REINER LEMOINE INSTITUT

The Practical Geospatial Planning Aspects for Transmission and Distribution Planning in Myanmar

Catherina Cader

Yangon, August, 16th 2016

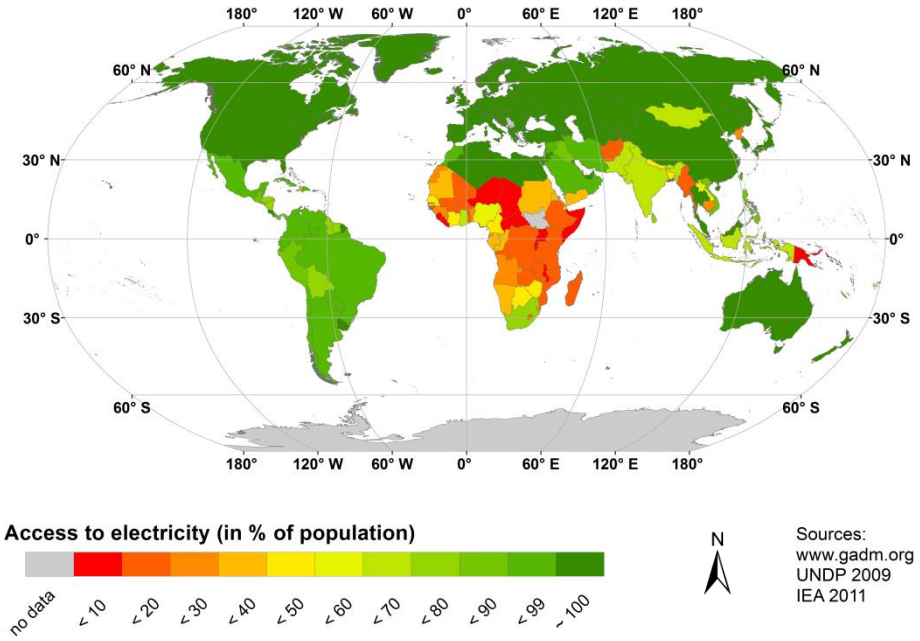
Reiner Lemoine Institut (RLI)

Overview

- Not-for-profit research institute
- 100 % subsidiary of Reiner Lemoine-Foundation (RLS)
- Established 2010 in Berlin
- Three research groups:
  - Transformation of Energy Systems
  - Mobility with Renewable Energies
  - Off-Grid Systems
- Member of: ARE, eurosolar, BNE, dena, EEA
- Managing Director: Dr. Kathrin Goldammer

Reiner Lemoine
Founder of Reiner Lemoine-Foundation

Research object: Access to electrification

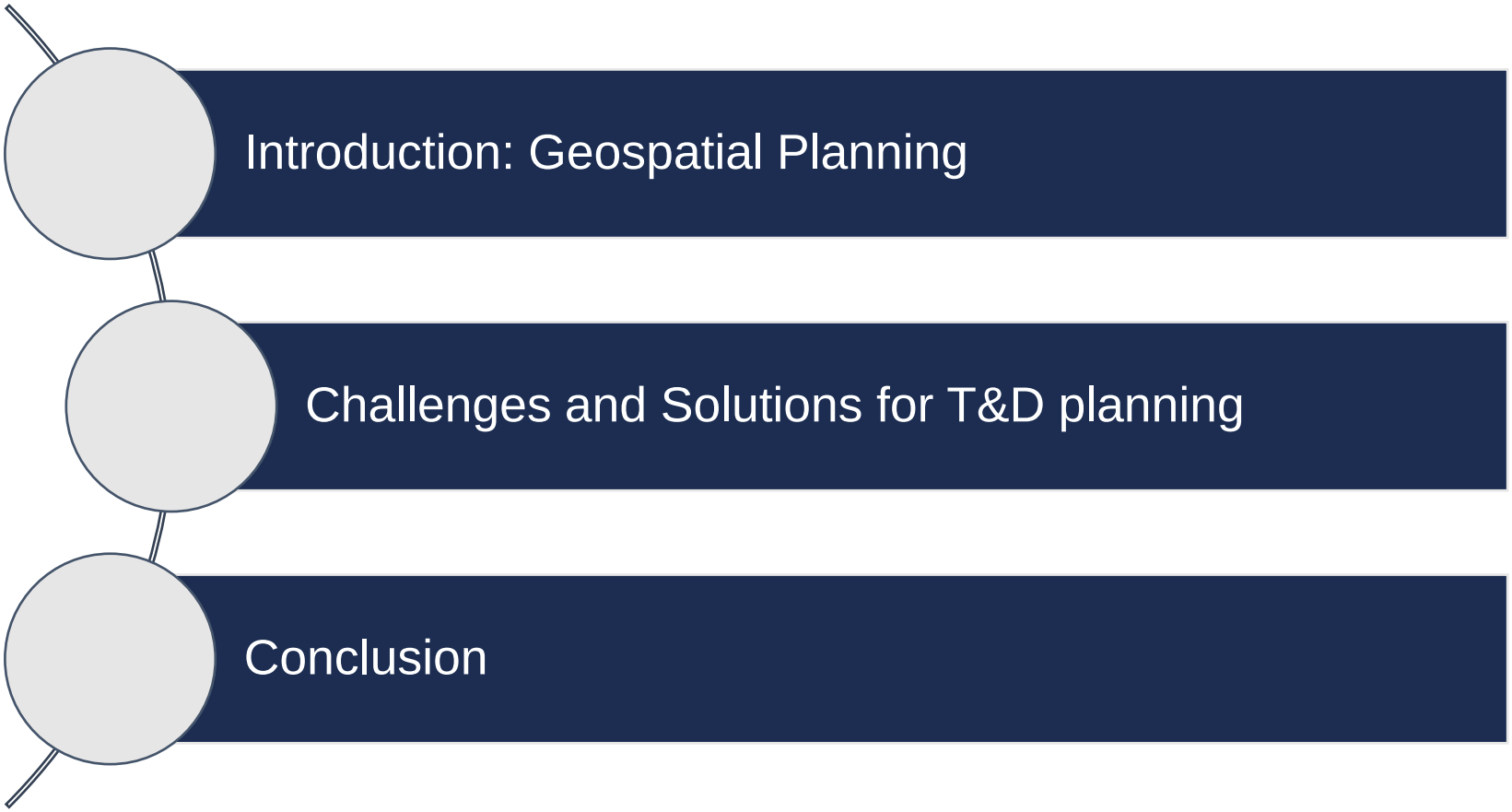


- Many regions have no access to electricity
- High costs for energy supply are prevailing
- Fossil fuel based supply in spite of abundance of renewable energies

	Rural	Urban	Total	Share of population
Developing countries	1,081	184	1,265	24%
Africa	475	114	590	57%
Developing Asia	556	62	628	18%
Latin America	23	6	29	6%
Middle East	16	2	18	9%
World	**1,083**	**184**	**1,267**	**19%**

Source: Number of people without access to electricity by region (million). World Energy Outlook 2012, International Energy Agency,

Agenda


Introduction: Geospatial Planning
Challenges and Solutions for T&D planning
Conclusion

Introduction – Importance of geospatial planning

At the 1987 Annual Conference of the Urban and Regional Information Systems Association it was stated:

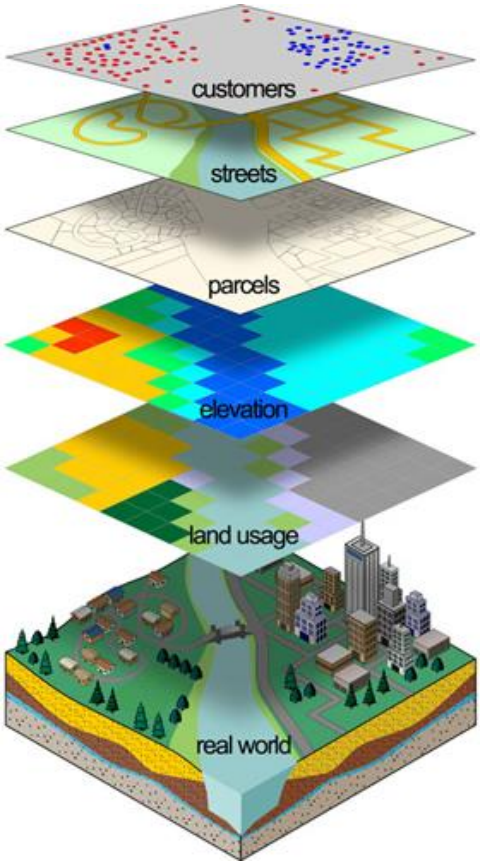
> *It had been estimated that 80% of the informational needs of local government policy makers are related to geographic location.*
>
> — Robert Williams

Introduction – What is geospatial planning?

A **geographic information system** or **geographical information system** (**GIS**) is a system designed to

- capture
- store
- manipulate
- analyze
- manage and
- present all types of spatial or geographical data

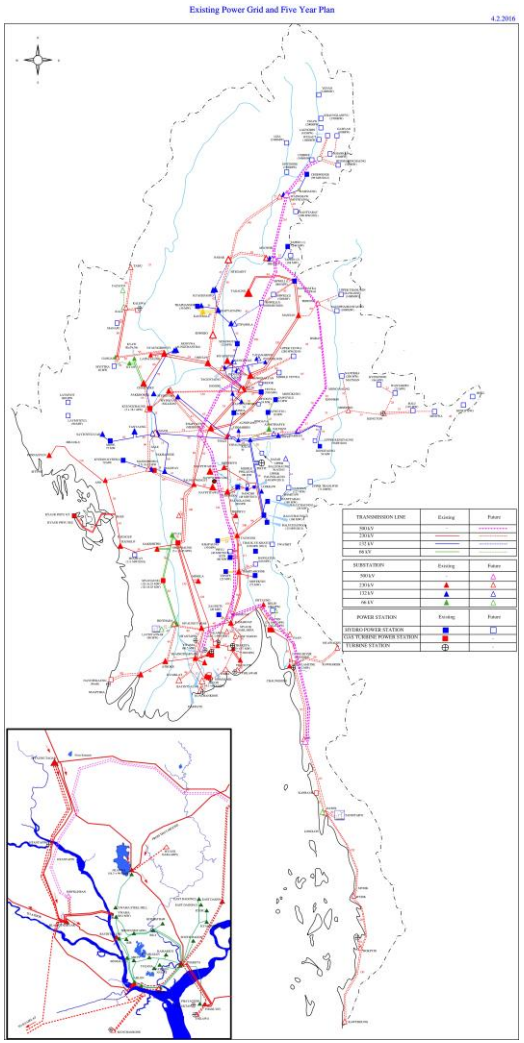
→ Considering the relative position of things on the earth's surface



Introduction – Geospatial planning in the power sector

Transmission and distribution planning is a spatial task:

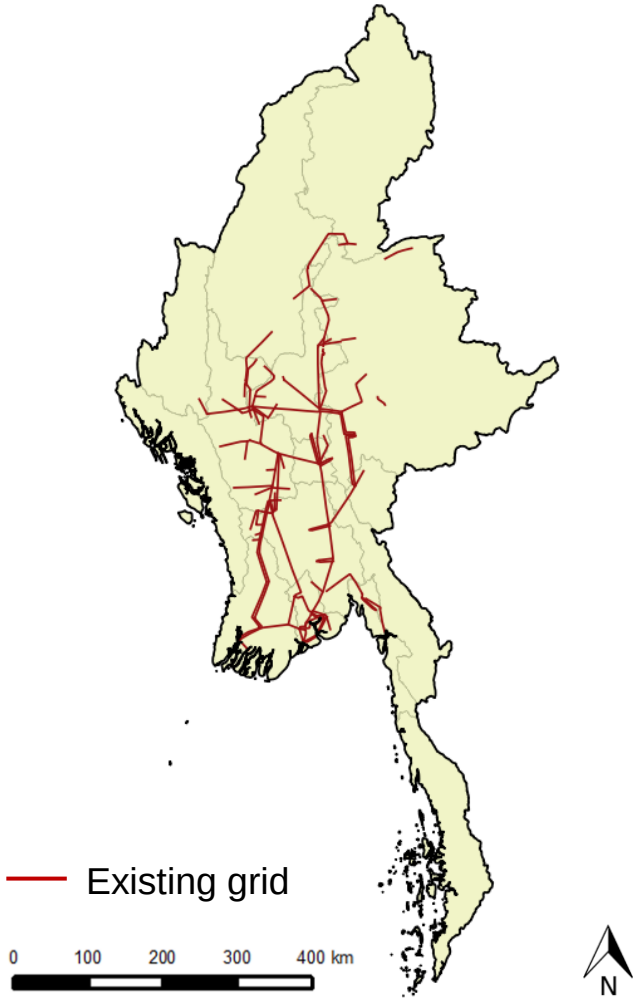
- **Where** is it required?
- **Where** is the closest power line?
- What is the **distance** to the next village, to the grid?
- Which resources are available in one **location**?



Source:
- MOEP, 2016

Introduction – Existing grid Myanmar

- The extension of existing transmission lines mainly reflects the status of electrification
- The power network mainly covers the central regions where a large share of the population lives - still major parts of the country are not connected to the grid
- Efforts to cover the whole country with grid infrastructure are high as Myanmar is a large country



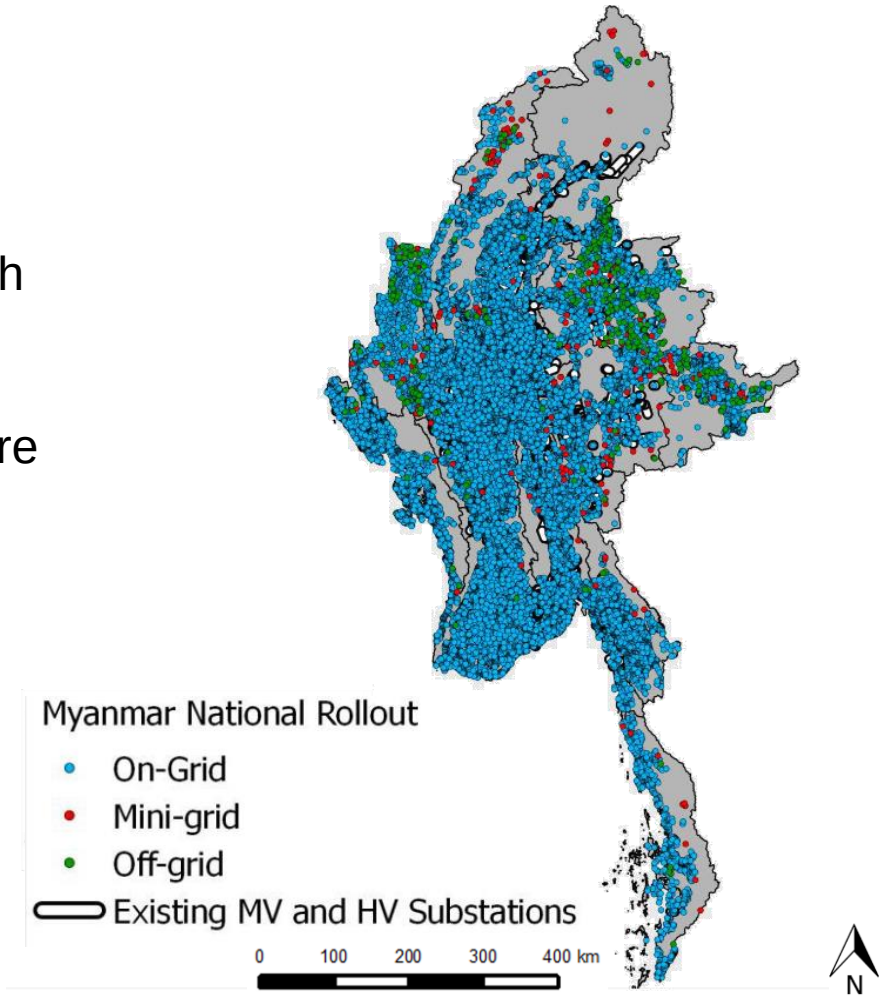
Source:
- MOEP, 2016

Introduction – Existing and planned grid Myanmar

- The national electrification plan, together with the energy master plan has a detailed vision on providing access to electricity to all by 2030, with a strong focus on grid extension

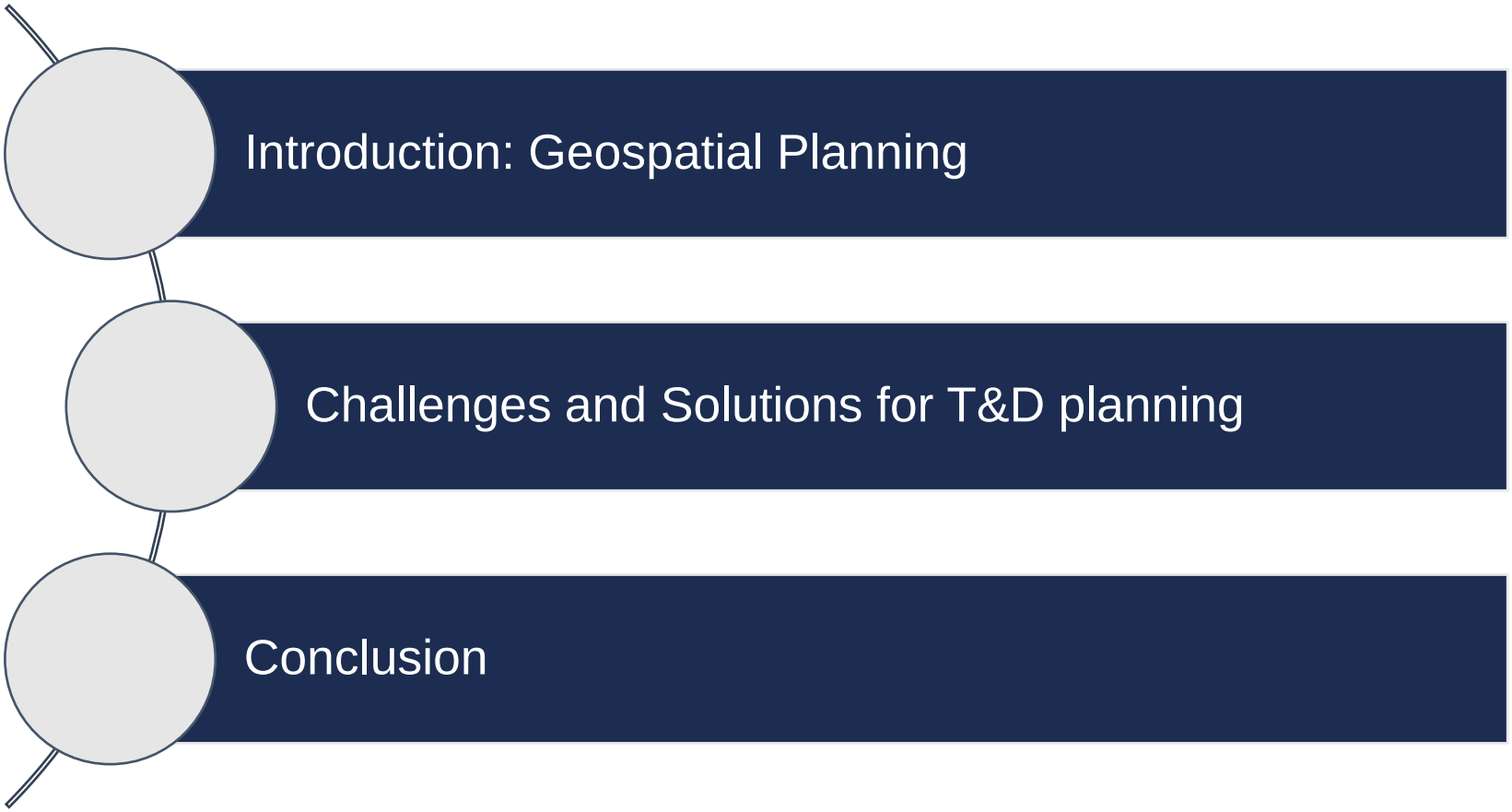
- The plan outlines the extension to more major towns and smaller settlements

- A focus is also on potential new hydro power generation sites which require a grid connection to transport and distribute the electricity



Source:
- Columbia Earth Institute

Agenda


Introduction: Geospatial Planning
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Challenges and Solutions

How to transfer the National Electrification Plan (NEP) into infrastructure on the ground?
What is the applicability of geospatial planning tools?

- Exact pathways for grid extension
  - Distribution of people
  - Topography/Land cover
  - Existing infrastructure

- Electro-technical challenges
  - Load projection
  - Generation capacity
  - Stability issues with renewables

- Cross-border electricity trade

"Geographic and other factors might, therefore, make connection of some portion of the population in a given area prohibitively expensive."
- Zvoleff et al. 2009

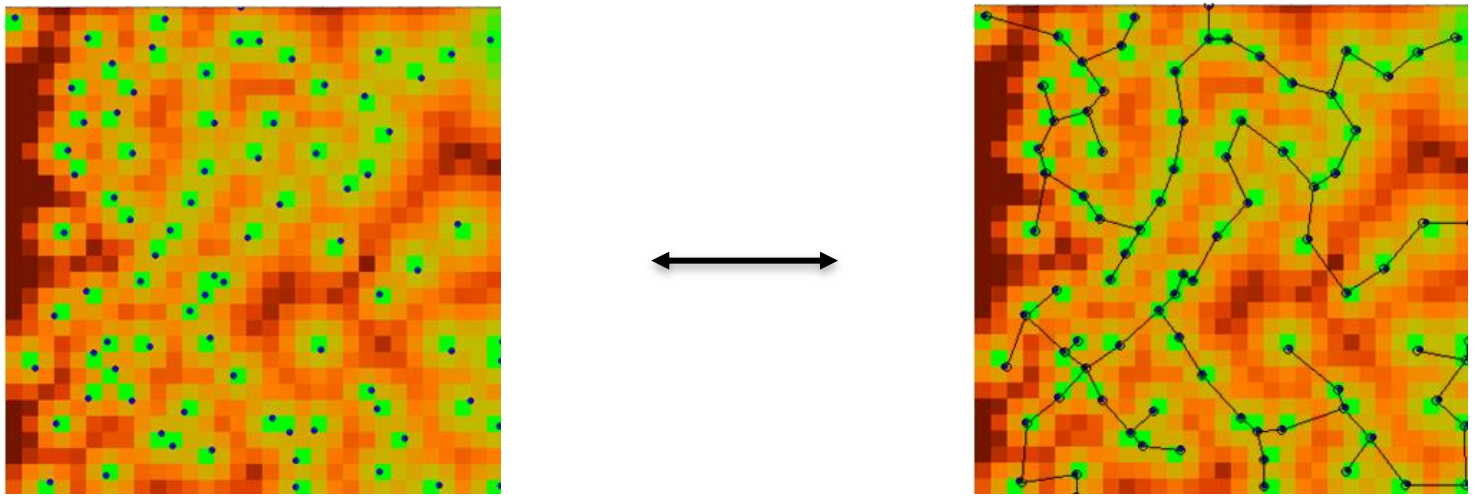
Multi-criteria-catalog for power sector development

1. Remoteness
Distribution of towns and villages
Population density and structure
Travel time
Urban / rural area distinction
2. Electricity Demand
Electricity access rate
GDP/poverty level
Population density
Tourism
3. Existing Electricity Generation and Transmission Schemes
Transmission line course
Quality of service (load shedding, limited supply)
Transport losses
Central electricity generation plants (capacity, type)
4. Natural Resource Assessment
Resource availability (solar irradiation, wind speed, hydro power potential)
Land cover
Digital elevation model (DEM)
5. Non-spatial Parameters
Policy structures (e.g. electrification objectives, renewable energy targets)
Investment incentives
Ownership structures of plant operators and transmission line infrastructure
Attractiveness for investors (e.g. ease of doing business index, corruption index)

from Cader et al. (2014). Proceedings of 7th International Conference PV-Hybrids and Mini-Grids. ISBN 978-3-94-3891-37-9

A multi-criteria catalog is developed to distinguish advantages and disadvantages of on- and off-grid electricity supply. In addition, it provides information on data requirements for an assessment.

Which is the optimum grid extension?



▲ Spatial planning of electrification options for scattered villages. Decentralized approaches (left side) have to be considered in addition to grid extension (right side).

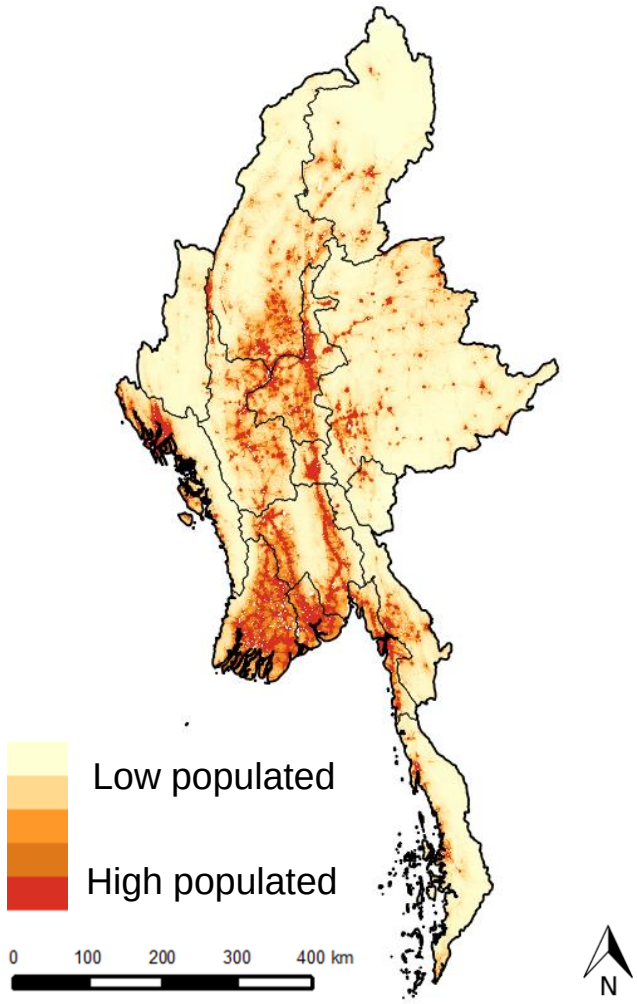
Geospatial analysis – Population

- Population distribution and density analysis shows that the largest part of Myanmar's population lives in the central dry region and along the coastline

- However, also major towns are located in more remote regions, such as in the Northern Kachin state and Sagaing regions as well as in Shan state in the east

- Industry sites such as special economic zones require large amounts of electricity

- Tourism is also increasing and might be a future focus for the development of the country, requiring reliable electricity supply

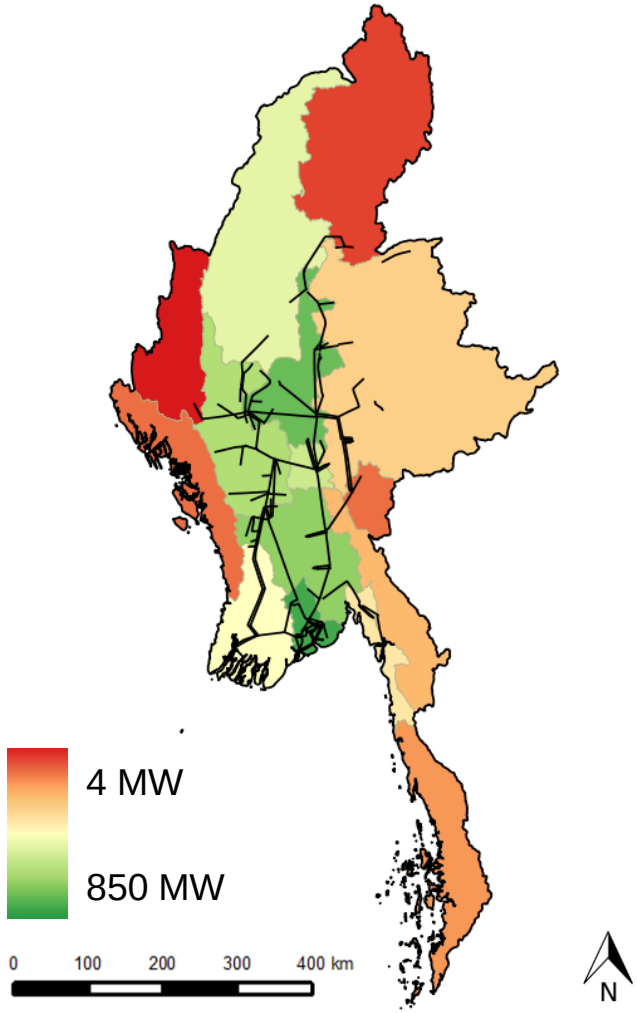


Geospatial analysis – Peak Load

Table 2: Peak Load in Region and State, 2013
(MW)

Region/State	Peak Load
Yangon	832.70
Mandalay	358.64
Bago	136.24
Magway	107.22
Nay Pyi Taw	106.23
Sagain Region	95.83
Ayeyarwaddy	79.02
Shan (South)	71.21
Mon	64.73
Shan (North)	51.52
Kayin	36.50
Shan (East)	14.25
Tanintharyi	13.20
Kayar	11.32
Rakhine	10.80
Kachin	7.85
Chin	4.00
Total	2,001.26

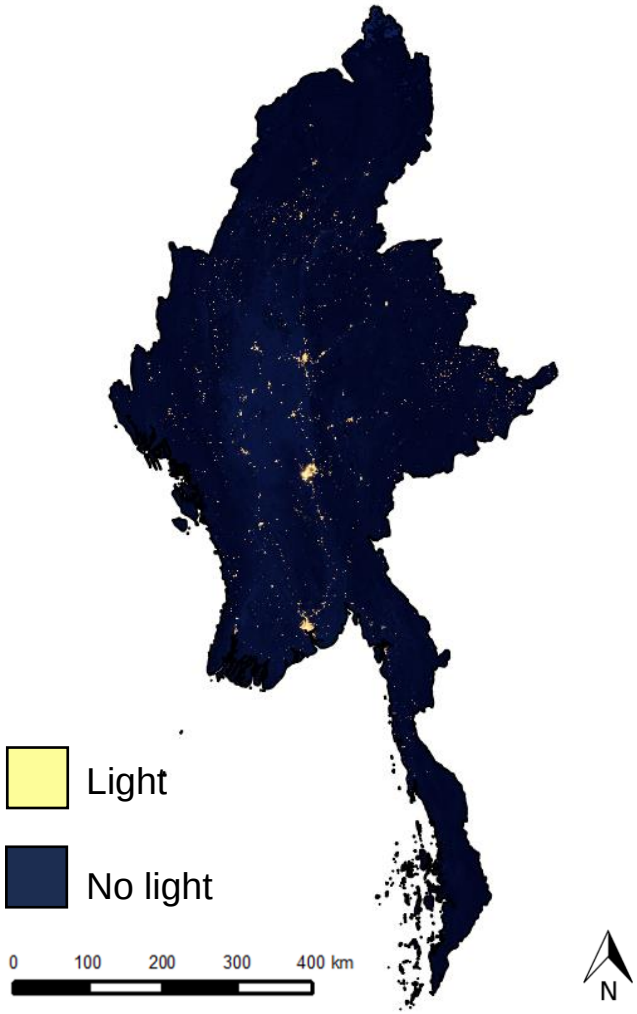
MW = megawatt.
Source: Ministry of Electric Power.



http://www.adb.org/sites/default/files/publication/175801/ewp-460.pdf

Geospatial analysis – Myanmar at night

- Satellite imagery allows the detection of the light from space
- This data is a yearly composite, showing emitted light. Main type of visible light is street lighting and other major types
- The most obvious light spots mark the larger cities such as Yangon, Naypyitaw and Mandalay
- Also in other regions lights can be considered as locations with economic activity



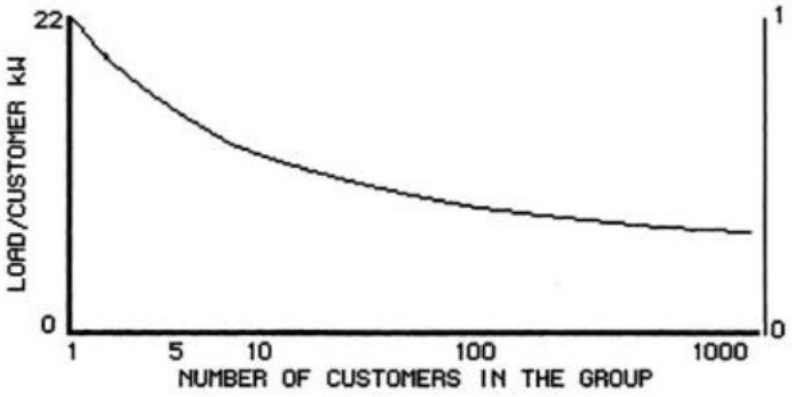
Source:

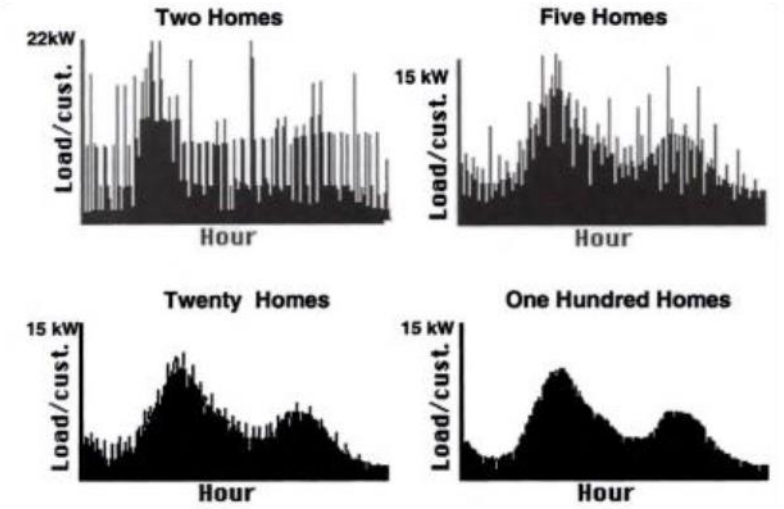
- *Night Light Imagery,* version 4 DMSP-OLS Night Lights Time Series, NOAA National Geophysical Data Center, US Air Force Weather Agency, Boulder, Colorado. LandScan 2011™ *High Resolution global Population Data Set ,* copyright UT-Battelle, LLC, operator of Oak Ridge National Laboratory under Contract No. DE-AC05-00OR22725 with the United States Department of Energy.

Load Management

- Coincidence factor: It is much easier to forecast a load for a larger customer group
- The required load per customer is smaller if the group of customers is larger
- As a consequence – it is easier to develop stable supply systems for larger customer groups

→ Detailed load modelling is required to estimate the correct load

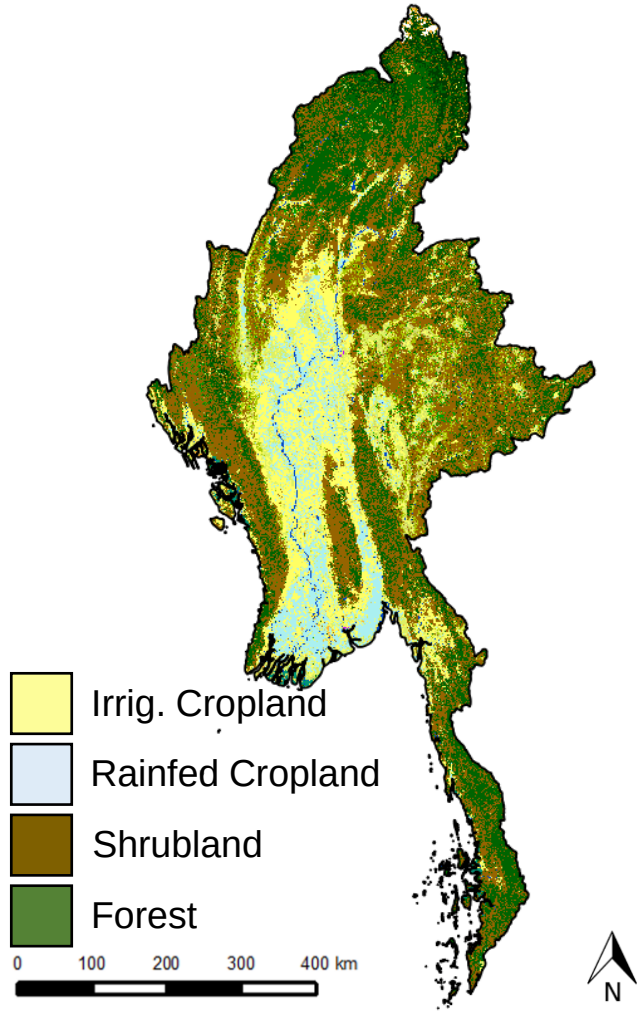




Geospatial analysis – Land cover

- Myanmar is a country with different land cover and land use types
- In the central regions cropland is the dominant use
- In the mountainous regions shrubs and forest is prevailing

→ Dense forest is especially challenging for the construction of T&D infrastructure, also maintenance is required

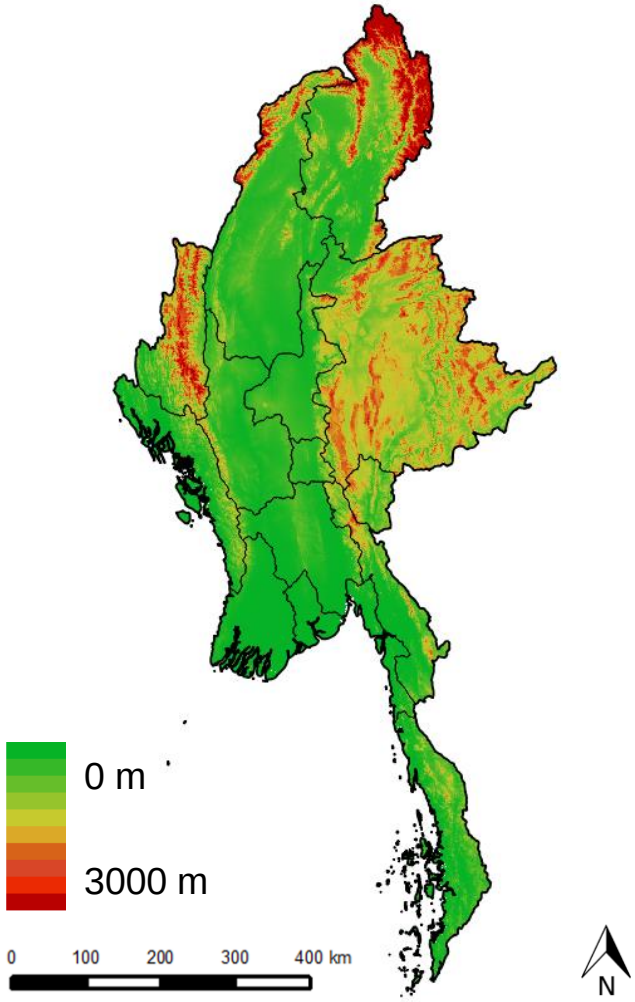


Source:

- Arino, Olivier; Ramos Perez, Jose Julio; Kalogirou, Vasileios; Bontemps, Sophie; Defourny, Pierre; Van Bogaert, Eric (2012): Global Land Cover Map for 2009 (GlobCover 2009). © European Space Agency (ESA) & Université catholique de Louvain (UCL), doi:10.1594/PANGAEA.787668

Geospatial analysis – Elevation

- Myanmar is a country with a diverse topography
- In the central regions and in the south the country reaches sea level whereas in the bordering regions mountain ranges are characteristic
- Mountains are up to 3000 m high
- This results in difficult terrain leading to a low accessibility, which can be even more difficult in cases extreme weather events

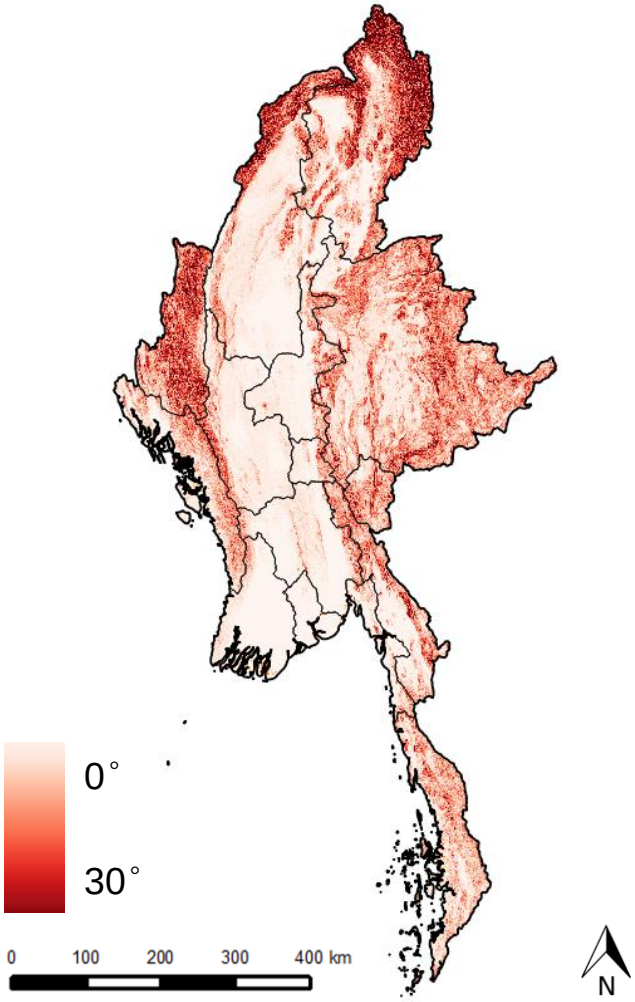


Source:

- Jarvis, A., H.I. Reuter, A. Nelson, E. Guevara, 2008, Hole-filled SRTM for the globe Version 4, available from the CGIAR-CSI SRTM 90m Database: http://srtm.csi.cgiar.org.

Geospatial analysis – Slope

- As an effect of the various altitudes across the country high slopes are a consequence
- This impacts on accessibility and also exacerbates infrastructure development
- Often agriculture is the main source of economic activity in these regions



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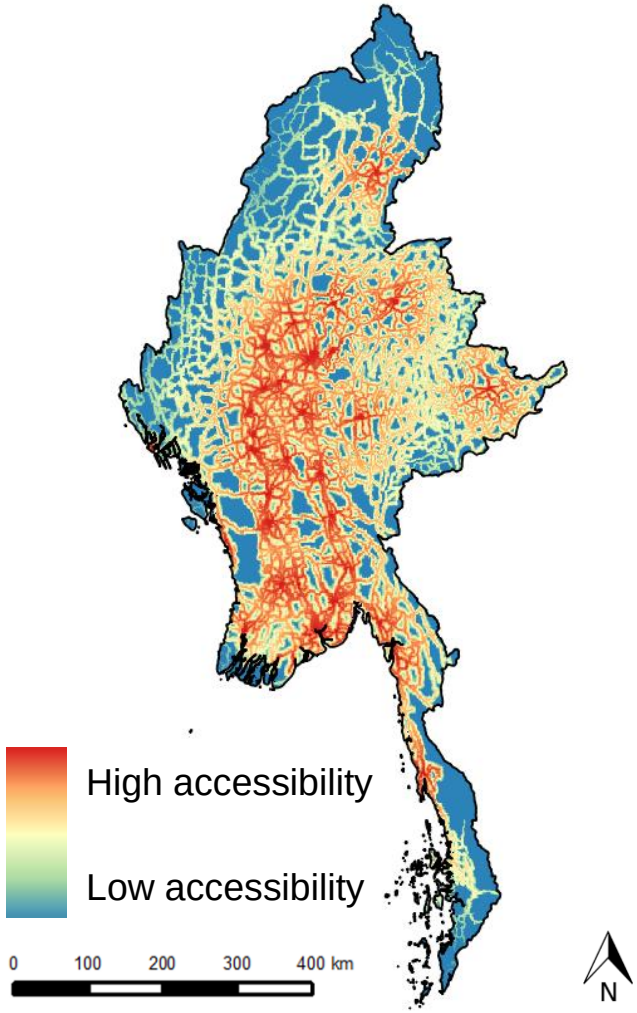
Geospatial analysis – Accessibility

- Travel time to the next city with more than 50,000 inhabitants
- Distribution of towns and villages
- Urban / rural area distinction



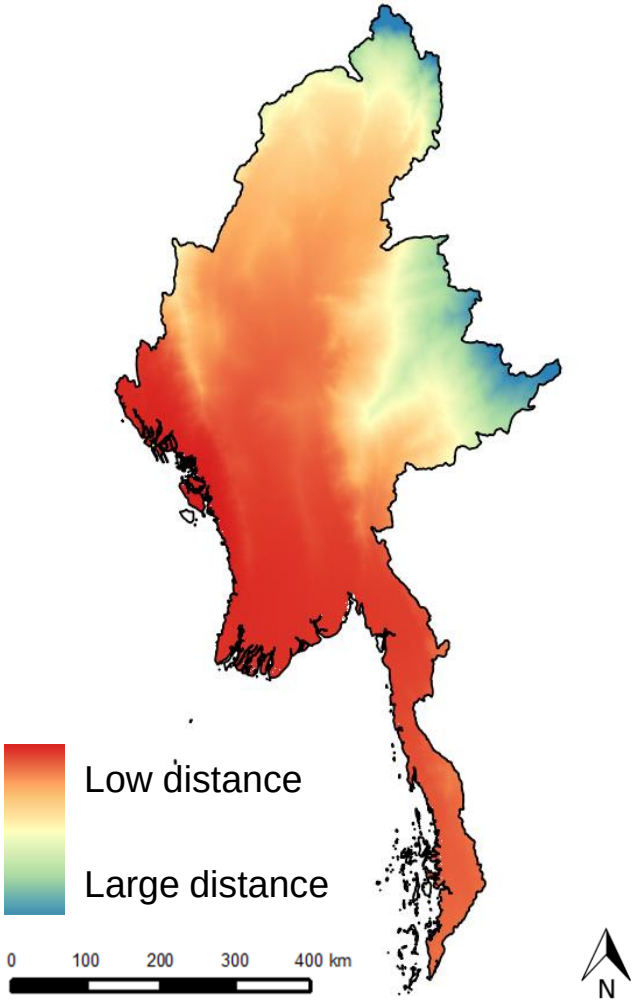
Source:

- Nelson , A., Estimated travel time to the nearest city of 50,000 or more people in year 2000, Global Environment Monitoring Unit - Joint Research Centre of the European Commission, Ispra, Italy, 2008.

Geospatial analysis – Accumulated distance to the grid

- When combining the existing grid with the elevation as topographical challenge for grid extension, it becomes clear that especially the far north and far east regions are the most difficult to reach locations by grid extension

- Other factors such as water bodies and land cover are not considered here



Source:

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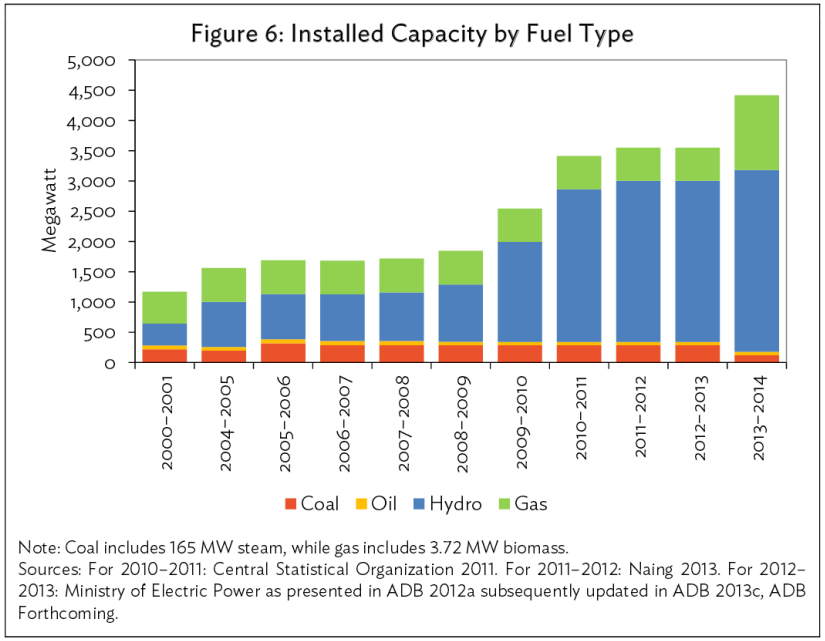
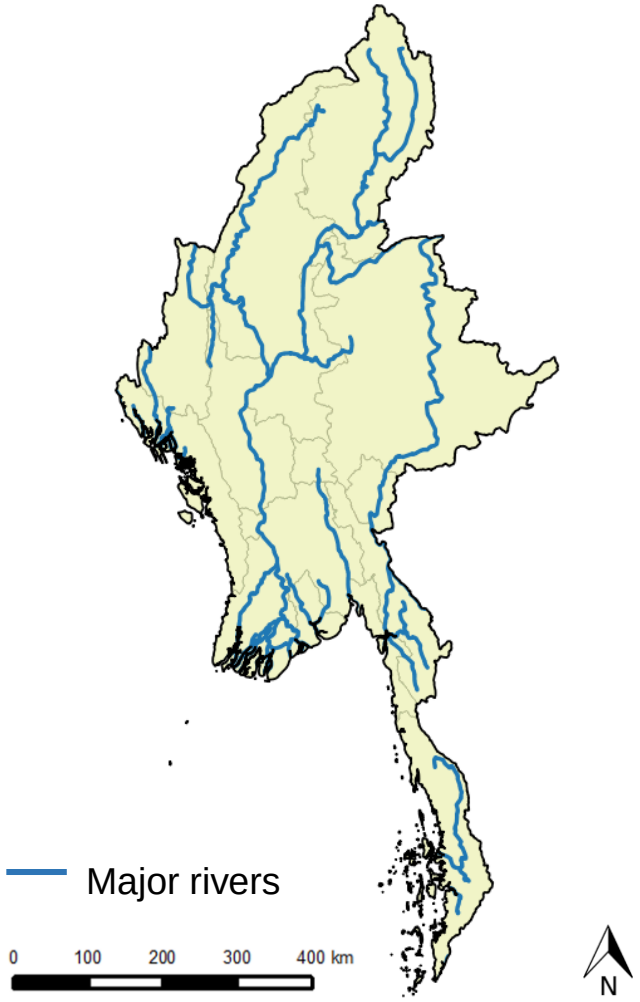
Geospatial analysis – Major rivers

- Myanmar has a large hydro power potential, right now the generation mix shows that hydro is a major source for electricity supply
- Large scale hydro but also small scale micro hydro is possible in many locations

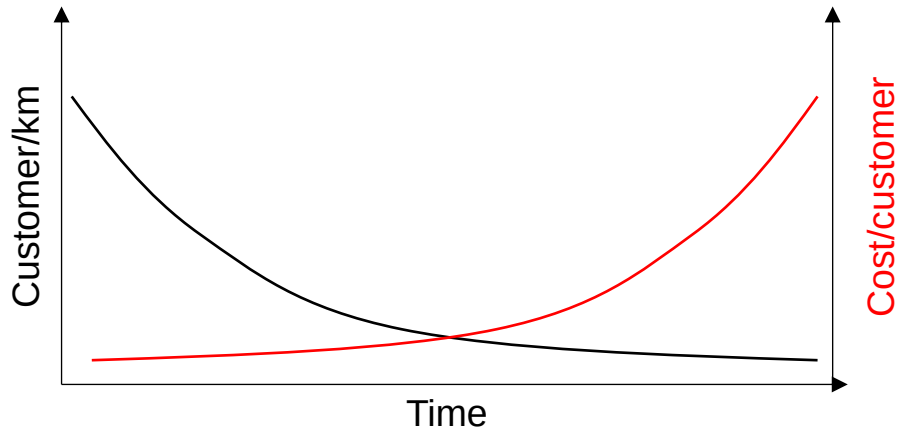




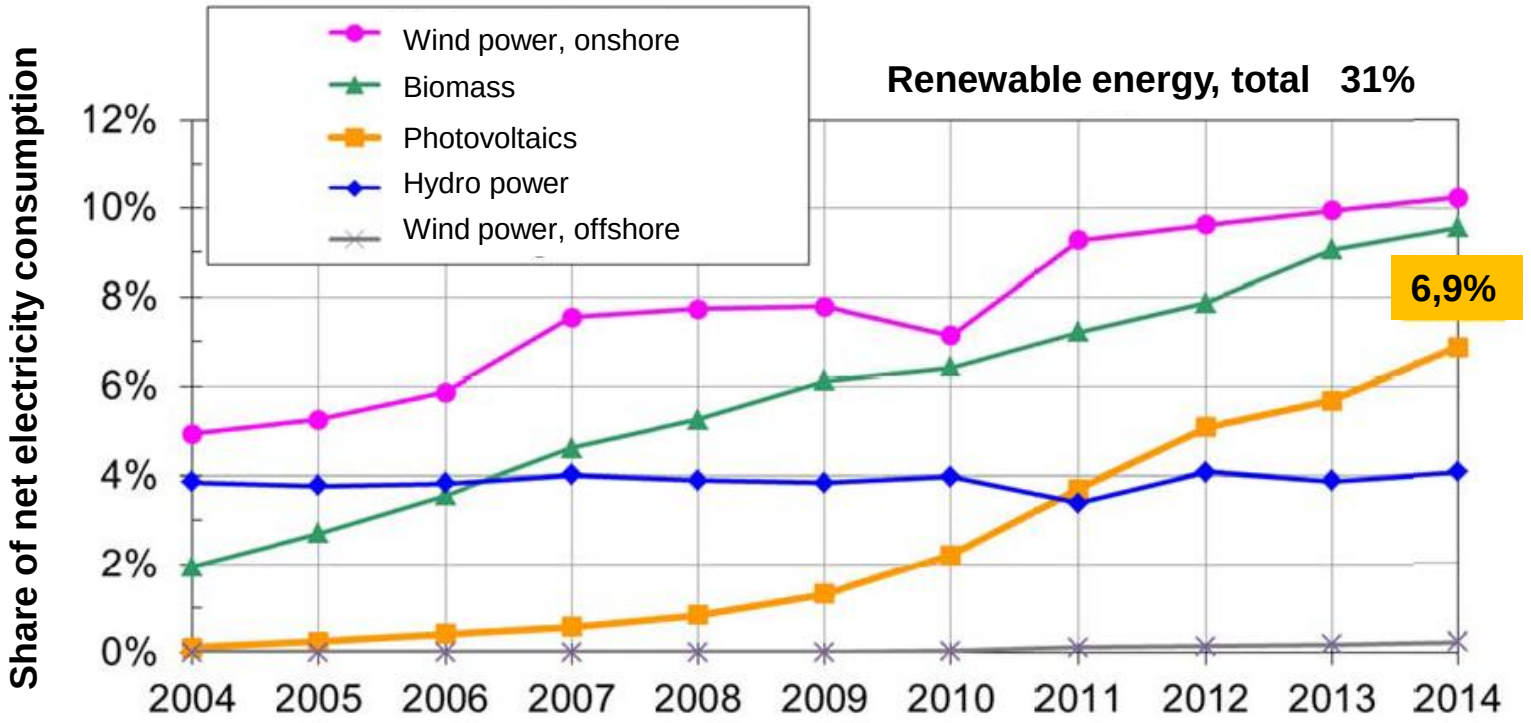
http://www.adb.org/sites/default/files/publication/175801/ewp-460.pdf

Geospatial analysis – Summary

- Most densely populated areas are already electrified by central infrastructure
- Population in non-electrified areas is dispersed and lives often in difficult to access regions
- Large distances are in between the existing grid and non-connected regions
- Myanmar has high shares of renewable energy in the generation mix
- “Low hanging fruits” are easy to reach by grid densification
- Large infrastructure projects such as grid extension are long-term projects and already feasibility studies and planning take significant amounts of time



Renewable Energy: Facts from Germany

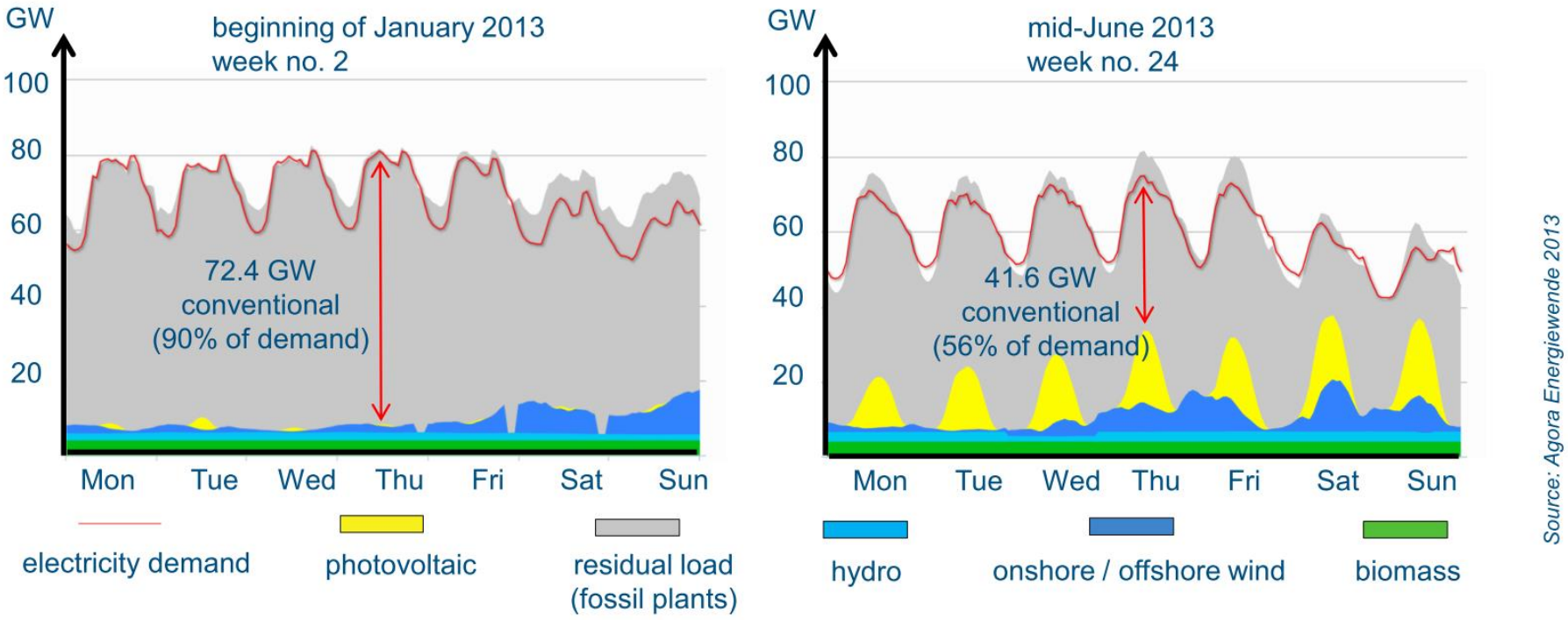


Source: Fraunhofer ISE (2015)

Goal: 80 % by 2050!

→ Stability of frequency and voltage (in all grid levels)

Intermittent renewable energies



Conventional power plants need to adapt to higher flexibility needs.

Power System Stability

Legal framework to ensure power system stability

Grid operators are legally bound to ensure a safe and stable energy supply in a non-discriminatory manner
14(1) EnWG

§

Motivation

Liability in cases of negligence

Guaranteed by the application of

- Generally acknowledged rules of technology
- Technical standards and specifications

Voltage stability

Voltage: $U_n \pm 10\ \%$
(DIN EN 50160)

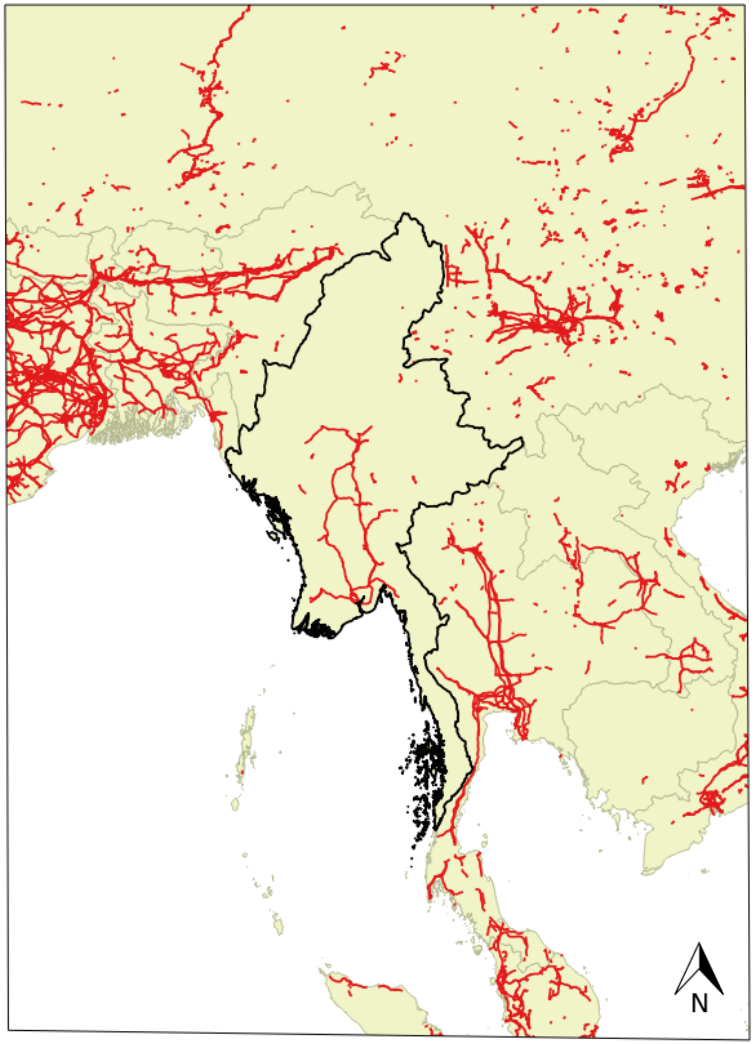
Over-loading

- Technical standards of assets
- (n-1)-criteria

Option of cross-border electricity trade

- As Myanmar is bordered by different countries the option of cross border electricity trade exists.

- Grid infrastructure near Myanmar exists in the Northwest to India, in the Northeast to China, in the Southeast to Thailand and to Malaysia in the South



Source:
- *OpenStreetMap, 2016*

Conclusion

- Many dimensions are important to consider for grid extension planning:
  - Spatial scale
  - Temporal scale
  - Availability of resources
  - Growing demand for electricity

- The advantage different alternatives should trigger the consideration of optimum technologies, especially looking at sustainability issues

- Modelling and planning tools are required to support strategic decision making for T&D infrastructure planning

„Renewable energies are have great potentials – both for the on-grid sector development and the off-grid electrification in Myanmar “

Thank You!

Get in touch with us

- Questions
- Discussion on further opportunities
- Research collaboration

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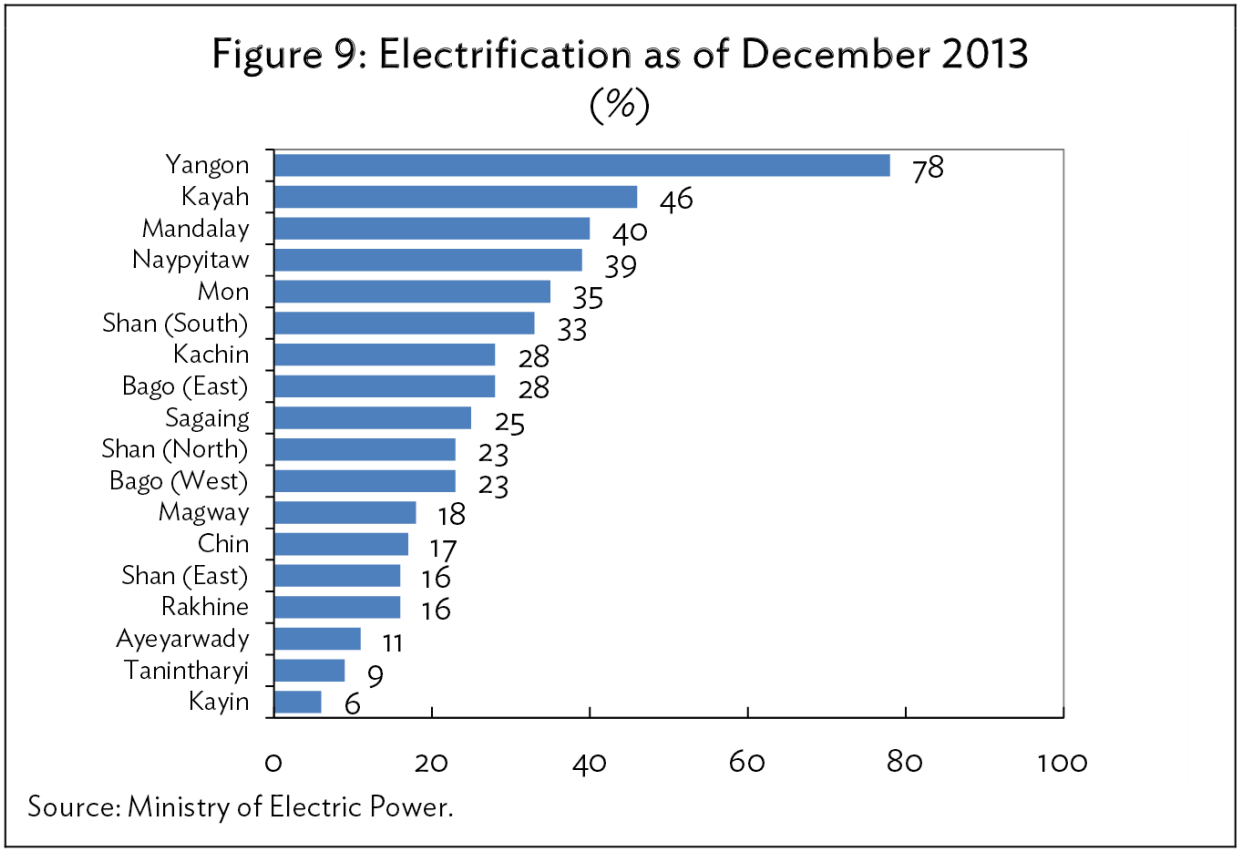
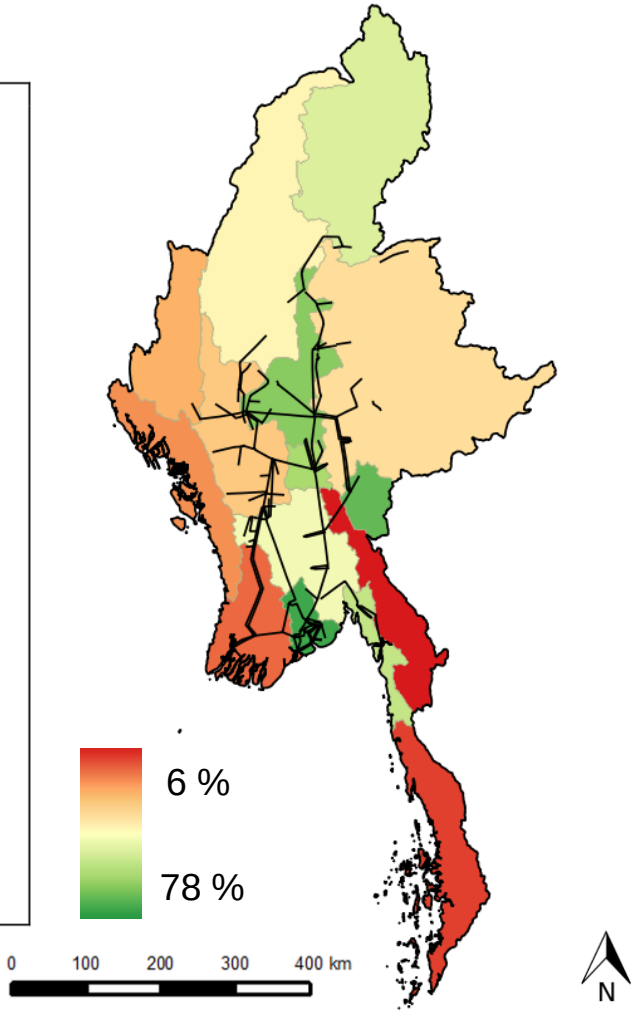
Introduction – Electrification rate Myanmar

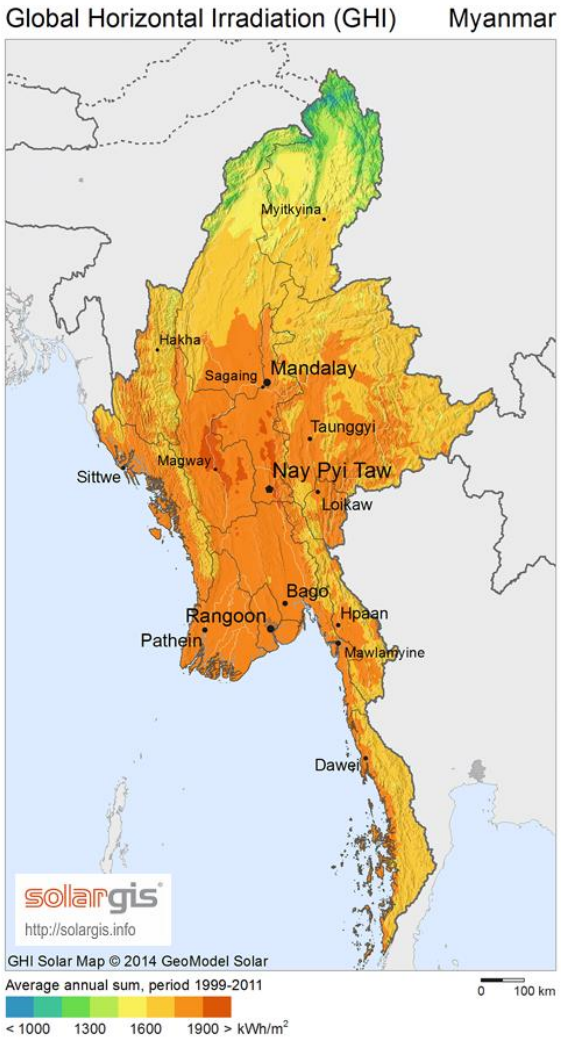




http://www.adb.org/sites/default/files/publication/175801/ewp-460.pdf

Large renewable energy potential

- Solar power
- Hydro power (large scale/small scale)
- Biomass gasifiers



The spatially distributed nature of renewable energy resources calls for their local usage, especially for remote, small clusters of electricity demand.