Afghanistan Energy Study

Universal Access to Electricity

Prepared by:
KTH-dESA

Dubai, 11 July 2017

A research initiative supported by:

Outline

Day 1. Energy planning and GIS

1. Energy access for all: An energy modelling approach
2. Introduction to basic concepts of energy planning
3. Misrepresented elements in energy planning - Open questions
4. Basic GIS concepts in energy planning
5. Data acquisition
6. Data creation and manipulation
7. Introduction to python and GIS
8. OnSSET dataset (csv file) preparation

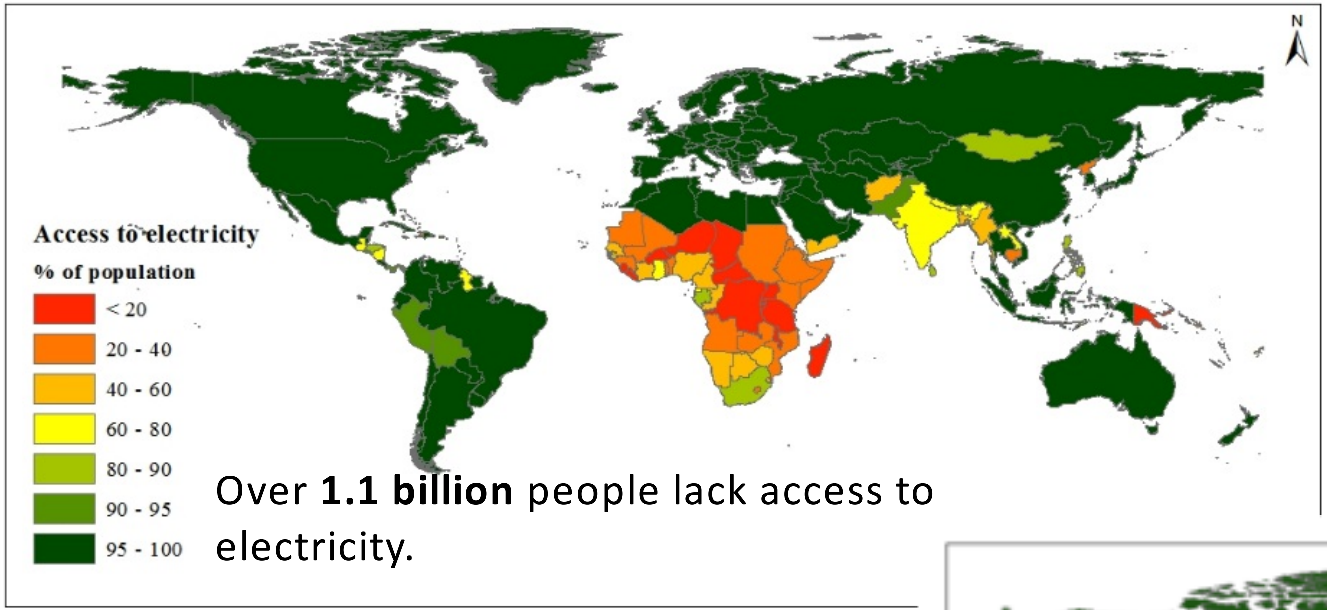
Day 2. Electrification planning with OnSSET

1. OnSSET website and the online interface
   a. Input data
   b. Scenario development
   c. Results & visualization
2. The stand-alone version of OnSSET
   a. Software installation
   b. Code download and run
   c. Debugging process
3. Visualization of results in maps
4. OnSSET analysis for Afghanistan (Inputs - Specifications - Results)

Day 3. Hands on exercise with OnSSET

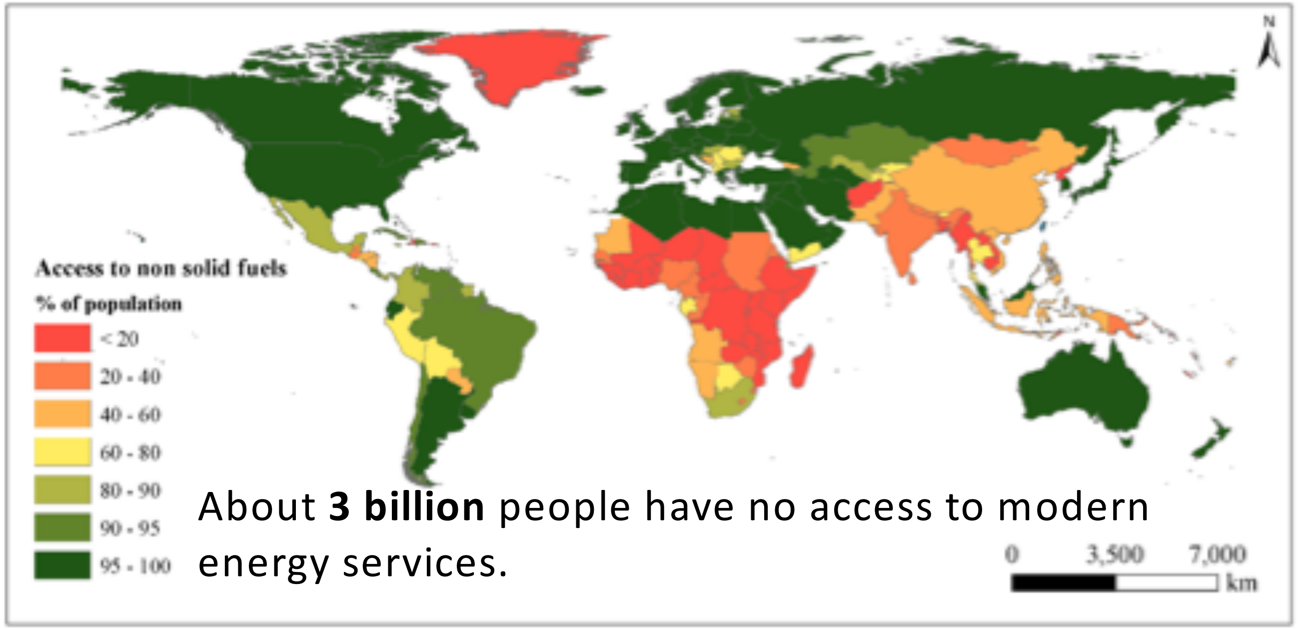
1. Hands on experience with OnSSET Part 1
   a. Input data
   b. Model & scenario development
2. Hands on experience with OnSSET Part 2
   a. Electrification analysis
   b. Post analysis and visualization
3. Group presentation
4. Open discussion on model modifications & new functionalities

Energy Access Today



Over **1.1 billion** people lack access to electricity.

The majority live mainly in rural areas of developing **Asia** and Sub-Saharan **Africa**.



About **3 billion** people have no access to modern energy services.

Universal Access to Energy

Energy and Sustainable Development

Sustainable Development Goals, Status of Electricity Access Report, 2017

Without access to electricity






With access to electricity






Sustainable Development Goals and key links to energy

- *Energy is interconnected with 125 (out of 169) targets*.*

- *Energy planning should be an integral part of national planning efforts to achieve SDGs.*

SUSTAINABLE DEVELOPMENT GOAL	HOW ENERGY IS RELATED TO THE SUSTAINABLE DEVELOPMENT GOALS
GOAL 1. End poverty in all its forms everywhere	Access to energy can increase household income and productivity and reduce disparities in wealth.
GOAL 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	The availability of energy is a key factor for increasing agricultural productivity and ending extreme hunger.
GOAL 3. Ensure healthy lives and promote well-being for all at all ages	Energy access for healthcare services can enhance maternal health, reduce infant mortality, and help curtail disease and epidemics.
GOAL 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Energy is a key factor of upgrading educational facilities and of facilitating modern quality education.
GOAL 5. Achieve gender equality and empower all women and girls	Better access to energy can lead to higher gender equality, freeing up women's time (previously wasted in collecting fuelwood for example) and
GOAL 6. Ensure availability and sustainable management of water and sanitation for all	In the energy sector, water is used for generating hydropower, cooling thermal power plants, extracting, processing and transporting energy resources, and growing energy crops. Conversely the water sector needs energy to extract, treat and transport water, as well as for irrigation and desalination.
modern energy for all	
GOAL 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	The provision of energy helps to increase GDP and productivity. Modern energy access empowers people.
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	Energy is needed for developing infrastructure and technological innovation, including information and communication technologies (ICT).
GOAL 10. Reduce inequality within and among countries	Access to energy is crucial for sustained income growth of the bottom 40 per cent.
GOAL 11. Make cities and human settlements inclusive, safe, resilient and sustainable.	Energy facilitates all urban systems, including transport and is needed for improving living standards in urban slums.
GOAL 12. Ensure sustainable consumption and production patterns (SCP)	Sustainable energy consumption & production is a key factor in sustainable consumption and production patterns including addressing inefficient fossil-fuel subsidies and removing market distortions.
GOAL 13. Take urgent action to combat climate change and its impacts	Emissions from the energy sector are the leading contributor to anthropogenic climate change. Access to renewable energy and energy efficiency are key to mitigation.
GOAL 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	Tidal energy and ocean wind power are important renewable energy technologies but may impact marine ecosystems.
GOAL 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	The environmental impacts of energy encompass deforestation, mineral extraction and changes in land use, and this can lead to desertification and land degradation. Sustainable use of energy resources is key to sustainable terrestrial ecosystems.
GOAL 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Access to fossil fuel resources has historically been a cause for conflict and global price volatility that leads to international instability among and within countries.
GOAL 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development	Strengthening the means of implementation involves transfer of energy technologies and capacity building for implementing SDG targets and indicators nationally.

** Status of Electricity Access Report, 2017*

Importance of Energy Planning

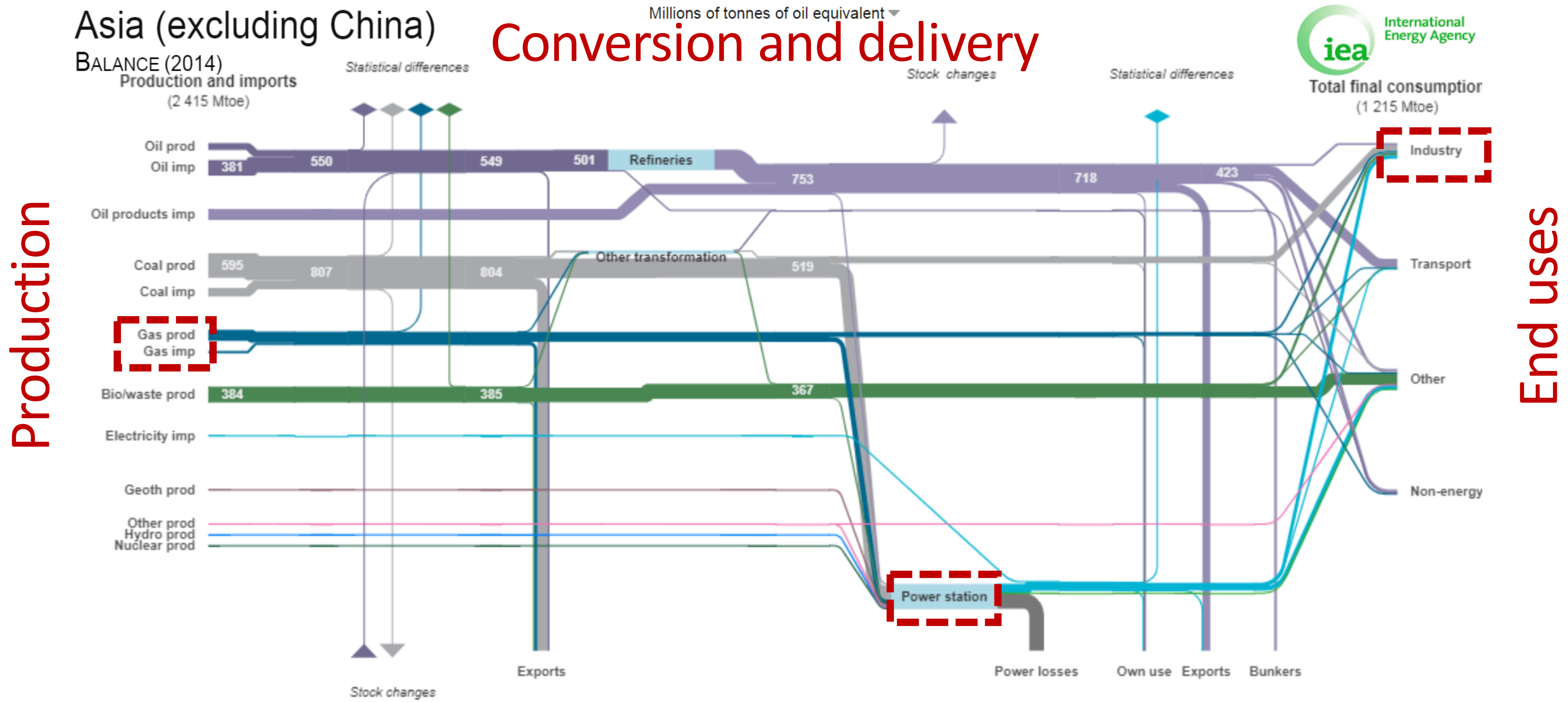
- Energy planning is essential for **matching demand and supply.**
- **System cost minimization** without compromising energy security, reliability of supply and environmental integrity is a primary planning objective.
- Fundamental **energy system transformation** is key to the implementation of SDG 7.

Energy Planning

Energy Planning: *"It is **the act** of assessing the ability of a regional **energy system** to provide dependable **energy services** under constantly **changing conditions** – which involves variables such as the cost of materials and fuels, investment costs in technologies, demand levels, and distribution."**

*IAEA, 1984. Expansion Planning for Electrical Generating Systems, A Guidebook

Energy Systems



Energy is strategic, integrated and intra-grated

Energy System Models

- ✓ Computer aided energy modelling has been used since mid-1970 to assess alternative energy system and technology developments, energy security issues and the optimal allocation of scarce resources.
- ✓ Models are ‘**test-beds**’ to compare different energy system development paths, explore future development options and their likely implications
- ✓ Experiments under ‘real word conditions’ are **impractical, too expensive or simply impossible.**



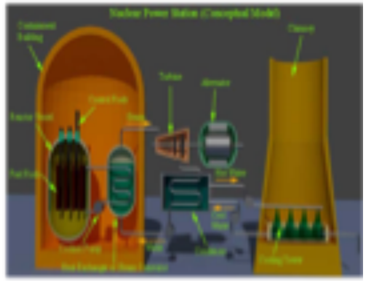




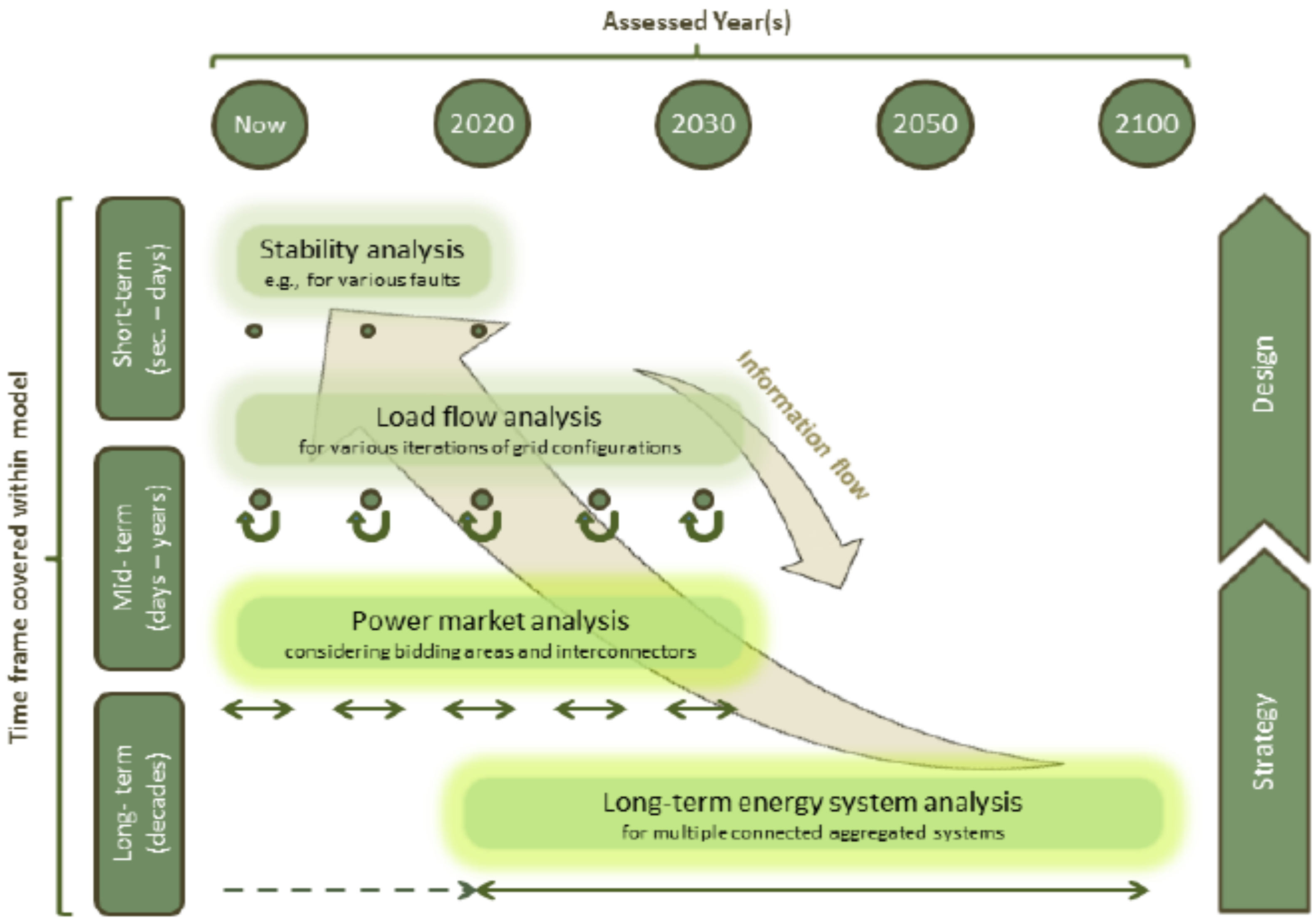








Energy System Models



Top-down medium-long term models

Econometric models

- driven by projected developments of major economic indicators, such as Gross Domestic Product, GDP, population or energy prices

Input-output models

- Rely on interrelations between various sub-sectors

Computational general equilibrium models (CGE)

- Consider economic effects beyond the energy sector

Bottom-up medium-long term models

Accounting Frameworks

- whatever a (very) basic Excel sheet can do
- ”The maths behind modelling”
- Main function of these tools is to manage data and results.

Simulation Models

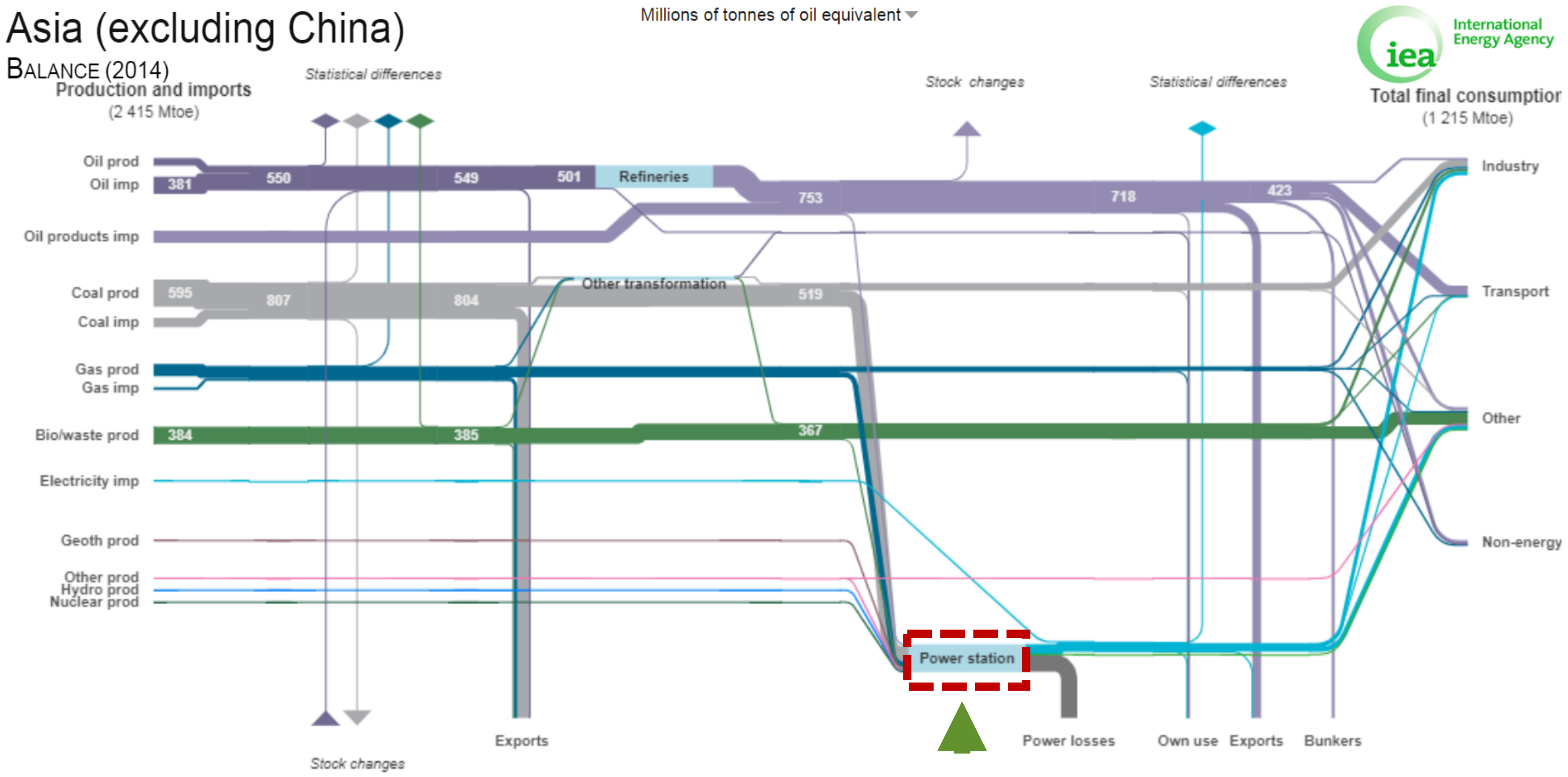
Simulate behavior of consumers and producers by adding certain rules to accounting models.

Optimization Models

- Overall energy sector-wide optimum is calculated
- Typically used to identify least-cost configurations of energy systems based on various constraints (e.g. a CO_2 emissions target)

Hybrids Models combining elements of each approach.

Energy Systems



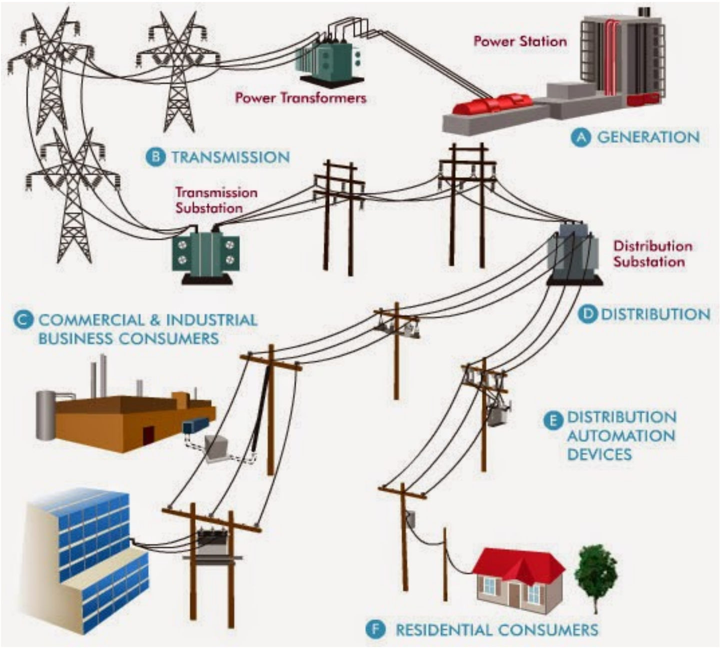
Different Electrification Options

Electrification options

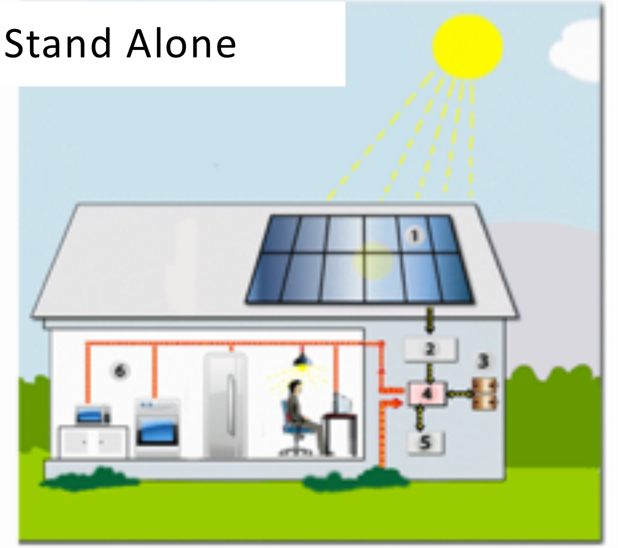
Supply technologies

Mini Grid

On Grid



Stand Alone



- Solar PV
- Wind turbines
- Mini and small hydropower
- Diesel gensets

- Solar PV
- Diesel gensets

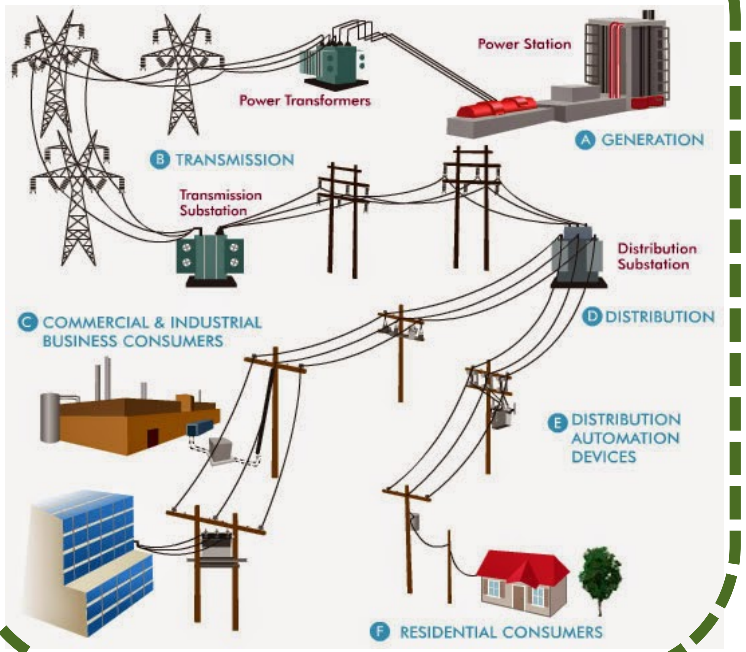
Electrification options

Supply technologies

Mini Grid

- Solar PV
- Wind turbines
- Mini and small hydropower
- ensets

On Grid



Typical medium-long term Energy System Models

Stand Alo

- Solar PV
- Diesel gensets

Energy System Models

Medium to long-term national energy system models typically fail to take into account the spatial fluctuations of energy resources and demand side.

- Intermittent energy resources (such as wind, solar, hydro, diesel supply) vary in time and space.
- Power infrastructure and energy demand differ from one area to another.

Without GIS models, these details, which are essential in energy planning, cannot be captured.

GIS and Energy System Models

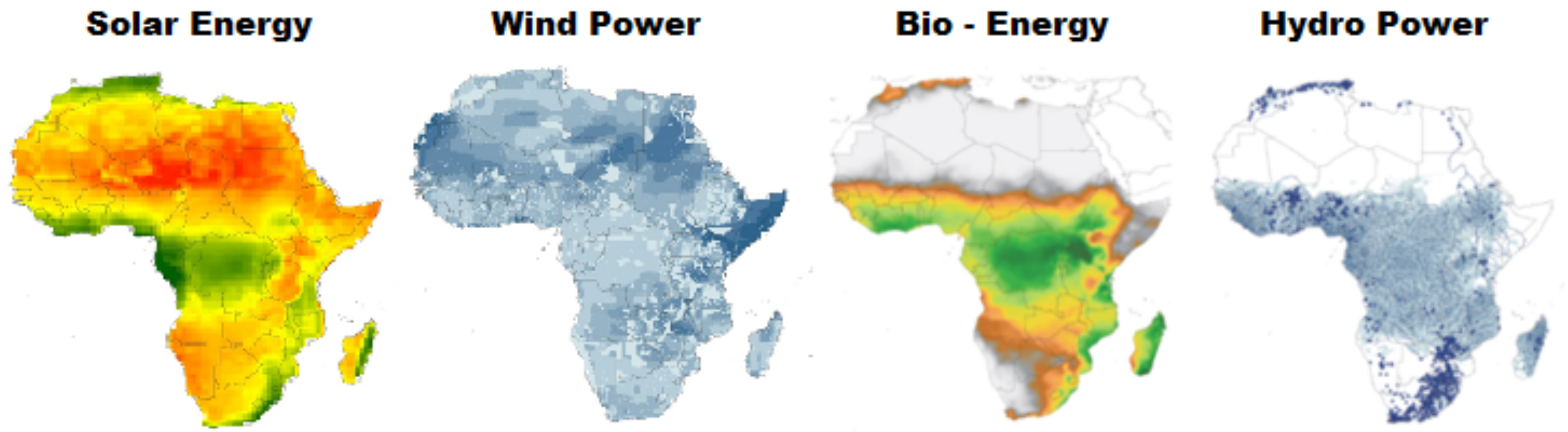
- Medium to long-term national energy system models are largely inadequate for regional access analysis and planning.
- Effective electrification planning requires **geospatial** information.
- In developing countries, there is a lack of reliable energy-related data.

GIS and Energy planning

Within energy planning, GIS have been used as:

- A planning tool for renewable energy infrastructure

However, most of the developed studies focus on renewable energy supply without considering the location dependant energy demand and the associated costs of delivering energy services



GIS and Energy planning

Within energy planning, GIS have been used as:

- A planning tool for national or subnational rural electrification and subsequent strategies and policies

However, the majority of the developed tools have one or more of the following **limitations**.

- ➢ Focus on how rural areas should be electrified and do not provide an overall electrification plan
- ➢ Deploy a limited number of electrification options
- ➢ Use a limited number of GIS data
- ➢ Use a limited number of demand nodes
- ➢ Lack a grid expansion algorithm
- ➢ Do not account for a dynamic change of the bulk gid electricity supply mix

GIS and Energy planning

Our objectives are…

- to develop further the intergraton of GIS and energy planning
- address the mentioned limitations
- provide insights on investment and capacity needs in order to provide electricity to the unserved

Open Source Spatial Electrification Tool (OnSSET)

- New bottom up optimization toolkit
- Based on GIS software and Python
- Spatially explicit demand, infrastructure, resources and technologies
- Least cost electrification technology mix to provide electricity to all
  - ➢ Extension of the national grid network
  - ➢ Mini-grid systems
  - ➢ Stand-alone systems

Part of OPTIMUS Practice 3

SUSTAINABLE DEVELOPMENT GOALS

Online Interface OnSSET

Github

reddit

Reflect…

1. Is Energy planning enough to increase electricity access?

2. Why is it important to have open energy modelling tools?