

Integrated course „Energy Economics“ Energy and Development

Chair of Energy Systems

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Part I

Poverty and Access to Energy

Transforming our world Agenda 2030 for sustainable development

Sustainable Development Goals (SDGs)

- Policy objectives of the United Nations (UN)
- Ensuring sustainable development at economic, social and ecological level
- Term of 15 years, until 2030
- Applies to all countries



Objective 7

Sustainable and modern energy for all

Sustainable and modern energy for all - ensuring access to affordable, reliable, sustainable and modern energy for all

- Universal access to modern energy services
 - Doubling the share of renewable energies in the global energy mix
 - Doubling the increase in global energy efficiency
- > The core element and basis for this is **access to energy**



Specialised UN-Agency Sustainable Energy for All (SEforALL)

Working with leaders in government, the private sector and civil society to drive further, faster action toward SDG 7 and towards goals of the Paris Agreement, which calls for reducing GHG emissions to limit climate warming to below 2° Celsius

Ensuring access to affordable, reliable, sustainable, and modern energy is part of the broader suite of commitments made by the UN's 193 member states

Global starting position

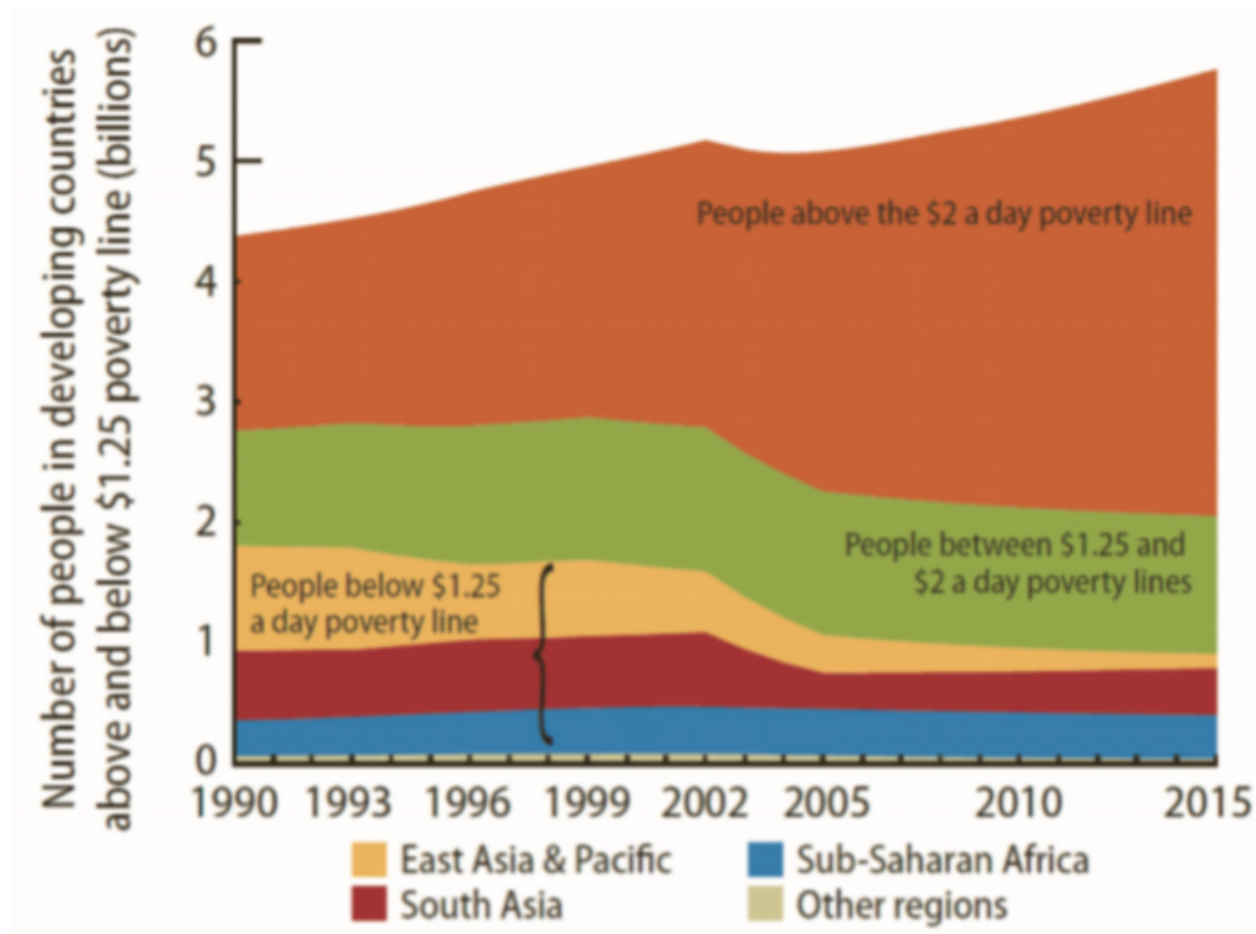
Status 2017

- About 1 billion people without access to electricity
- More than 3.1 billion people without access to clean energy for food preparation
- 18.3% share of renewables in global final energy consumption (target of 35% in 2030)
- Global energy intensity with an increase of 2.1% annually (target 2.6%)

Access to energy as a necessary basis for achieving further objectives

- Production
- Food and agriculture
- Mobility
- Education
- Health
- Water
- Environment
- Poverty reduction
- Economic development

Population and poverty line



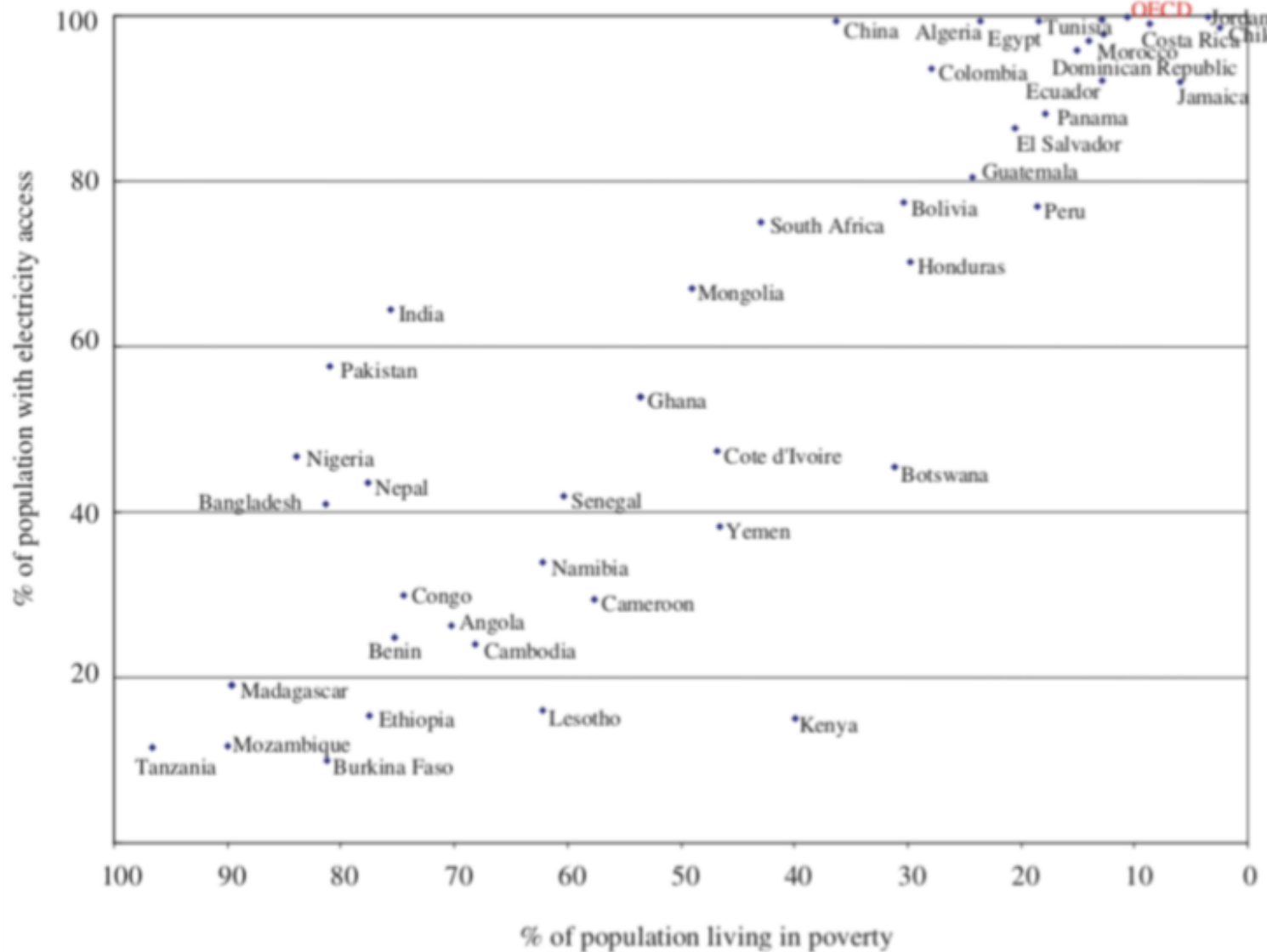
Source: Worldbank 2010 Monitor

Urban and rural population without Electricity - IEA 2010

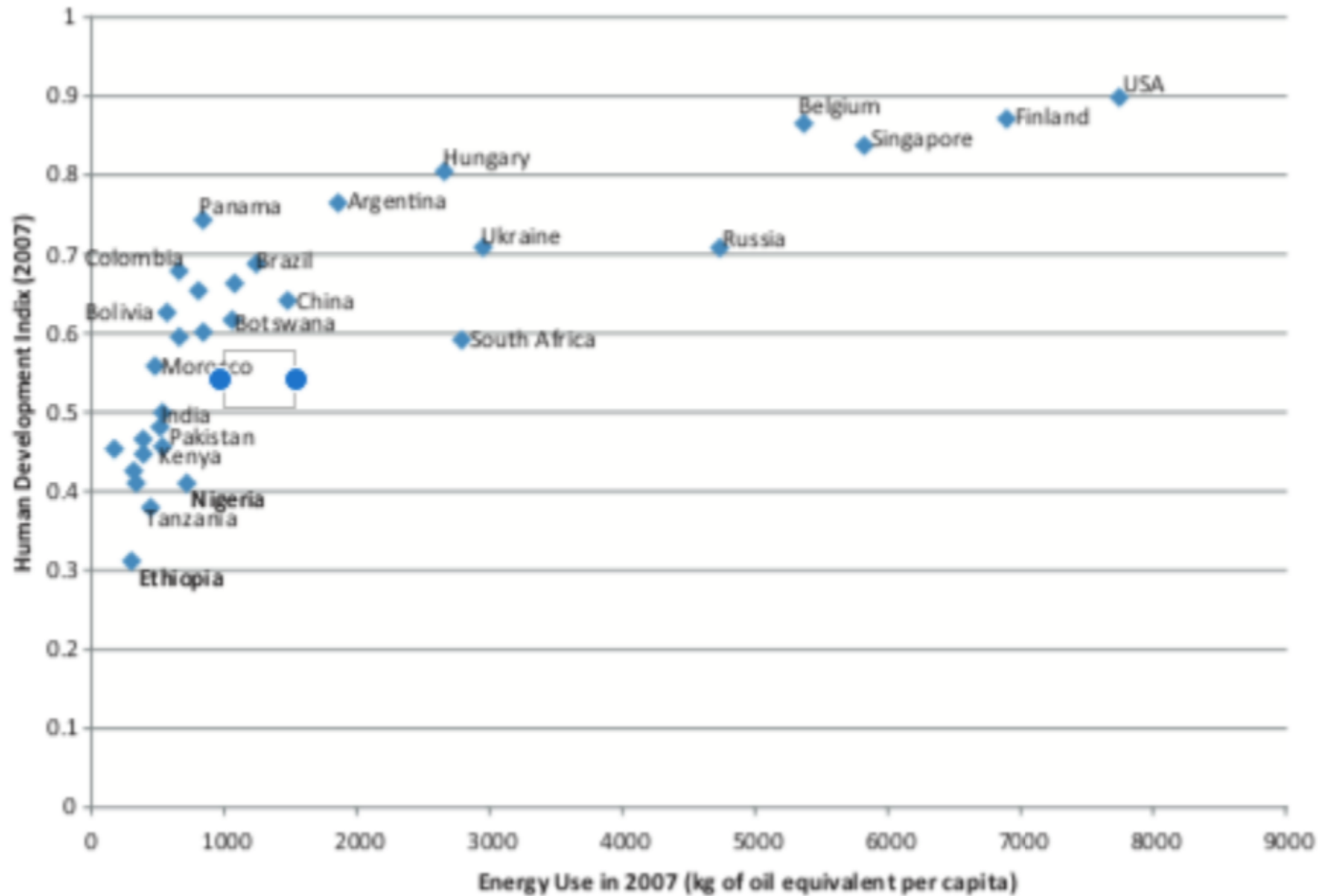
Region	Rural (million)	Urban (million)
Sub-Saharan Africa	465	120
China	8	–
India	381	23
Other developing countries in Asia	328	59
Latin America	27	4
Total	1209	206

Poverty and access to electricity

Worldbank 2010



Development and electricity consumption UNDP 2009



Energy and development 1

Goal and target	Some direct and indirect contributions of cleaner/affordable energy options
<p>MDG 1. Extreme poverty and hunger:</p> <p>To halve, between 1990 and 2015, the proportion of the world's people whose income is less than one dollar per day.</p> <p>To halve, between 1990 and 2015, the proportion of people who suffer from hunger.</p>	<ul style="list-style-type: none"> • Cleaner burning fuels and electricity can reduce the large share of household income spent on cooking, lighting and heat. The bulk of staple foods (95%) need cooking before they can be eaten and need water for cooking. • Post-harvest losses can be reduced through improved electric-powered preservation (for example, drying and smoking) and chilling/freezing. • Energy technologies such as wind pumps and treadle pumps can be used for irrigation in order to increase food production and improve nutrition. Access to affordable energy options from gaseous and liquid fuels and electricity can assist enterprise development. • Electrically driven machinery can increase productivity and provide opportunities for income generation. • Local energy supplies can often be provided by small-scale, locally owned businesses creating employment.
<p>MDG 2. Universal primary education:</p> <p>To ensure that, by 2015, children everywhere will be able to complete a full course of primary schooling.</p>	<ul style="list-style-type: none"> • Lighting at homes (e.g., through solar lanterns) allows children to study after school hours, with a significant impact on learning outcomes. • Lighting in schools can assist in retaining teachers, especially if their houses are electrified. • Availability of electricity can enable access to educational media and communications in schools and, at home, can facilitate distance learning. • Access to energy can provide opportunities for using specialized equipment for teaching. • Cleaner energy systems and efficient building design can reduce heating/cooling costs and thus school fees. • Energy can help create more child-friendly environments, thus improving attendance at school and reducing dropout rates.

Energy and development 2

MDG 3. Gender equality and women's empowerment:

To ensure that girls and boys have equal access to primary and secondary education, preferably by 2005, and to all levels of education no later than 2015.

- Availability of cleaner energy options can free girls' and young women's time from survival activities (gathering firewood, fetching water, etc.).
- Good-quality lighting can facilitate home study and organization of evening classes for girls and women who are often housebound due to traditional family responsibilities.
- Affordable and reliable energy options can broaden the scope for women's enterprises, thereby fostering employment and income generation among women.
- National decision-making by women representatives, especially on energy use at household level, can be beneficial, hence improving energy access among the poor.

MDG 4. Child mortality:

To reduce by two-thirds, between 1990 and 2015, the death rate for children under the age of five.

- GEA estimates for 2005 put the burden of disease caused by household air pollution at about 2.2 million premature deaths annually, mostly affecting children and women (see Chapters 4 and 17). Gathering and preparing traditional fuels exposes young children to health risks and can reduce time spent on childcare.
- Cleaner energy options facilitate the provision of nutritious cooked food and space heating, while boiled water contributes to better health.
- Improved energy options can provide access to better medical facilities for pediatric care, including vaccine refrigeration and equipment sterilization.
- Energy can be used to purify water or pump clean groundwater locally, which can reduce the burden of water-borne diseases.

Energy and development 3

<p>MDG 5. Maternal health: To reduce by three-quarters, between 1990 and 2015, the rate of maternal mortality.</p>	<ul style="list-style-type: none"> • Clean cooking fuels and equipment can reduce pregnant women's exposure to indoor air pollution and improve health. • Improved energy options can provide access to better medical facilities for maternal care, including laboratory services, medicine refrigeration, equipment sterilization, and operating theatres, as well as safer caesarean sections. • Improved energy options can also help retain qualified medical personnel in remote rural areas. • Cleaner energy options can reduce excessive workloads and heavy manual labor (carrying heavy loads of fuelwood and water), which could adversely affect a pregnant woman's general health and well-being.
<p>MDG 6. HIV/AIDS, malaria, and other major diseases: By 2015, to have halted and begun to reverse the spread of HIV/AIDS, malaria, and other major diseases that afflict humanity.</p>	<ul style="list-style-type: none"> • Electricity in health centers can help provide medical services at night, retain qualified staff, and allow the use of more advanced medical equipment (e.g., sterilization). • Energy for refrigeration can facilitate vaccination and medicine storage for the prevention and treatment of diseases and infections. • Energy is needed to develop, manufacture, and distribute drugs, medicines, and vaccinations. • Electricity can enable access to health education media through information and communications technologies.

Energy and development 4

MDG 7. Environmental sustainability:

To stop the unsustainable exploitation of natural resources.

To halve, between 1990 and 2015, the proportion of people who are unable to reach or afford safe drinking water and sanitation.

- Increased agricultural productivity can be facilitated by the greater use of electric-powered machinery and irrigation, which in turn reduces the need to expand the amount of land under cultivation.
- Increased renewable energy technology use can contribute greatly to alleviation of deforestation and reduction of green house emissions that lead to climate change.
- Cleaner burning fuels can reduce greenhouse gas emissions, which contribute to climate change conversion technologies.
- Simple cleaner energy solutions such as low-cost sterilization of drinking water can save many lives.

MDG 8. Global partnership for development

- Global and subregional partnerships are valuable for ensuring cross-border trade and exchange of skills in cleaner energy options as well as joint lower-cost development of transmission interconnections.

Energy and sectors

Activity	Service	Traditional technology	Mechanical power alternative
Water supply	Drinking	Container (bucket) for lifting/carrying water	Diesel pump Treadle pump Rope pump Ram pump Persian wheel Hand pump River turbine Wind pump
	Irrigation		
	Livestock watering		
Agriculture	Tillage/plowing	Animal-drawn tiller/hand hoe	Power tiller/ two-wheel tractor
	Harvesting	Scythe Animal-drawn mower Manual practices	Harvester
	Seeding	Hand planting	Bed planter Row planter Seed drill
Agro-processing	Milling/Pressing	Hand ground/Flail	Powered mill Oil expellers
	Cutting/Shredding	Knife	Sawmills Powered shredder
	Winnowing/Decorticating	Winnowing basket	Powered shaker Grinder
	Spinning	Manual spin	Powered spinner
	Drying	Handheld fan Sun drying	Powered fan Solar dryer

Energy and sectors

Natural resource extraction	Small-scale mining	Shovel Chisel Hammer Pickax	Manual percussion drill Petrol-powered drill Expandable tube with hydraulic pump
		Hand washing	Hand /fuel/water-powered water jet
		Hand screen	Hand/fuel/water-powered shaker
	Lumbering	Hand saw	Powered saw (saw mill, chain saw)
Small-scale manufacturing	Metal working	Hammer	Sheet metal/pipe bender Hole puncher
	Woodworking/Carpentry	Hand saw	Sawmill Treadle lathe
	Briquetting/brick pressing	None	Hand/foot-powered pressers
	Textile making	Hand-woven	Treadle loom
	Papermaking	Mould and deckle	Paper press Pulp mill
	Pottery	Hand powered potter's wheel	Treadle pottery's wheel
Lifting and crossing	Lifting	Manual labor (climbing, lifting)	Chain/rope hoist
	Crossing	Manual labor (swimming, walking)	Gravity ropeway Twin (aerial tramway in Himalaya)

Source: adapted from Bates et al, 2009.

Access to energy

Proximity and availability of modern energy sources

Electricity, natural gas, liquid petroleum gas, biogas, ethanol

Availability of efficient end-user applications

Cooking units, lighting, water pumps, food processing, energy-efficient housing and transport

Economy and security of supply

Access includes affordable and stable supply of clean energy, reliability of supply and quality

Energy poverty and energy access

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Chapter I

Energy poverty and energy access

→ Overview

Predicted changes in energy-poor populations in sub-Saharan Africa 2014-2040

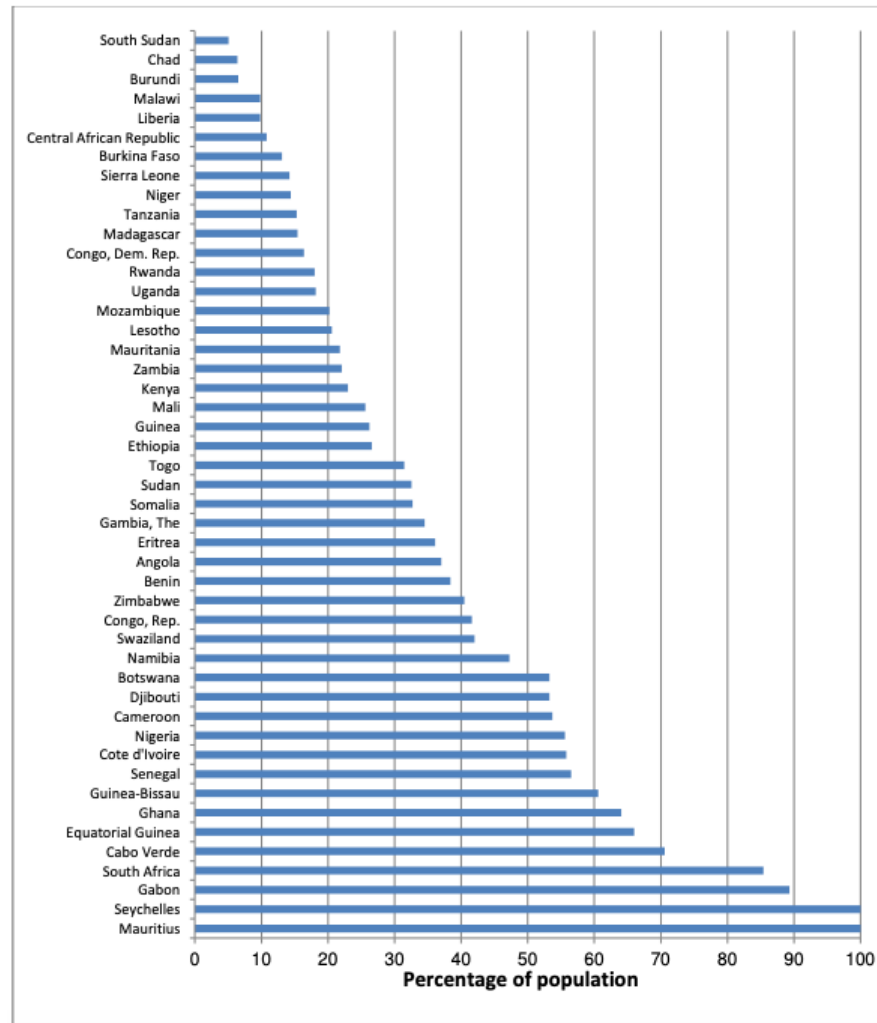
	2014	2030	2040
Number of people without access to electricity (millions)	633	619	489
Number of people reliant on traditional biomass for cooking (millions)	792	823	708

Source: IEA, 2016.

Energy poverty and energy access

→ Overview

Rates of electricity access across sub-Saharan Africa countries



Source: World Bank, 2012.

Energy poverty and energy access

Two main ways to look at the subject

- Energy poverty as the energy consumption habits of populations who are deemed poor by other measures, such as income
- Energy poverty is itself a form of deprivation, so that energy-poor populations are those that lack access to the energy required to meet their basic needs
 - Many populations must expose themselves to undue risks (such as risks from pollution) or hardships (such as having to walk long distances and expend significant amounts of time collecting fuelwood) in order to meet their basic energy needs

Energy poverty and energy access

→ Energy poverty as the energy usage habits of the poor



- People, no matter how poor, need some basic amount of energy to survive
- The extent to which poor people spend a greater portion of their income and time meeting their energy needs than do wealthy households, despite the fact that wealthy households tend to consume more energy overall
- accessing even the small amount of energy needed for survival can mean spending a greater proportion of their income on energy than the proportion spent by wealthy households that consume much more energy (often fuels and appliances are less efficient than those available to wealthy populations → spend more time and money
- Empirics: poor households spend somewhere between 5 and 20 percent of their income on meeting their energy needs
- Considered *energy poor* if spend more than 10% of income on energy needs

Energy poverty and energy access

→ Energy poverty as deprivation

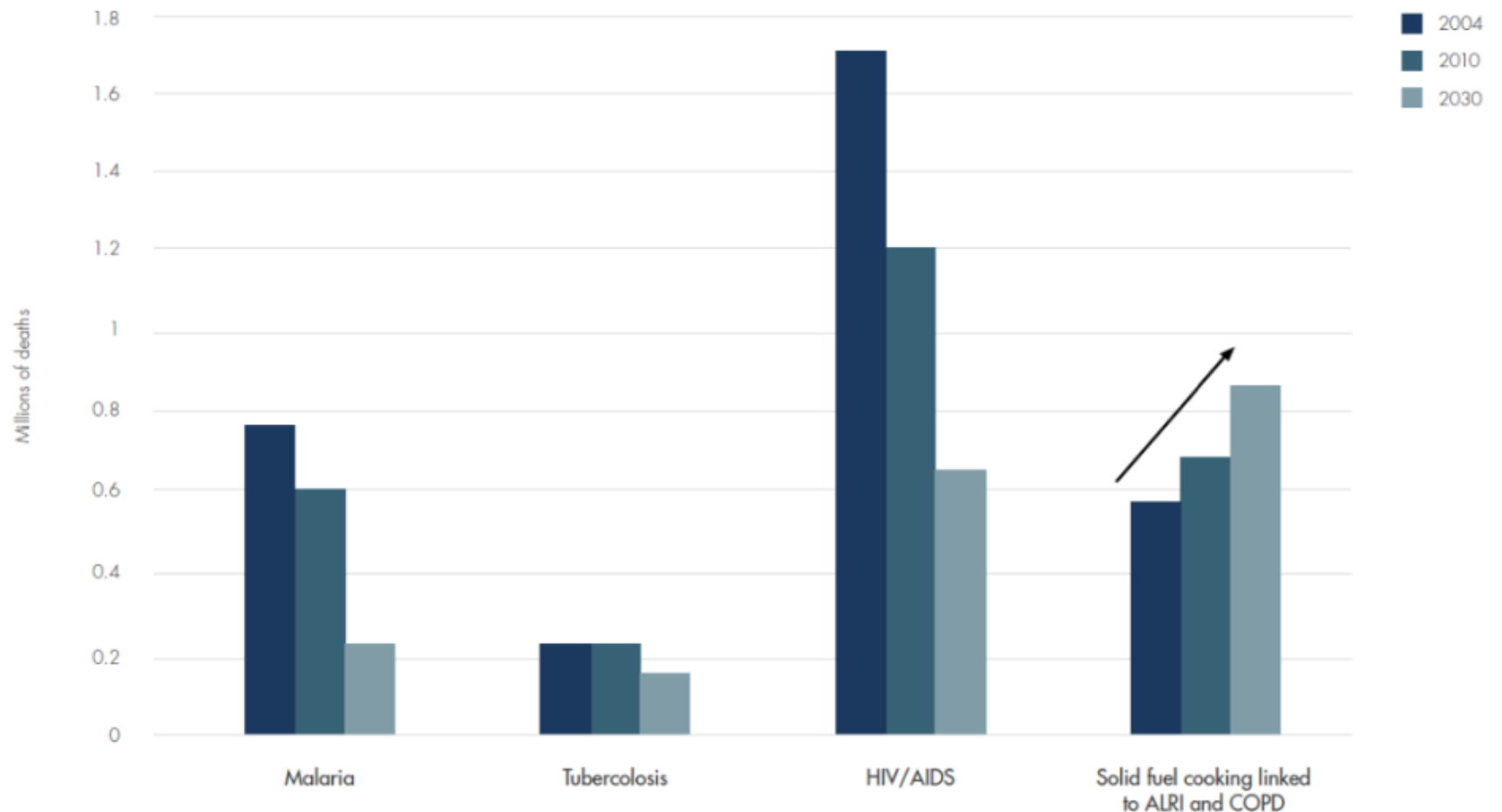
The experience of deprivation or exposure to undue risks or hardships

- The idea is that the availability of energy itself has no direct impact on human well-being
- When energy is able to provide services, such as heat for cooking or light for illumination, it can have a profound effect on human well-being
- It matters to provide people with the energy services required to meet their basic needs
- Focusing on energy services makes clear that definitions of energy poverty are both context specific and subjective (what are basic needs?) (Bhattacharyya, 2012)
- Energy poverty defined as deprivation of “the full range of energy supplies and services required to support human social and economic development ...[for]... households, enterprises and community service providers” (Practical Action, 2014, p. 2)
 - Thresholds pertain to illumination, thermal energy, cooling, refrigeration, and access to information and communications technology (risks & opt costs)

Energy poverty and energy access

→ The impacts of energy poverty I

Deaths caused by major infectious diseases compared with acute lower respiratory infections, 2004, 2010, and 2030



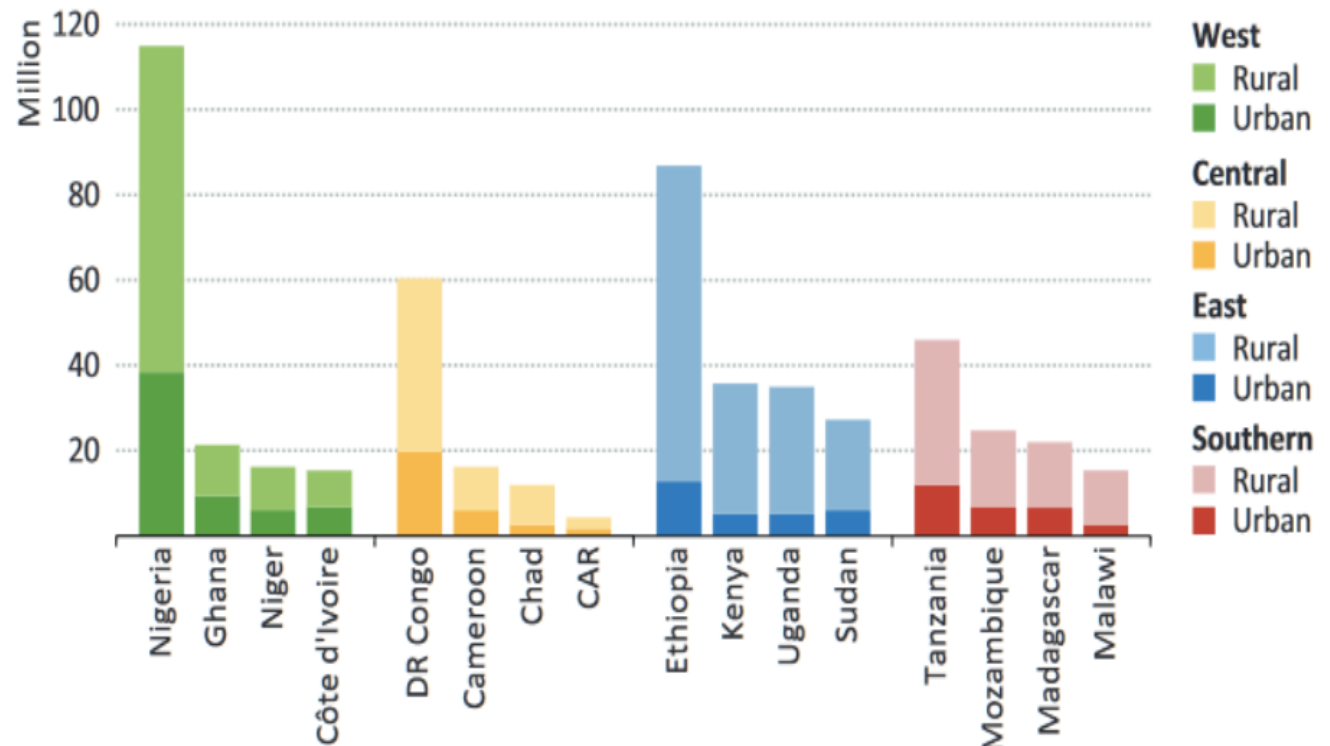
Energy poverty and energy access

→ The impacts of energy poverty II

Time for collecting fuelwood and cooking food on unimproved stoves places an additional burden on energy-poor populations

- The losses in Africa due to cooking and collecting firewood are estimated at \$36.9 billion annually, if the value of unpaid labour is included. The impacts are greatest among women and girls, who are usually responsible for these chores (Lambe et al., 2015)

The largest populations cooking with traditional biomass in sub-Saharan Africa, 2012



Energy poverty and energy access

→ The impacts of energy poverty III

Myriad positive outcomes through energy to households in safe and sufficient quantities

- Improved health outcomes
 - Reduced burning of biomass and kerosene in homes will reduce people's exposure to harmful pollutants. Access to modern fuels is expected to help prevent the cuts, falls, bites, and episodes of sexual harassment and assault that women and girls might otherwise sustain while collecting fuelwood. Improvements to the cold chain to be vital for vaccination and access to electrified clinics
- Increased household income
 - Households that purchase modern fuels are expected to reap savings from the use of more efficient fuels. Access to sufficient illumination will give households more productive hours, including increased study hours for students. Pumped irrigation as potentially improving farm incomes, as well as for the diversification of income as households engage in agroprocessing and light manufacturing
- Improved environmental outcomes
 - Reduced demand for biofuels will lessen pressures on forests, with positive impacts for forest services including reducing runoff and climate change mitigation

Energy poverty and energy access

→ The impacts of energy poverty IV



- Improved quality of life
 - Addressing households' reliance on fuelwood will reduce the drudgery experienced by women and girls whose job it is to collect those fuels. Greater access to entertainment services requiring electricity will improve people's well-being
- Access to ICTs and improved services
 - Most ICTs require electricity to operate. The impact of television, radio, cell phones, and computers on people's lives will be significant. They can increase productivity, provide people with access to crucial information, and create new industries. In terms of services, schools, clinics, and government offices are all thought to be made more effective by access to electricity, with important impacts for the well-being of people who access them. Improved quality of life in rural areas is expected to help retain qualified staff (such as teachers, nurses, bureaucrats), which will further improve access to services.

Source: Modi et al. 2006, Practical Action 2014, (Lewis & Pattanayak, 2012)

Energy poverty and energy access

→ Energy access

Providing energy access

- Electricity has come to play a central role – array of services and distinct advantages
- Disadvantages: Be connected, have (costly) appliances, have sufficient and reliable supply
- Compare to simple stove burning wood/charcoal
 - Energy access policy has frequently focused on only the first of these issues: connecting households, has led to an overly simplified account of energy access.
 - Binary: “connected” or “not connected”
 - Inequality: who consumes electricity?

Recent push to develop more comprehensive measures of energy access

- Capture the multidimensional and multi-tiered nature
- Energy (1) capacity, (2) duration and availability, (3) reliability, (4) quality, (5) affordability, (6) legality, (7) convenience, and (8) health and safety

Energy poverty and energy access

→ Multi-tier matrix of energy access



Attributes of energy supply		Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5	
Capacity	Household electricity	No electricity ^a	Very low power	Low power	Medium power	High power		
	Household cooking	Inadequate capacity of the primary cooking solution				Adequate capacity of the primary cooking solution		
Duration and availability	Household electricity	<4 hours	4–8 hours		8–16 hours	16–22 hours	>22 hours	
	Household cooking	Inadequate availability of the primary cooking solution				Adequate availability of the primary cooking solution		
Reliability	Household electricity	Unreliable energy supply				Reliable energy supply		
Quality	Household electricity/cooking	Poor quality of energy supply			Good quality of energy supply			
Affordability	Household electricity	Unaffordable energy supply		Affordable energy supply				
	Household cooking	Unaffordable energy supply				Affordable energy supply		
Legality	Household electricity	Illegal energy supply			Legal energy supply			
Convenience	Household cooking	Time and effort spent sourcing energy cause inconvenience			Time and effort spent sourcing energy do not cause inconvenience			
Health and safety	Household electricity	Unhealthy and unsafe energy system				Healthy and safe energy system		
	Household cooking ^b	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	

It has been challenging to move the conversation beyond a simple focus on electrification as a means to address energy poverty, and the binary definitions of energy access this focus has created

Energy poverty and energy access

→ Summary

Providing energy access

- Field of endeavour linking energy and development has been animated by concerns about the impacts of energy poverty and a desire to address these by promoting energy access
 - Despite the longstanding focus on both issues (energy poverty, energy access), neither has a clearly established definition, although recent efforts to provide nuanced definitions that capture the complexity of these issues have been advanced
 - Policy advocates in this field have found it challenging to move the conversation beyond a simple focus on electrification as a means to address energy poverty, and the binary definitions of energy access this focus has created

Expanding access to electricity

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Chapter II

Expanding access to electricity

Grid and centralized sources

- Traditionally households connected to centralized power plants
 - Advantage of economies of scale; disadvantage of high up-front costs during expansion
- Disadvantage: Challenge to address climate change and advances in renewable energy technologies drive focus on electricity through distributed sources

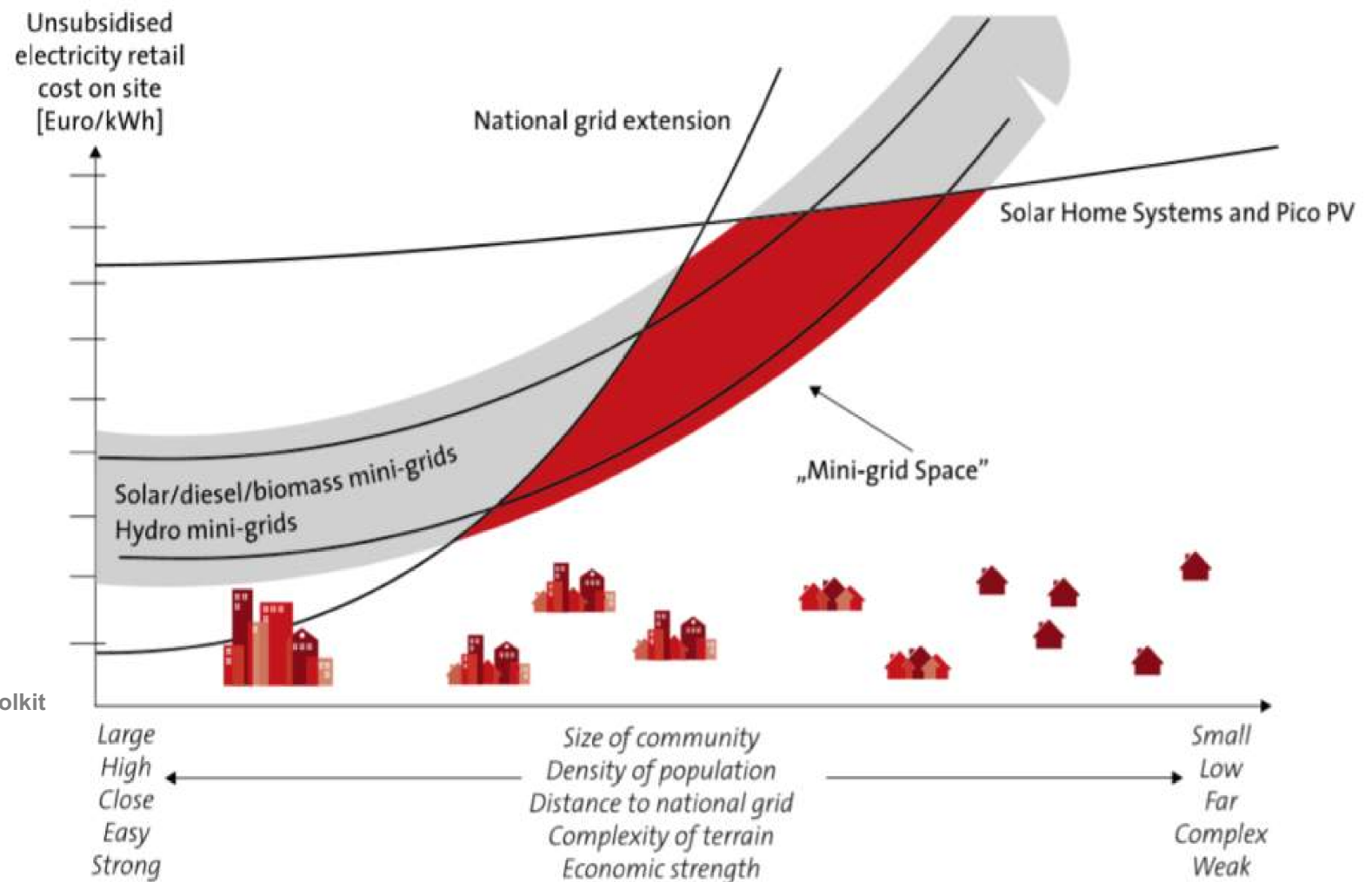
Distributed sources

- Households connected to distributed sources
- Proximity to the point of consumption, largely renewable, not connected among sources
- Advantage of being able to reach poor and remote populations quickly and cheaply, while simultaneously mitigating carbon emissions

Source: (Bhattacharyya & Palit, 2016; Deshmukh et al., 2013; TERI- GNESD, 2014; Terrapon-Pfaff et al., 2014; Alstone et al., 2015)

Expanding access to electricity

- Grid vs. Mini-grid as small-scale electricity generation (10kW to 10MW) in isolation supplying relatively dense settlements with electricity at grid quality level



Source: Mini-Grid Policy Toolkit