rural
has access

Methodology

Electrification model

0.5°x0.5° grid-cell

Decision tree to determine the lowest-cost electrification system



Source: PBL

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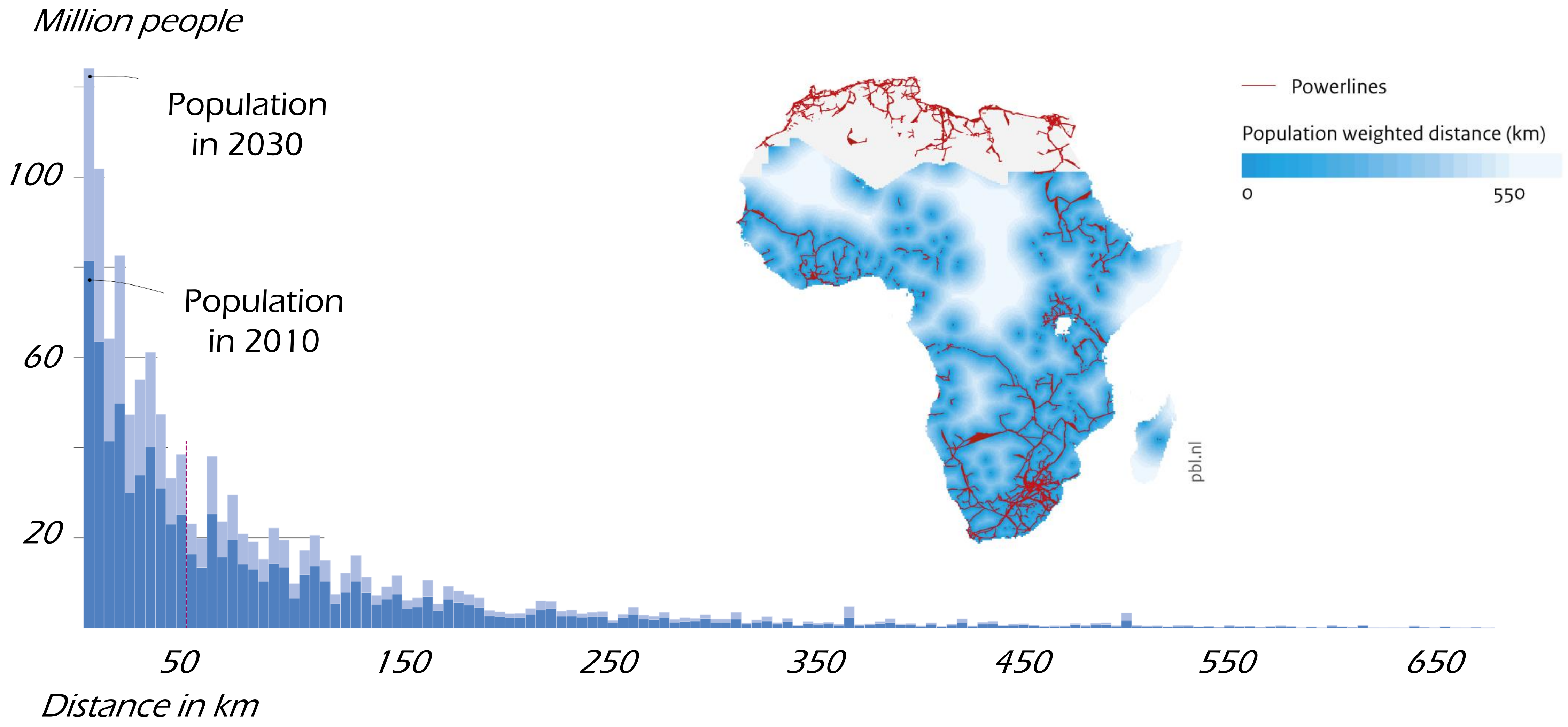
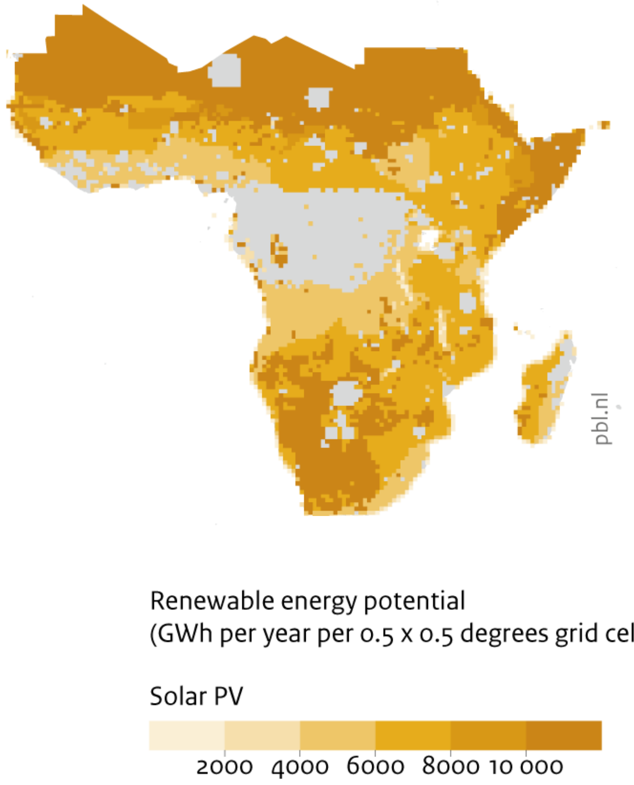
Distance to power line

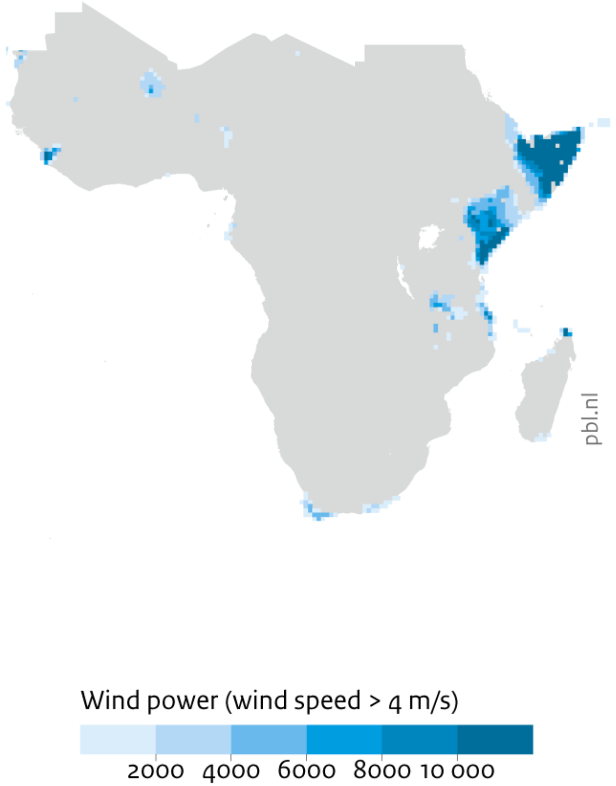


Renewable energy resources Technical potential

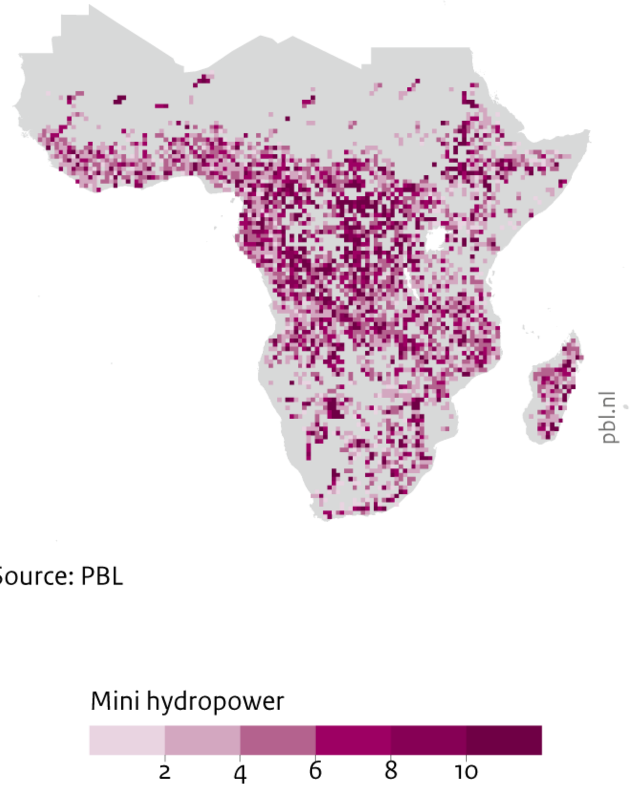
Solar PV



Wind power



Mini-hydro



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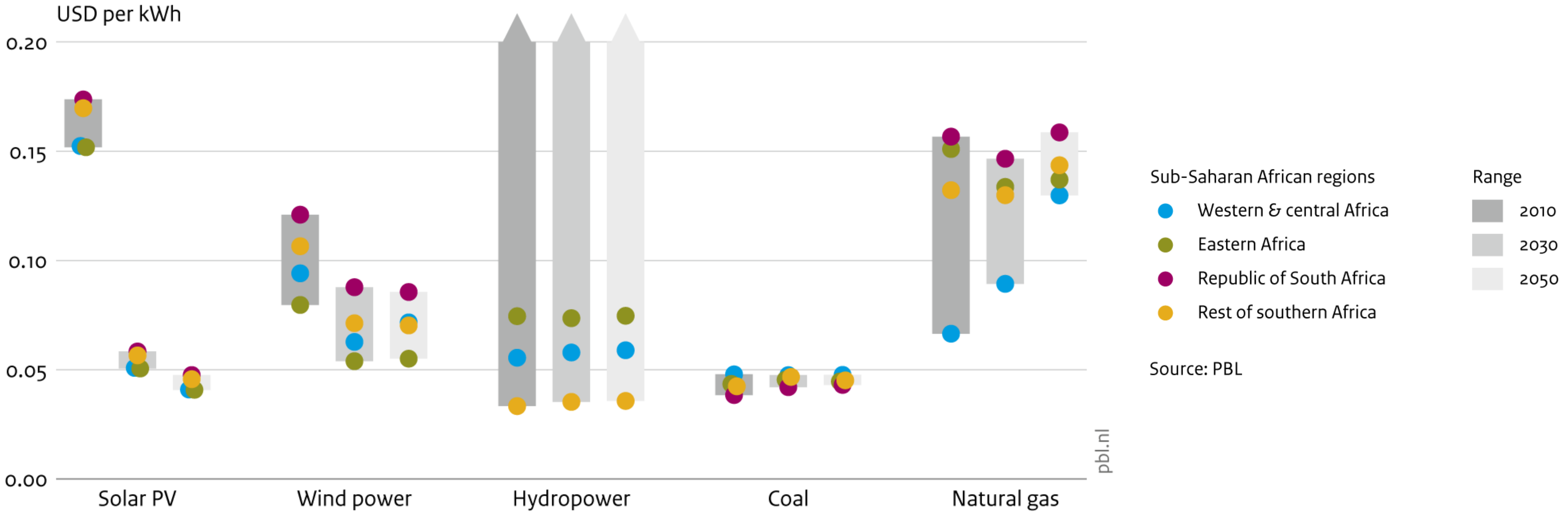
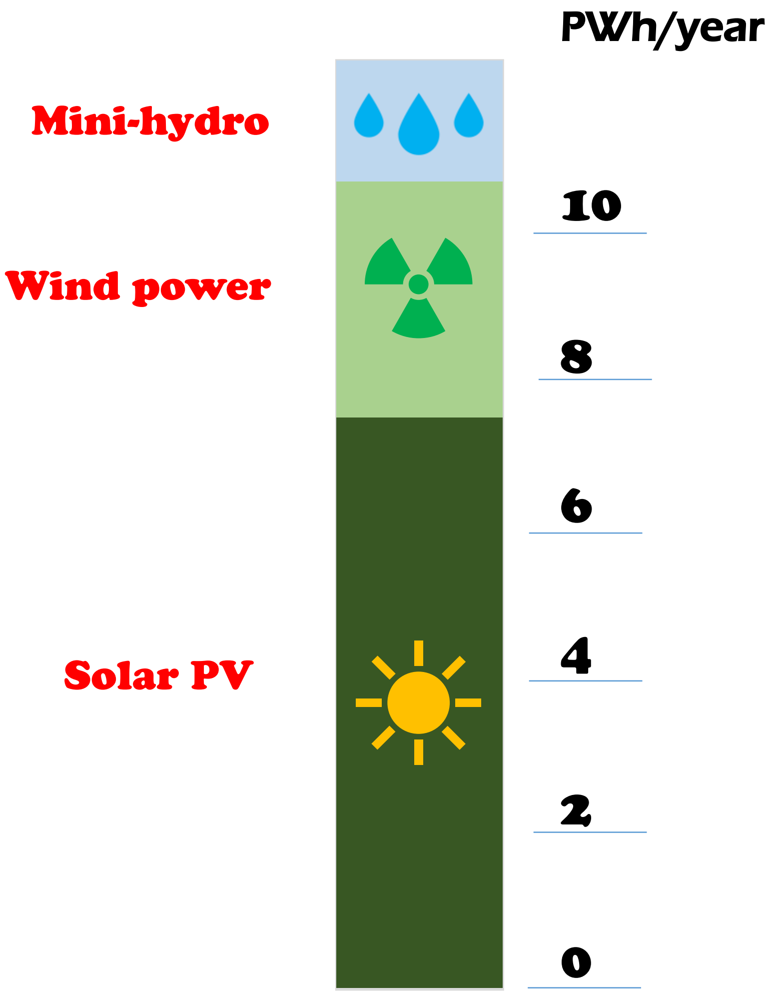
Development in renewable energy prices



Renewable energy resources — Economic potential



Renewable energy economic potential for under 0.20USD/kWh in 2010

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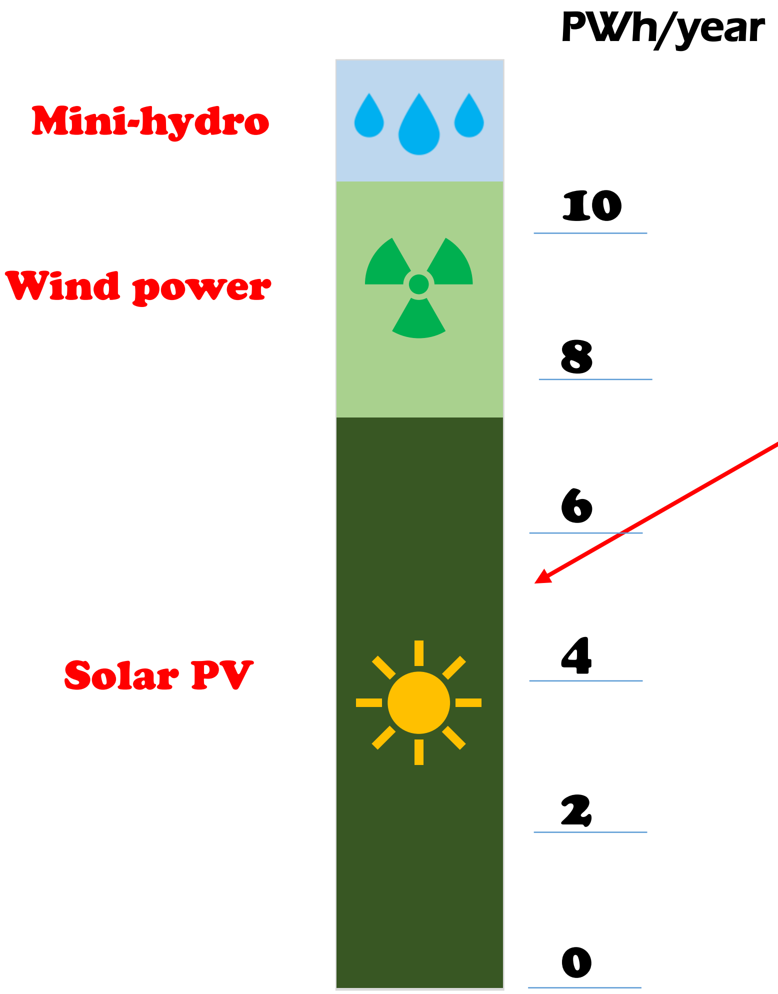
Renewable energy resources Economic potential



Half the potential is in Western & central Africa

Competition between CSP and PV

CSP potential is higher than PV potential because the thermal storage increases the capacity factor.

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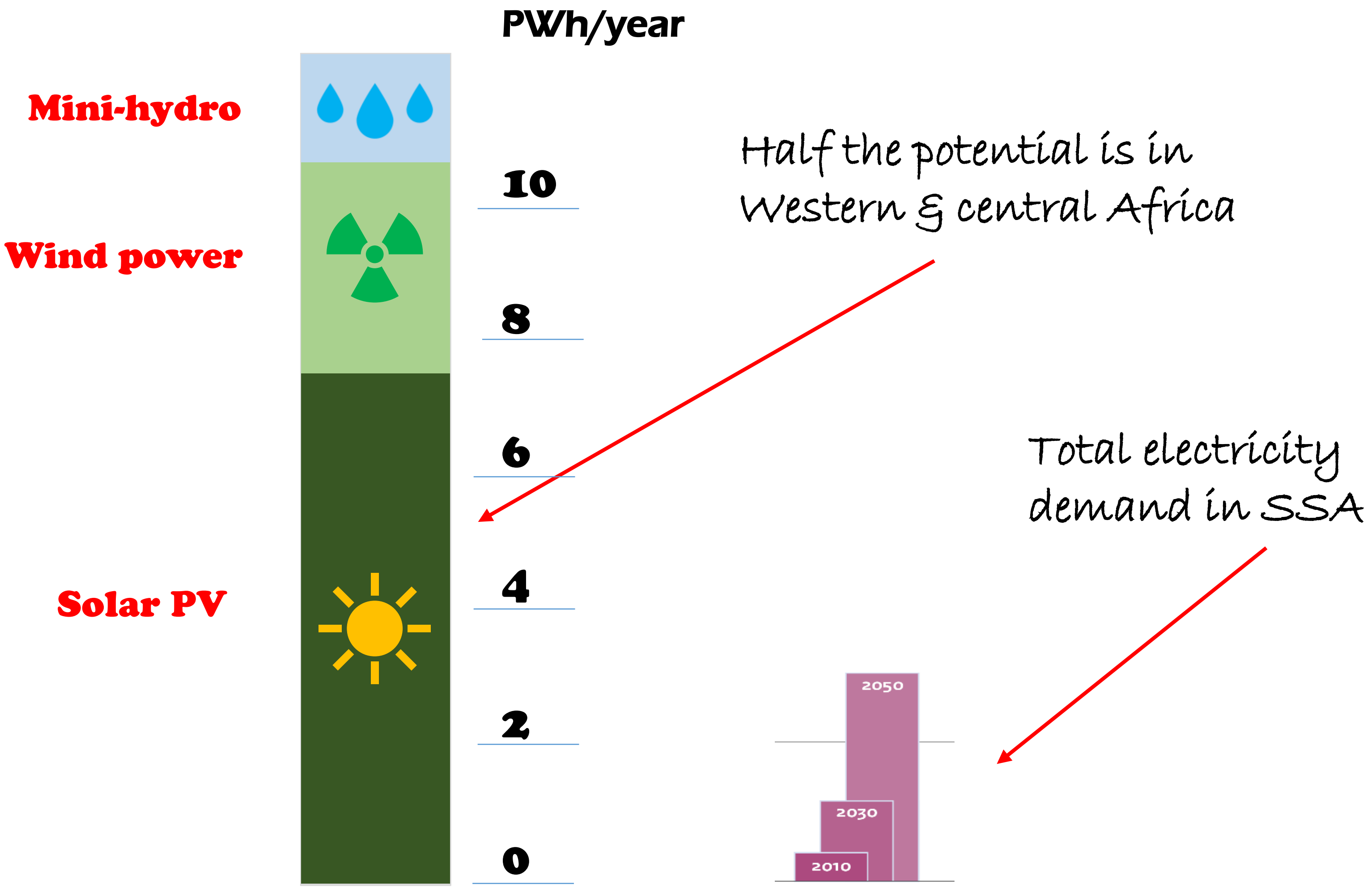
Renewable energy resources Economic potential



Scenarios

Baseline (BL) ---- Business-as-usual

Universal access (UA) ---- Electricity access for all in 2030

Universal access with climate mitigation policy (UA-CP) ----
Stringent global climate policy in a form of carbon tax

Results

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ACCESS RATE - SSP2

= 5 MILLION PEOPLE

830 MILLION
WITH ACCESS

515 MILLION
WITHOUT ACCESS

Regional differences

Urban-Rural differences

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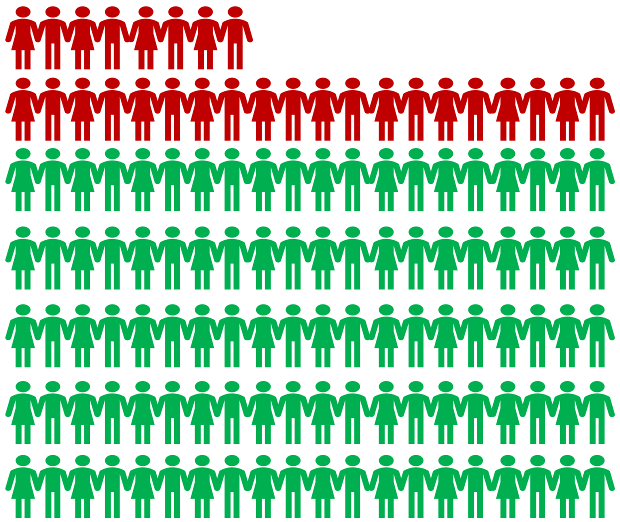
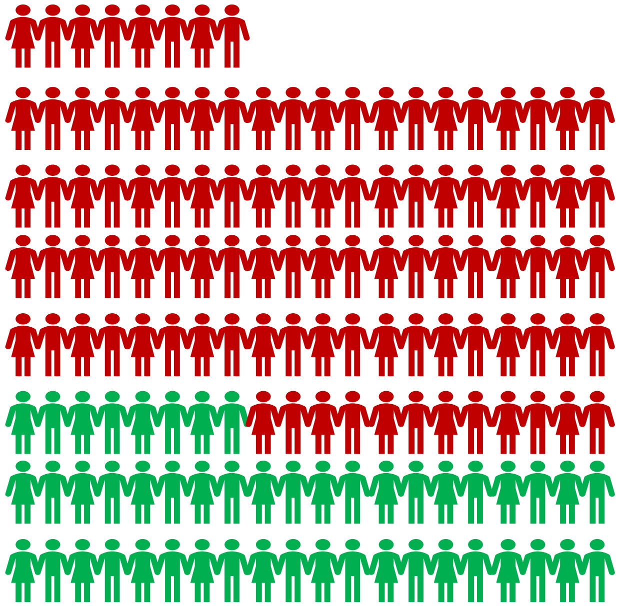
Access rate - SSP2

URBAN
88% has access



RURAL
36% has access



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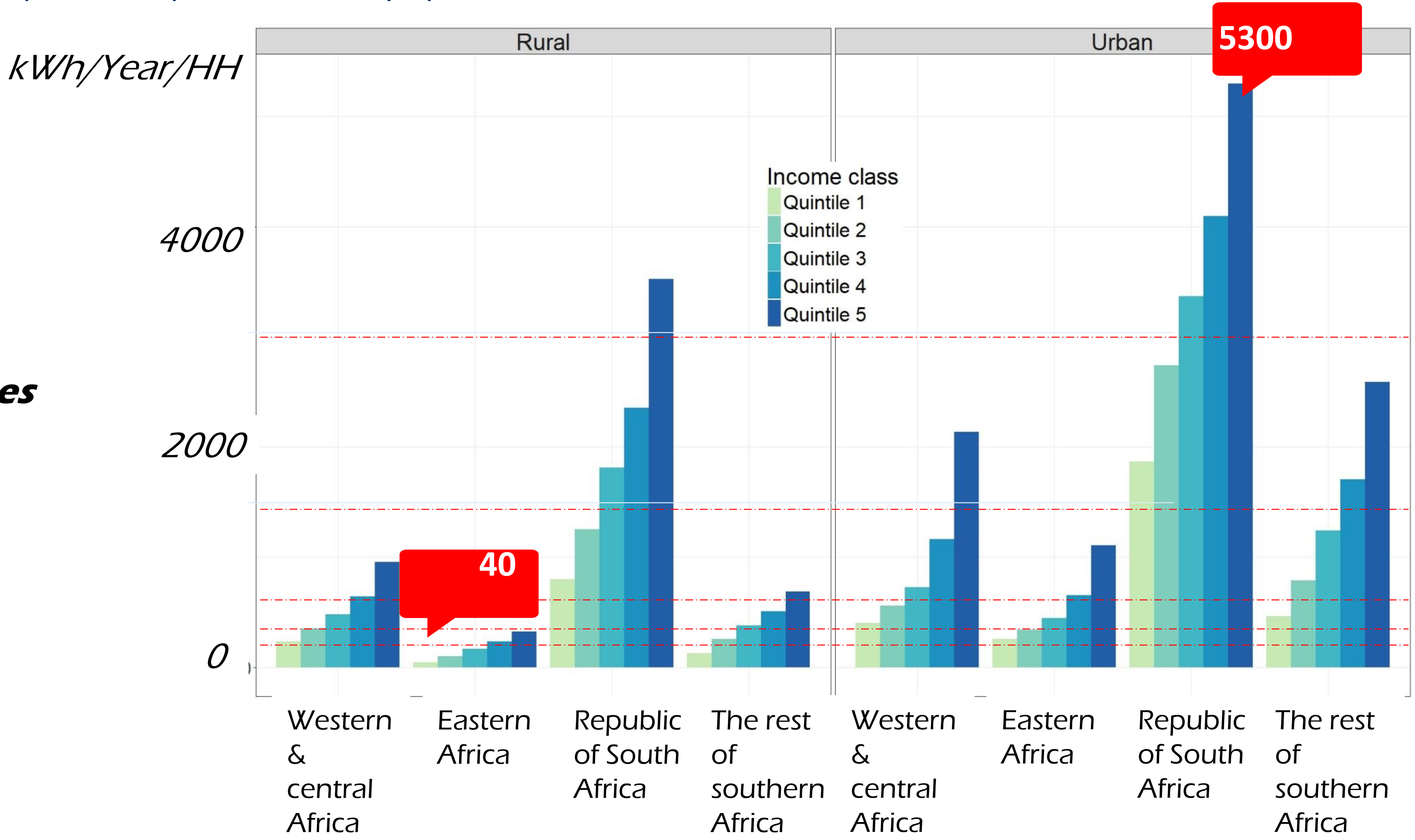
Household demand 2030

Regional differences

Urban-Rural differences



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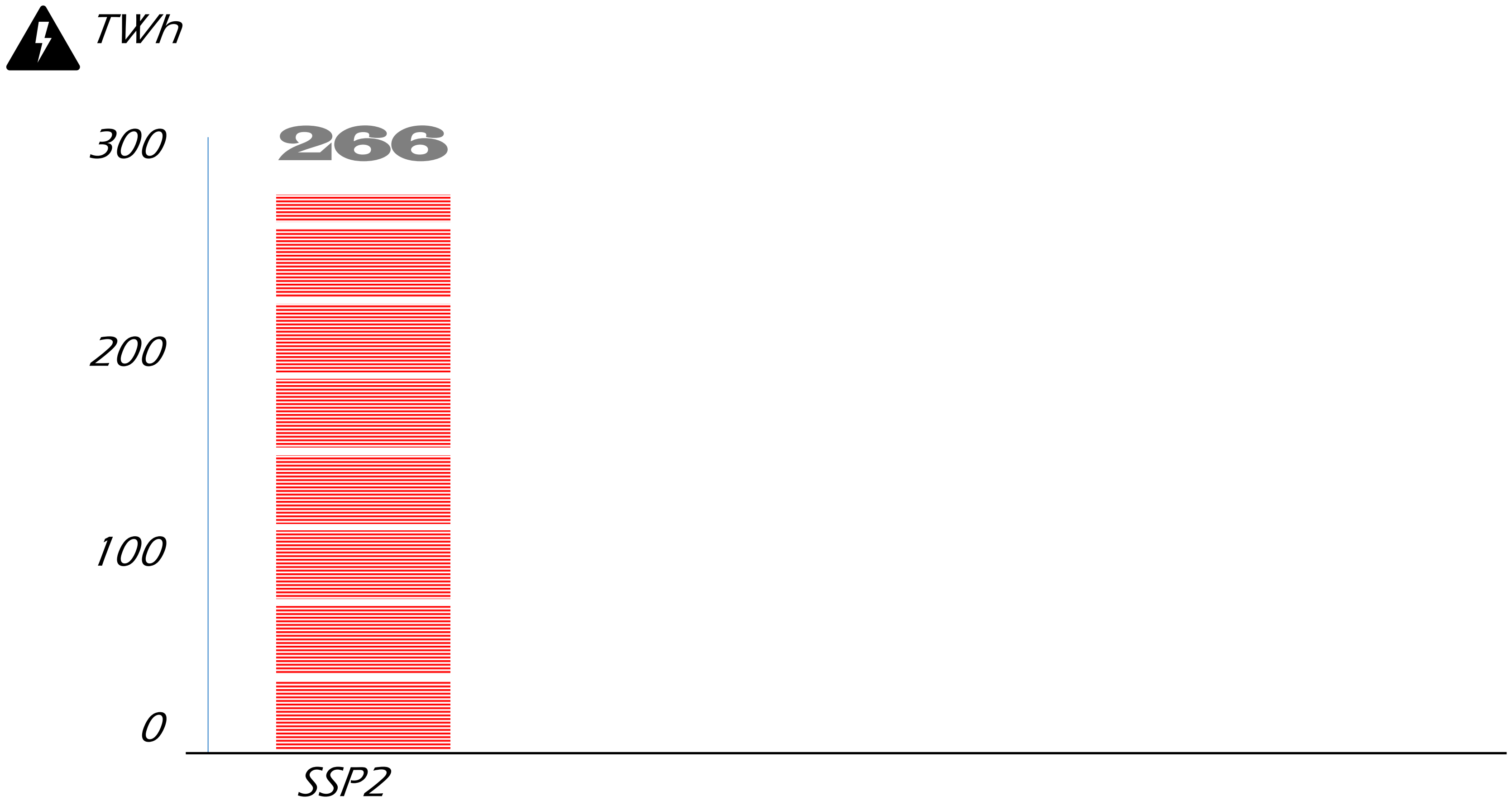
Total Residential Demand



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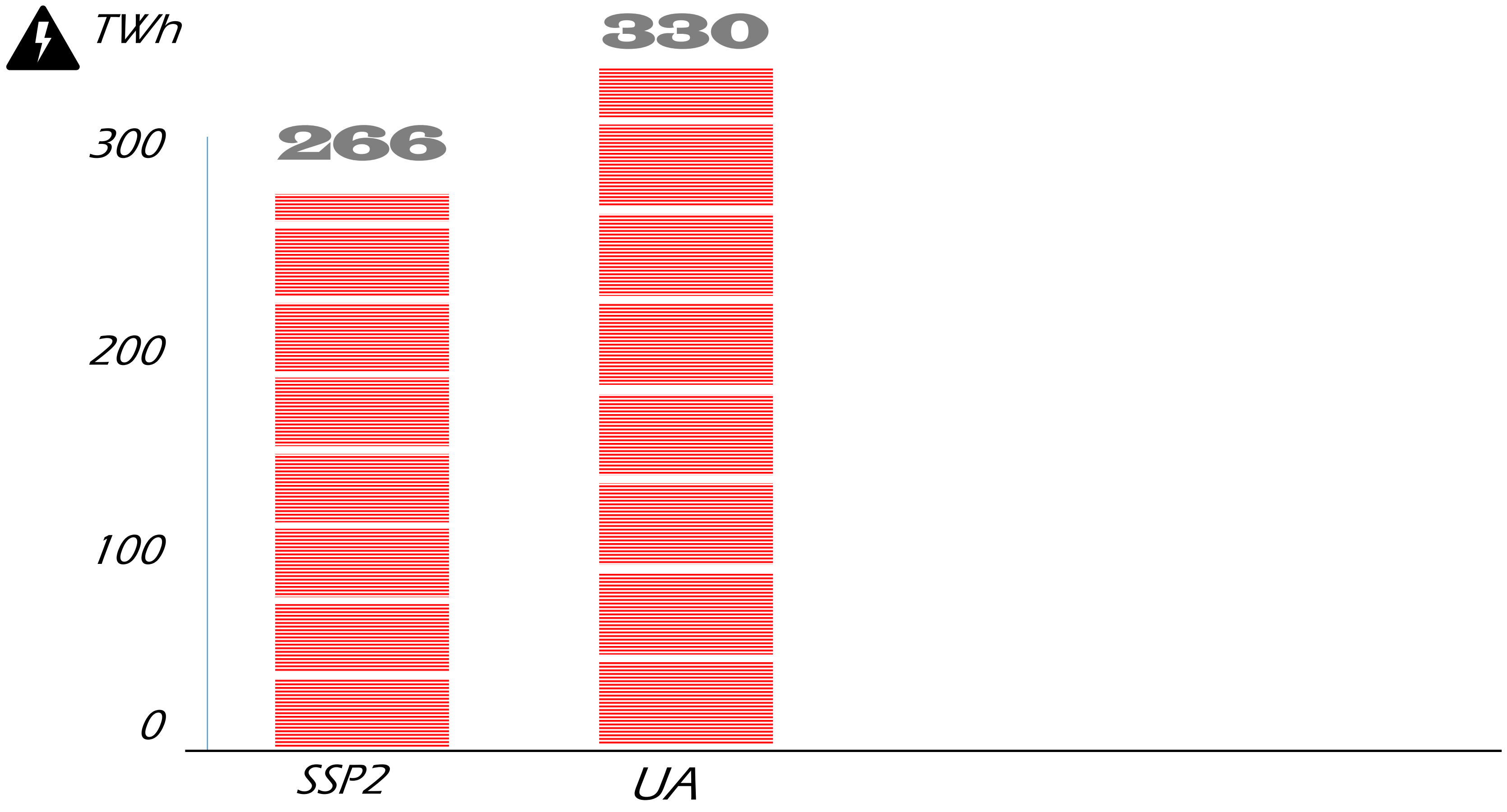
Total Residential Demand



Universal electricity access adds little to the total residential demand

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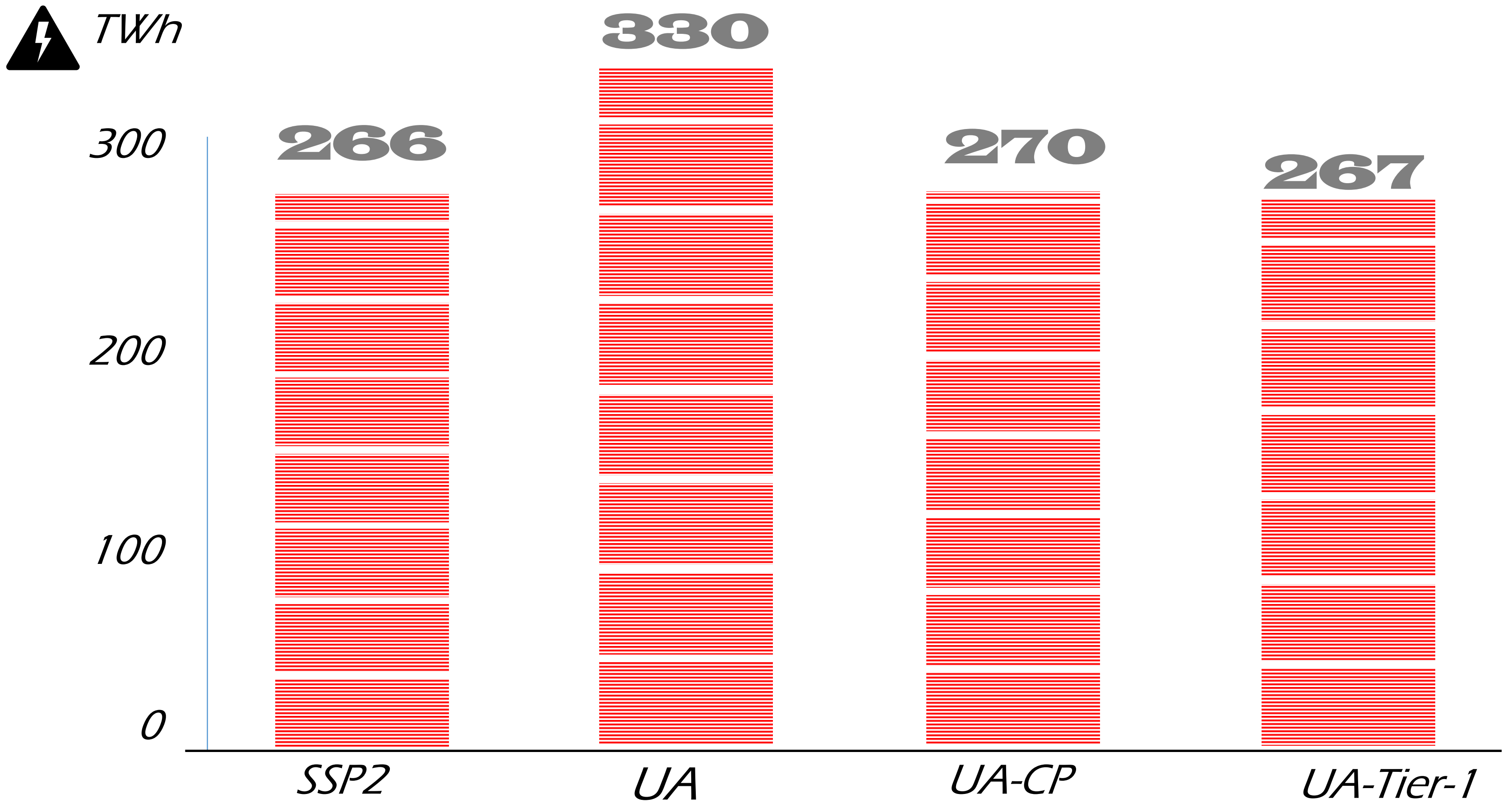
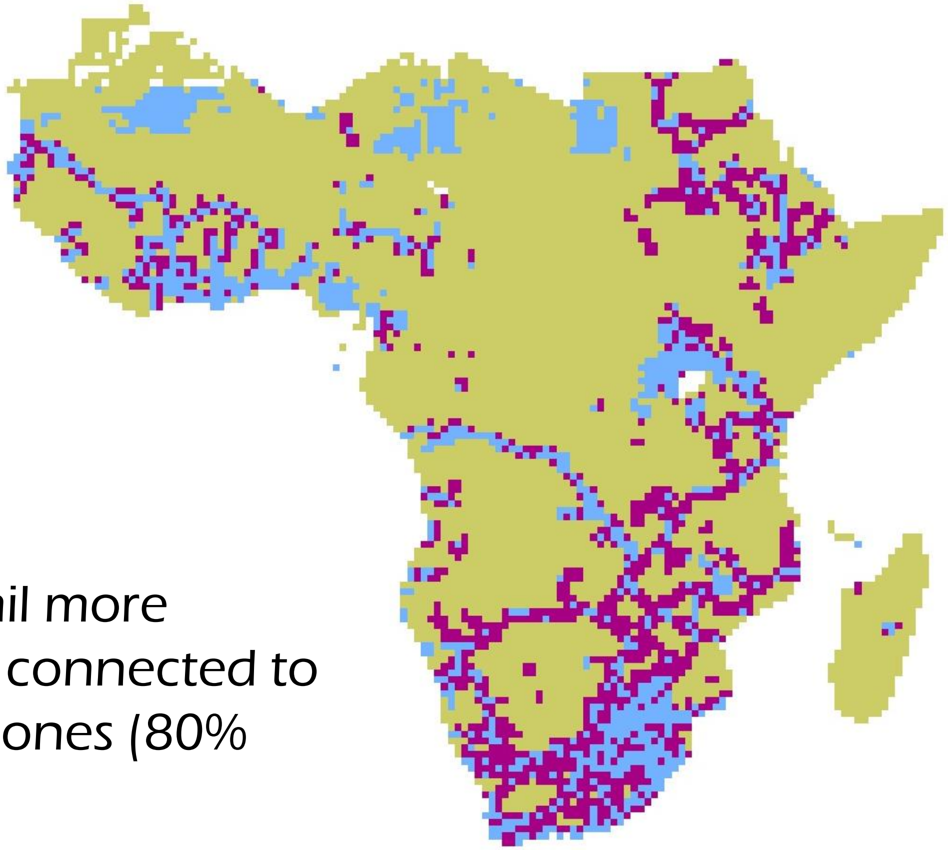
Total Residential Demand

Universal electricity access adds little to the total residential demand



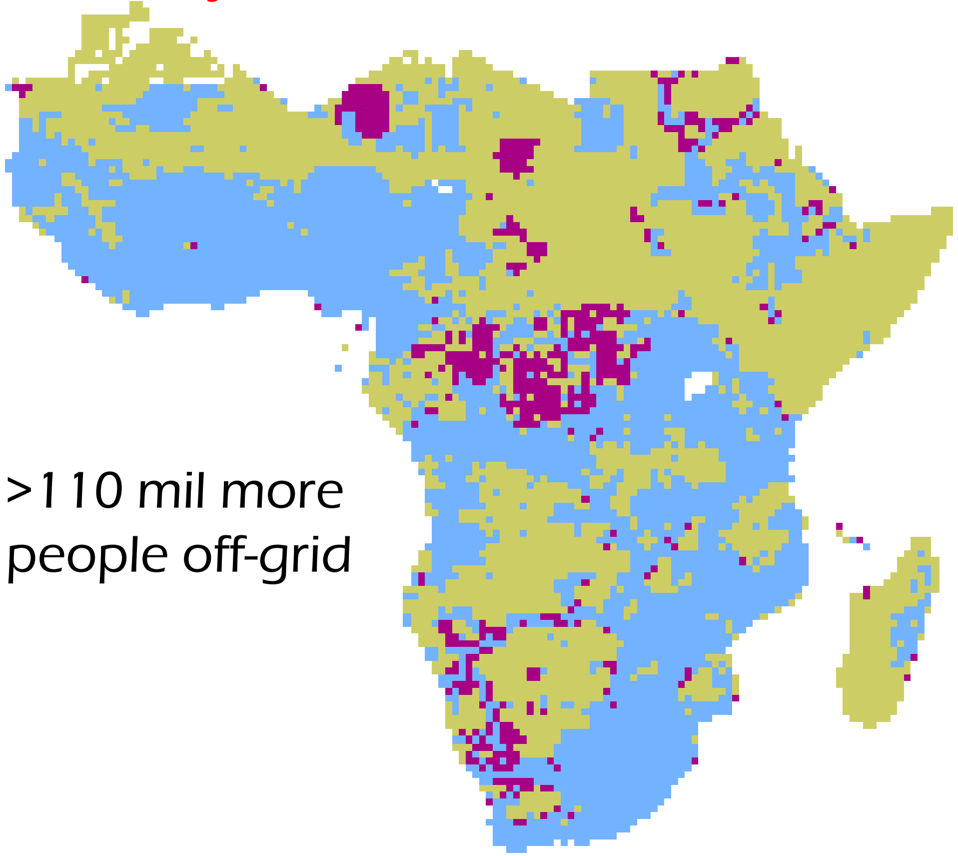
Electricity system-mix

At a very low consumption level (Tier 1-4.5kWh)



>500 mil more people connected to standalones (80% SHS)

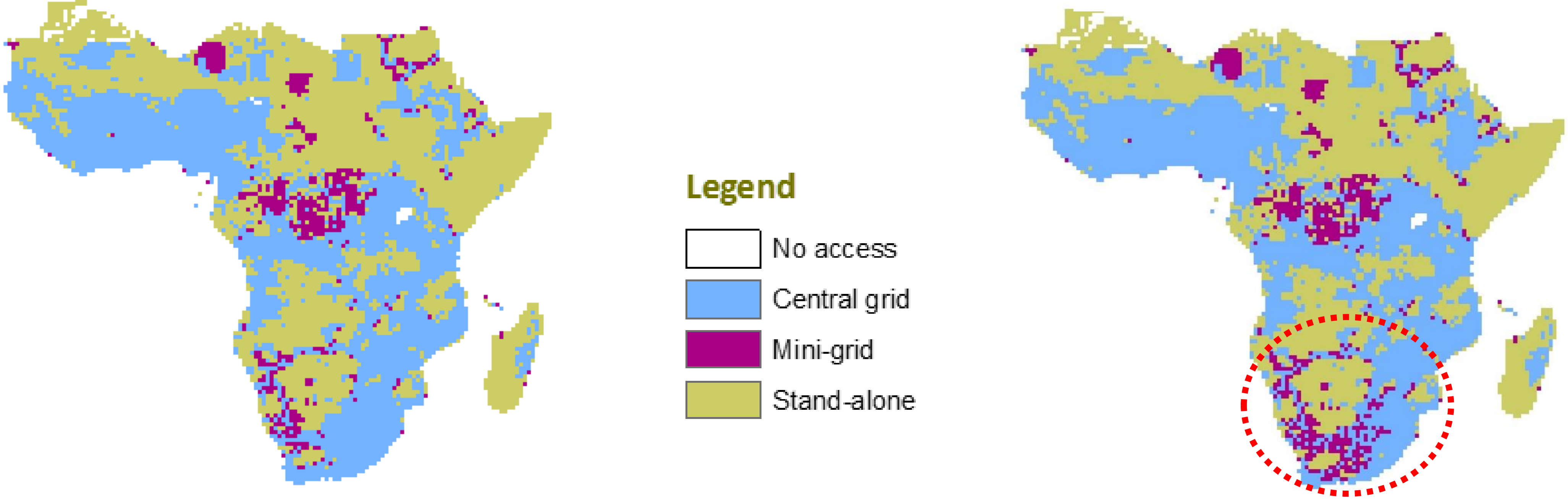
At projected consumption levels based on GDP per capita, fuel prices, appliance efficiency, etc..



>110 mil more people off-grid

CLIMATE CHANGE MITIGATION POLICY

UA scenario *UA-CP scenario*

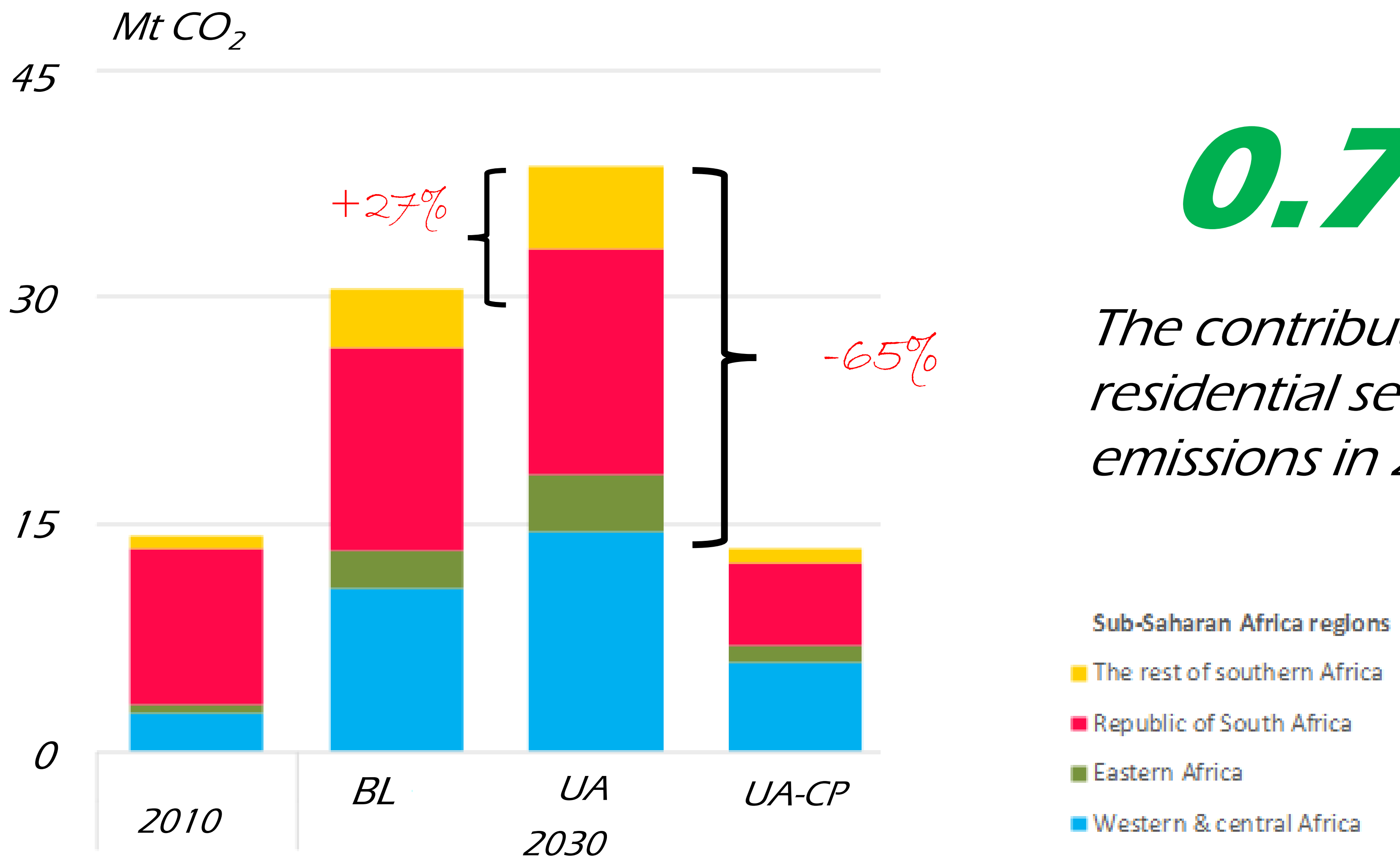


Niger, Chad, Ethiopia, Somalia, Angola, Namibia & Madagascar rely largely on standalone systems

Southern and Western Africa can be economically connected to the central grid

A considerable shift from fossil fuel to renewable under UA-CP!

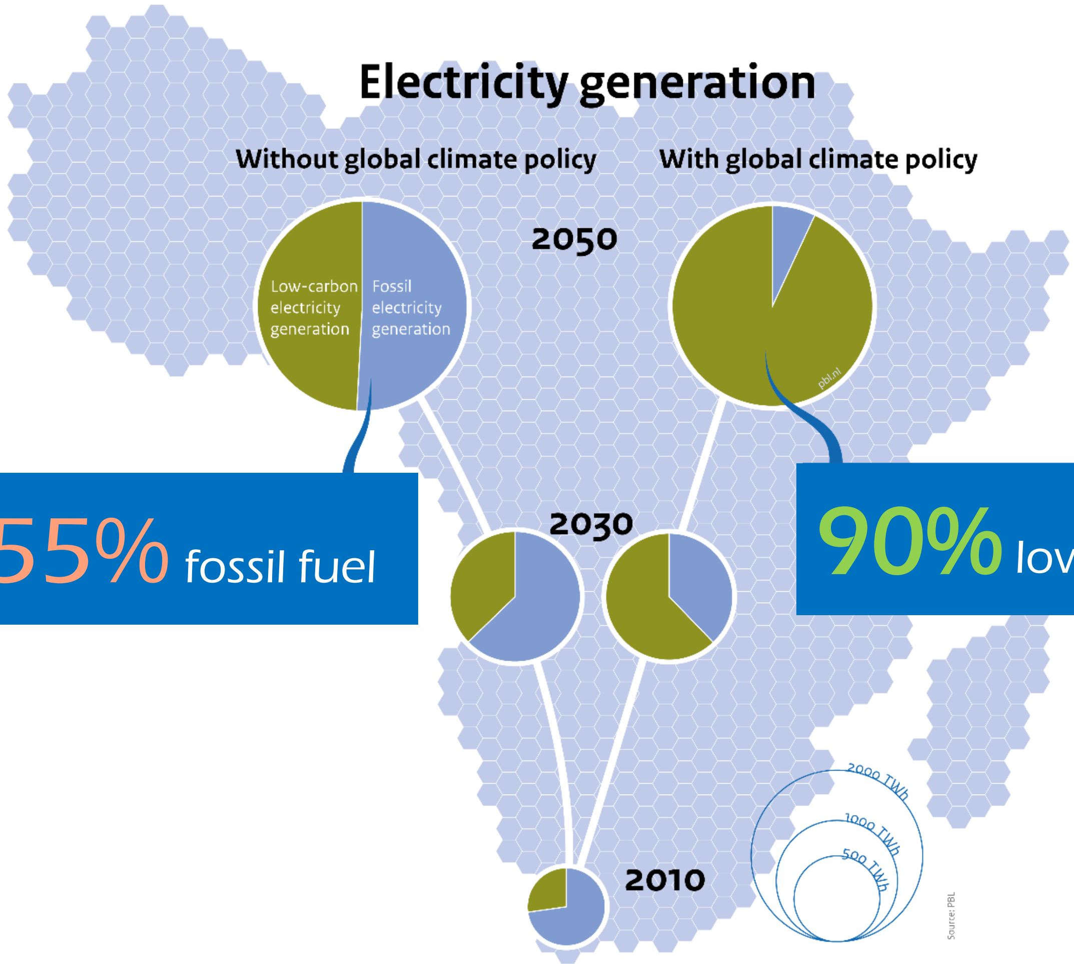
EMISSION



0.7%

The contribution of SSA's residential sector to global emissions in 2030

Fuel mix



55% fossil fuel

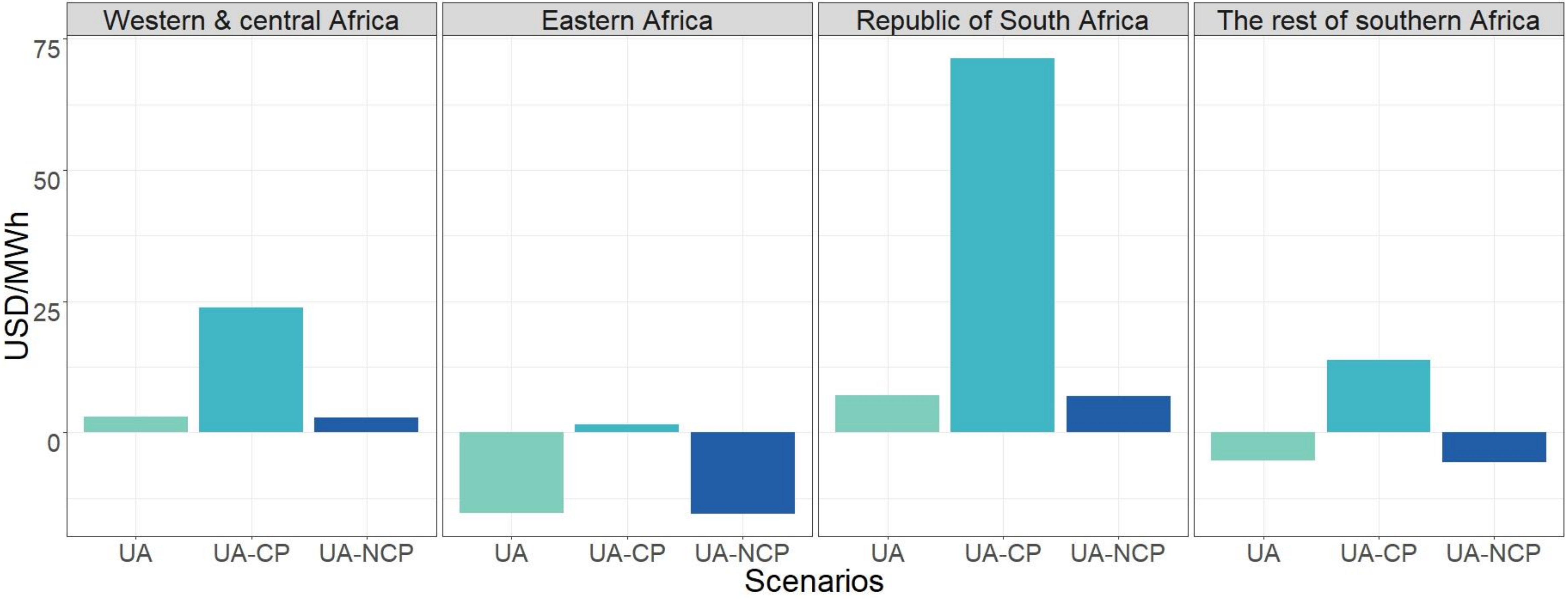
90% low-carbon

Regional differences in RE shares 2030

10% in RSA

65% in Eastern Africa

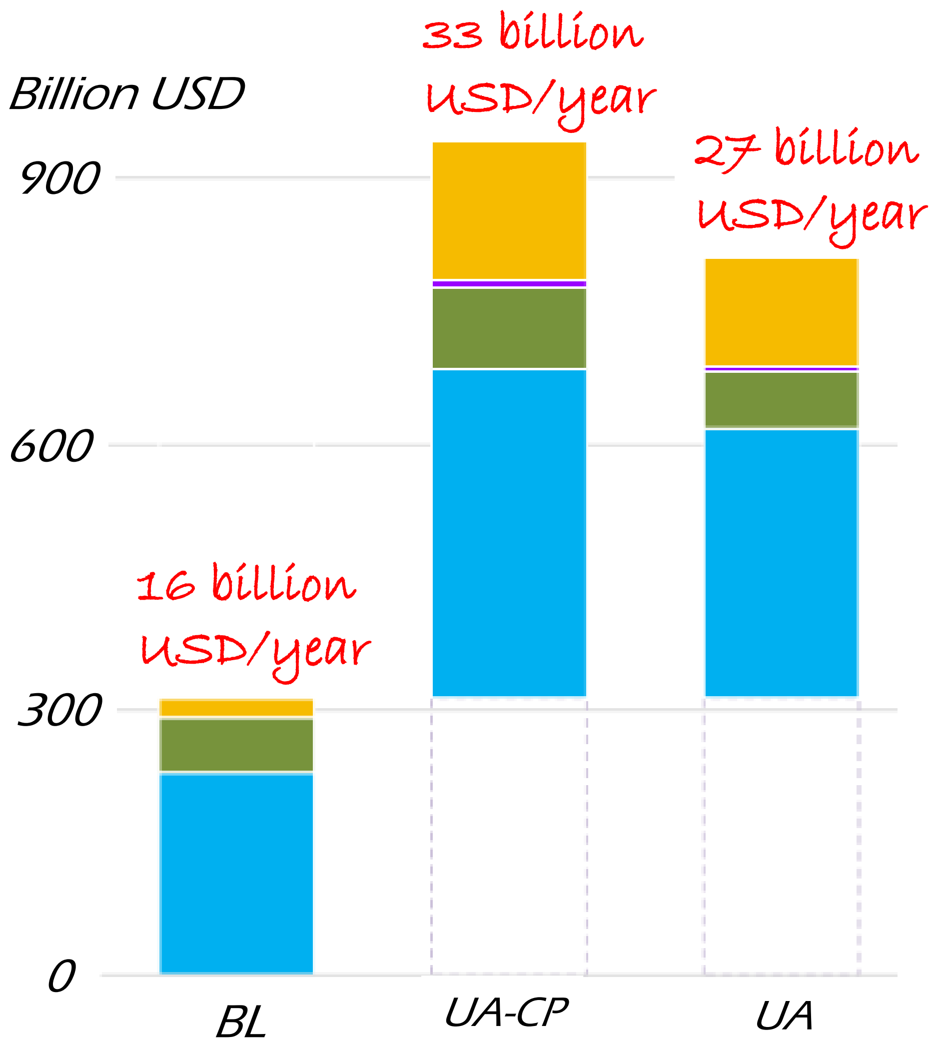
Electricity costs



25-120% increase

The higher the fossil fuel share in the mix, the higher the cost increase

Electrification investment



Baseline requires 16-19 billion USD/year

Universal access needs 27-33 billion USD/year

70-80% goes toward T&D

+ recurring costs- fuel, O&M

Discussion & Conclusion

Conclusions

- Business-as-usual ≠ Universal electricity access
- Synergies between climate mitigation and universal access to electricity
- Imposing carbon price can increase electricity prices in the regions
- The increase in CO_2 emissions due to achieving universal electricity access is small
- Achieving universal electricity access requires at least a tripling of the current annual investments
- Decentralized systems will play an important role to meet the SDGs

Strengths

- high resolution data
- dynamic elec. consumption levels
- various technologies

Uncertainties and Weaknesses

- socio-economic projections
- some aggregated variables
- simplified network design

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Thank you

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Shared Socio-economic Pathways (SSP)

	2010	SSP1 (2050)	SSP2 (2050)	SSP3 (2050)
Population Million people	860	1570	1800	2100
Economy GDP per capita USD	2000	12200	7600	4500
Urban pop %	37%	70%	57%	44%

(pbl.nl)

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Shared Socio-economic Pathways (SSP)

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(pbl.nl)

Methodology

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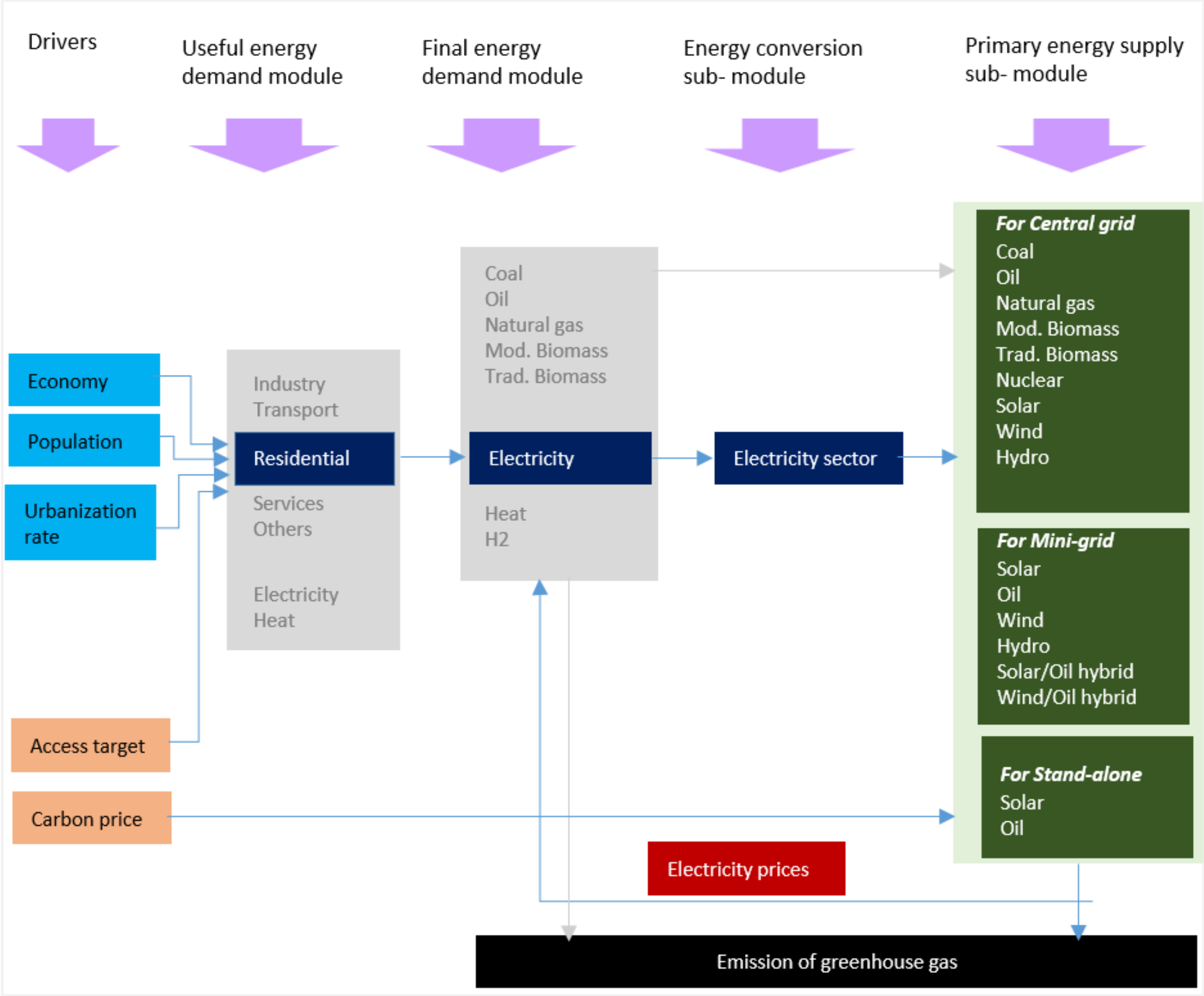
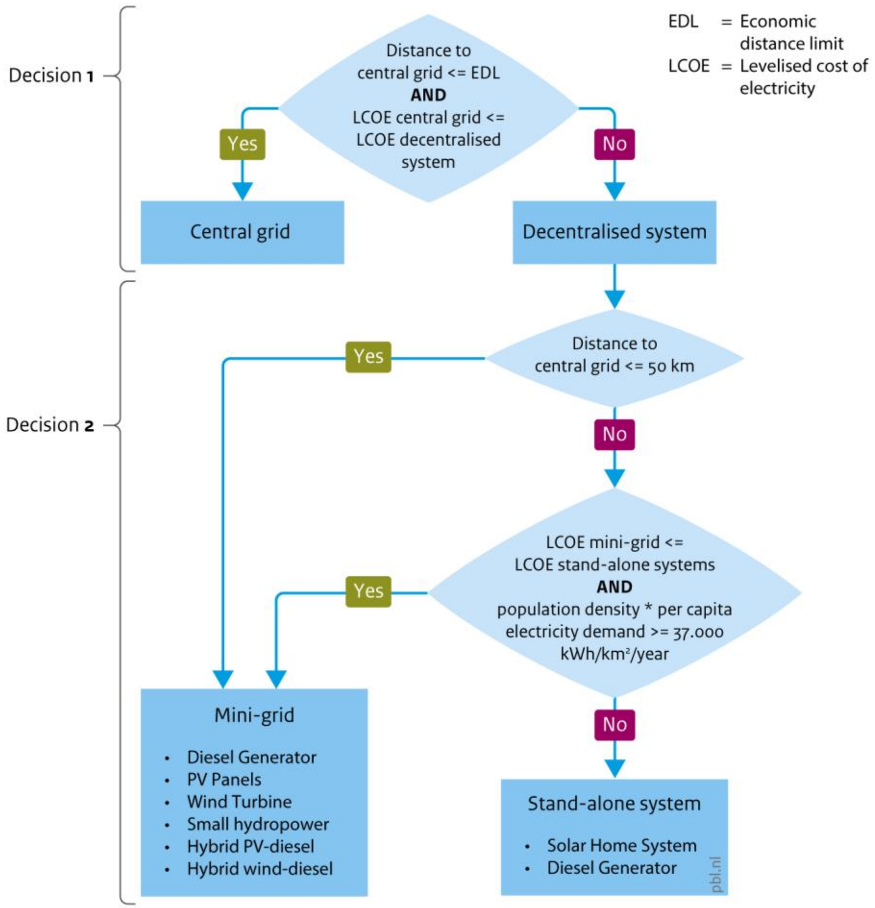
IMAGE-TIMER MODEL



Decision tree to determine the lowest-cost electrification system



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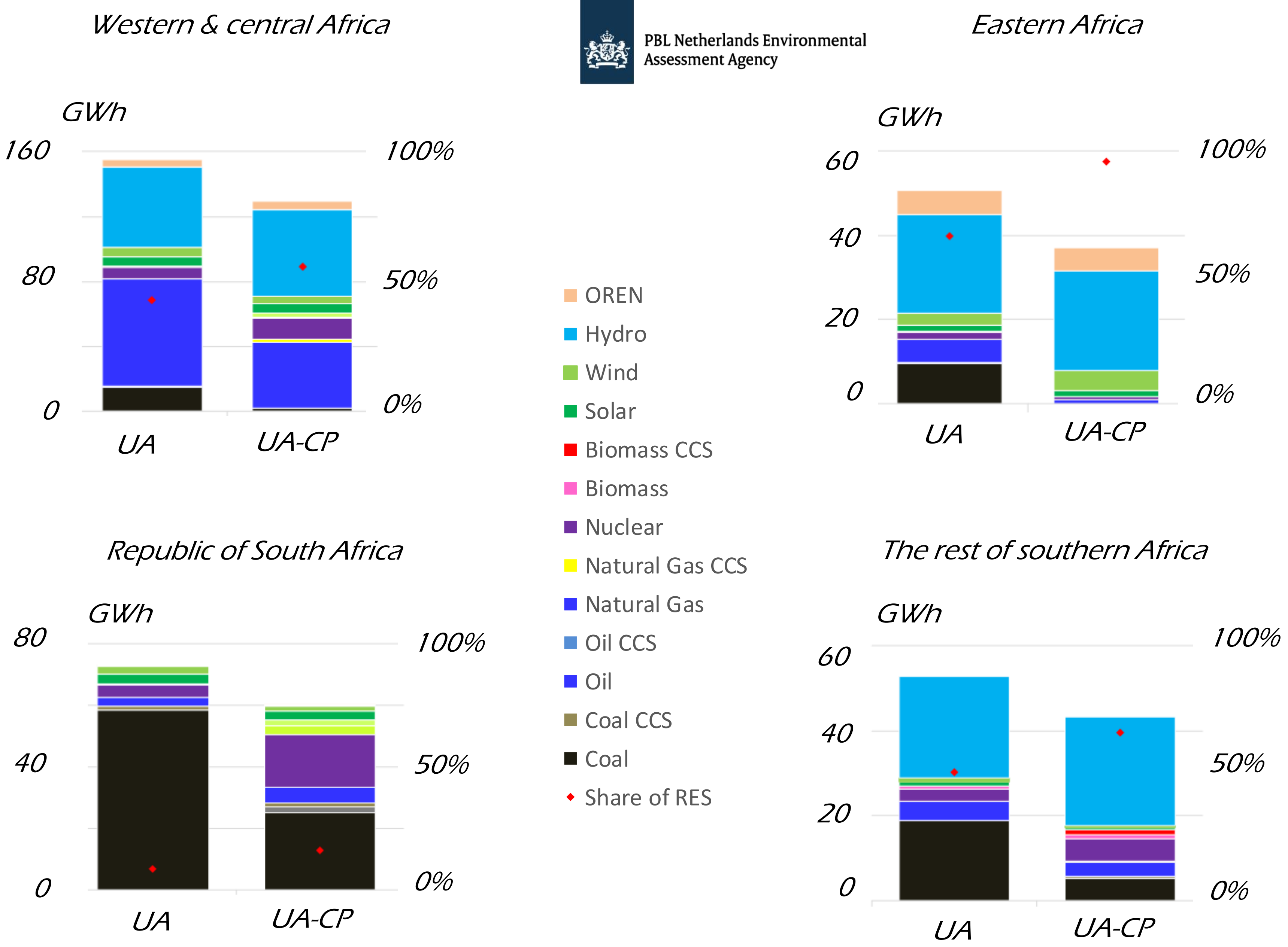
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Western & central Africa
GWh
160
80
0
100%
50%
0%
UA
UA-CP
Eastern Africa
GWh
60
40
20
0
100%
50%
0%
UA
UA-CP
Republic of South Africa
GWh
80
40
0
100%
50%
0%
UA
UA-CP
The rest of southern Africa
GWh
60
40
20
0
100%
50%
0%
UA
UA-CP
OREN
Hydro
Wind
Solar
Biomass CCS
Biomass
Nuclear
Natural Gas CCS
Natural Gas
Oil CCS
Oil
Coal CCS
Coal
Share of RES

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SSP1 73%

SSP2 63%

SSP3 57%

UTOPIA:
Sustainable development, low population growth, high economic growth, high urbanization growth, emphasis is on human wellbeing

DYSTOPIA:
Extereme poverty, regional rivalary, moderate economic growth, rapid growing population, emphasis on national security

Solar irradiation