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Ministry of Economic Affairs
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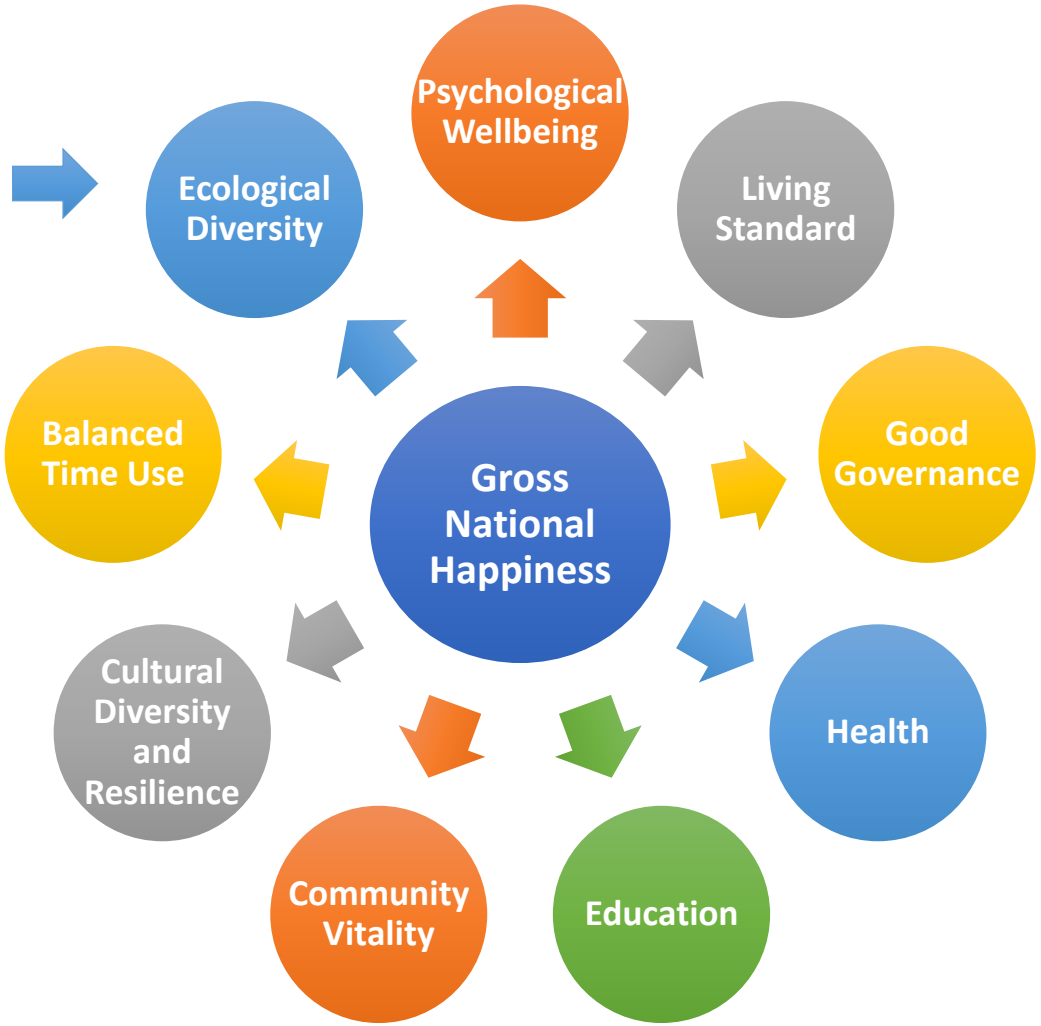
Renewable Readiness Assessment for Bhutan

Findings and Rationale

Thimpu, 25 December 2018

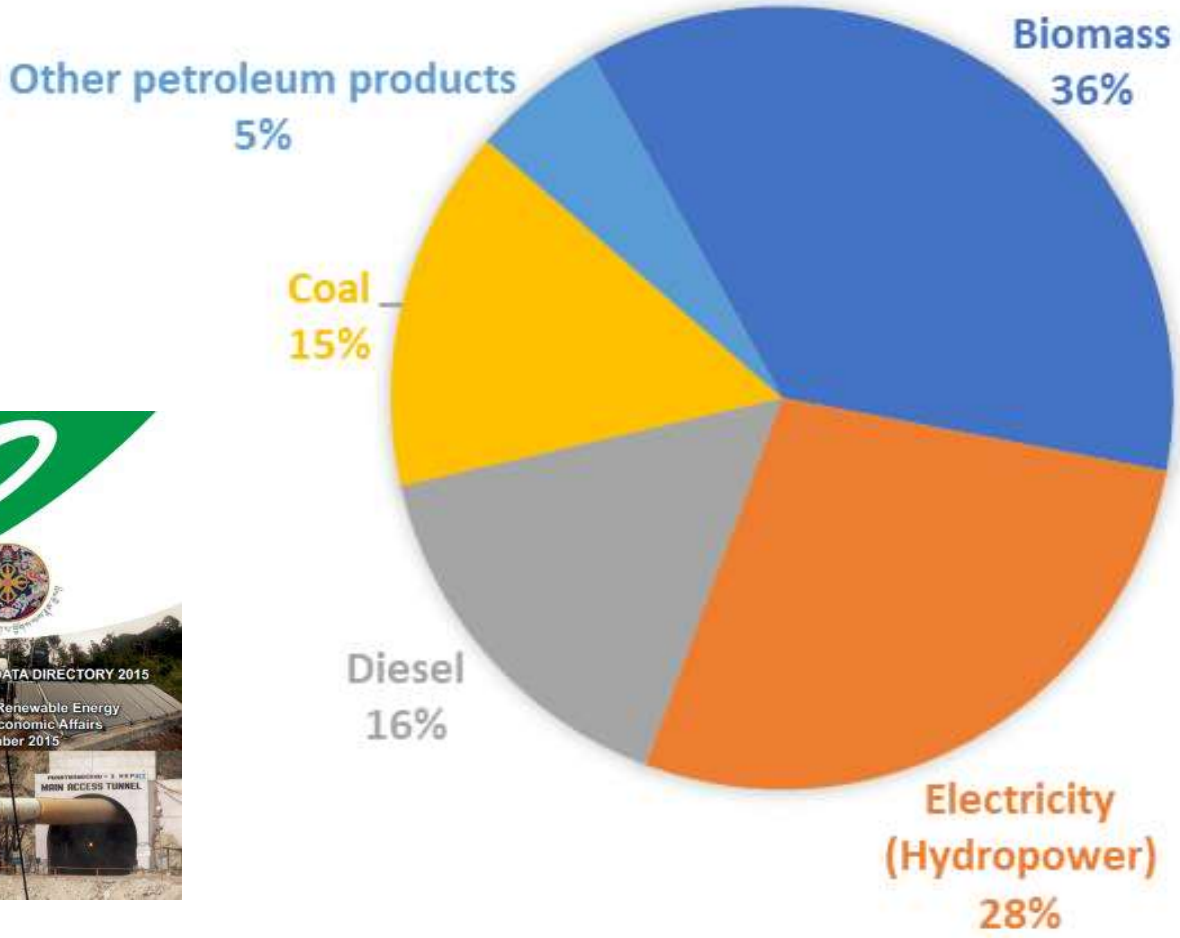
A Nation Blessed with hydropower

- The Kingdom of Bhutan is net carbon negative – sequesters more carbon than its emissions.
- Strong focus on environmental conservation and protection as part of government's strategies
- Hydropower is addressing the local electricity demand and creating economic value through export



Exploring the energy sector

Energy consumption by fuel (TOE)



Total Energy
650,220 TOE

On-grid hydropower	=	180,006 TOE
Off-grid hydropower	=	74 TOE
Off-grid solar	=	12 TOE

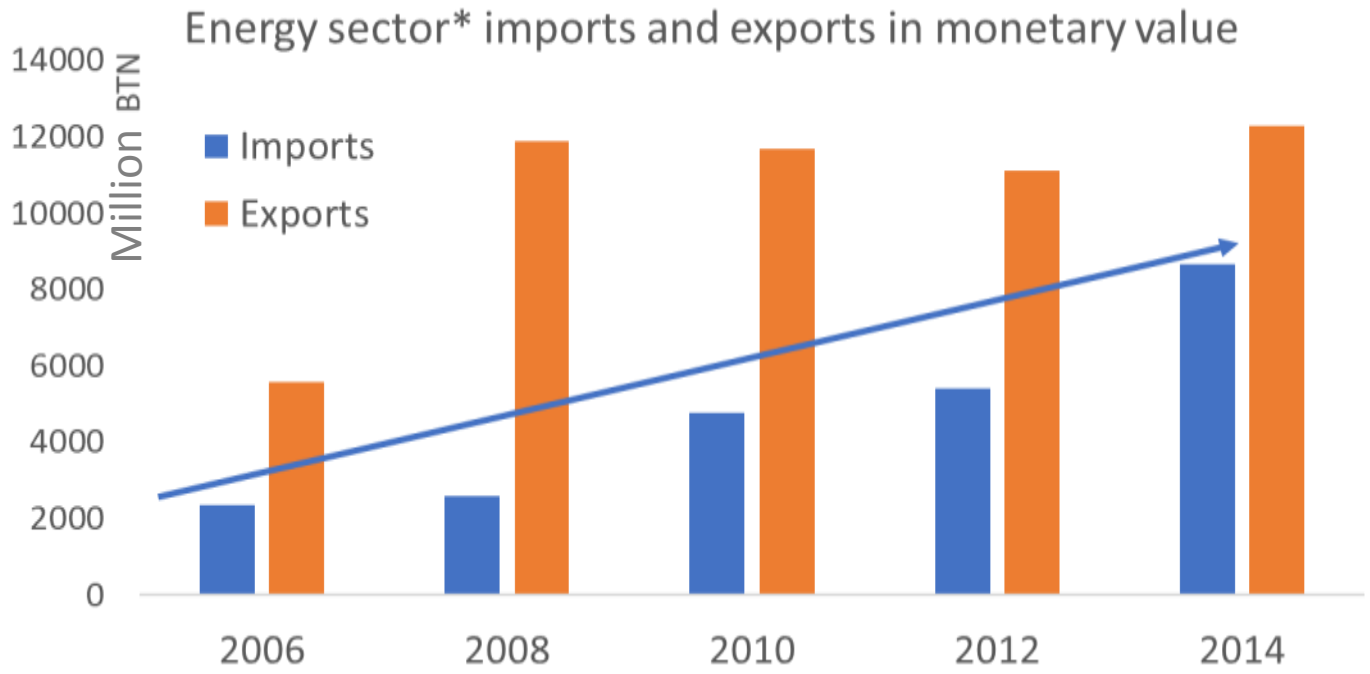
Rationale for diversification

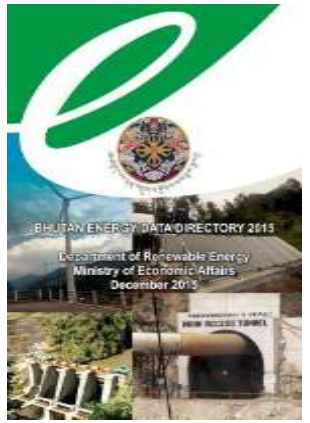
Rising demand and fuel imports

Petroleum products consumption growth CAGR (2006 to 2014)

- **Diesel** ↑9.8%
- **Petrol** ↑8.3%
- **LPG** ↑ 3.9%
- **ATF** ↑ 18%
- **Kerosene** ↓9.8%

Energy import bill has quadrupled
2280 million BTN (2006) to 8300 million BTN (2014)





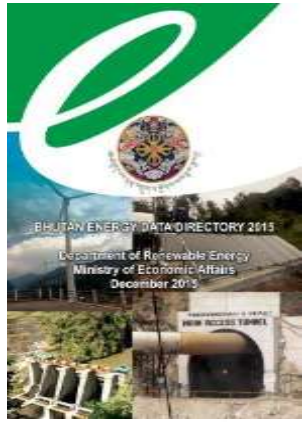
** Excludes imports and exports of coal*

A combination of increased **energy efficiency** and penetration of **renewable energy** can help **address the domestic demand in an environmentally and economically sustainable**

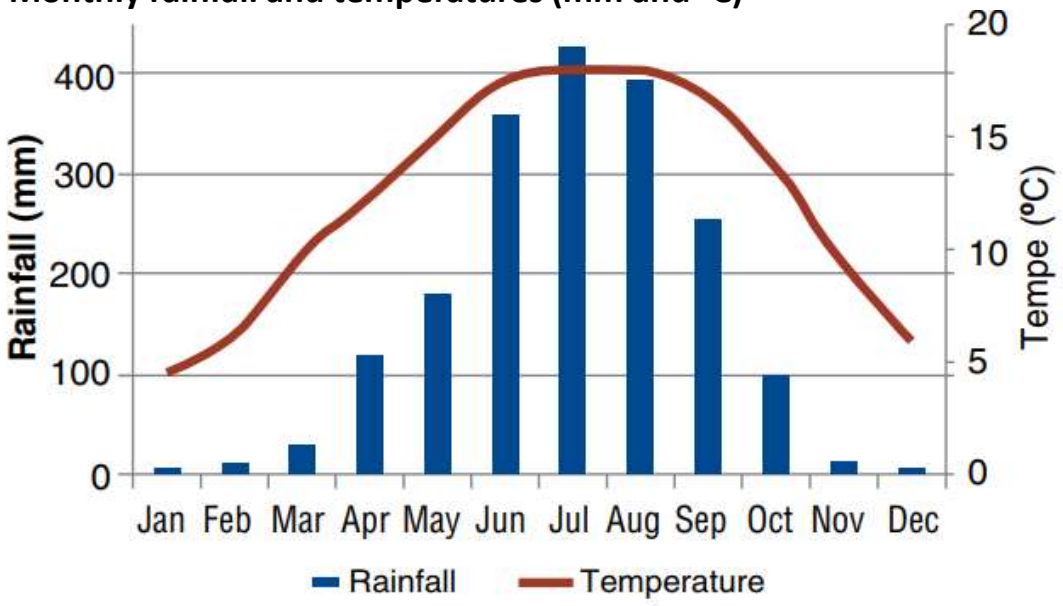
Seasonal variation hydropower

Rainfall in Bhutan tends to decline in winter months (below)

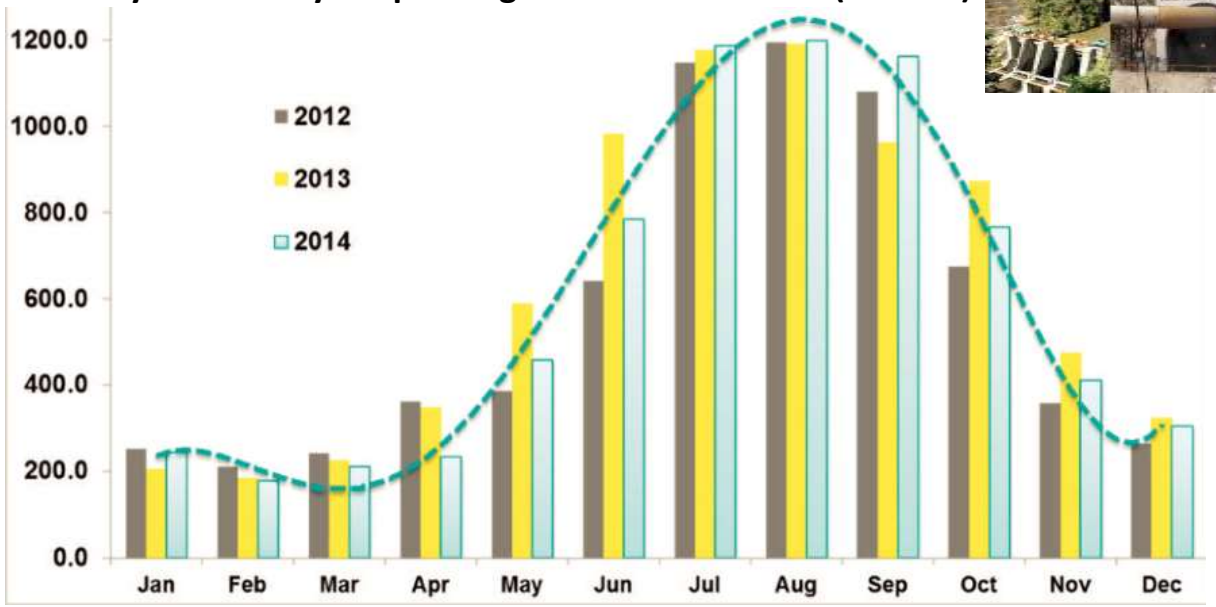
Hydropower generation is significantly reduced in winter



Monthly rainfall and temperatures (mm and ºC)



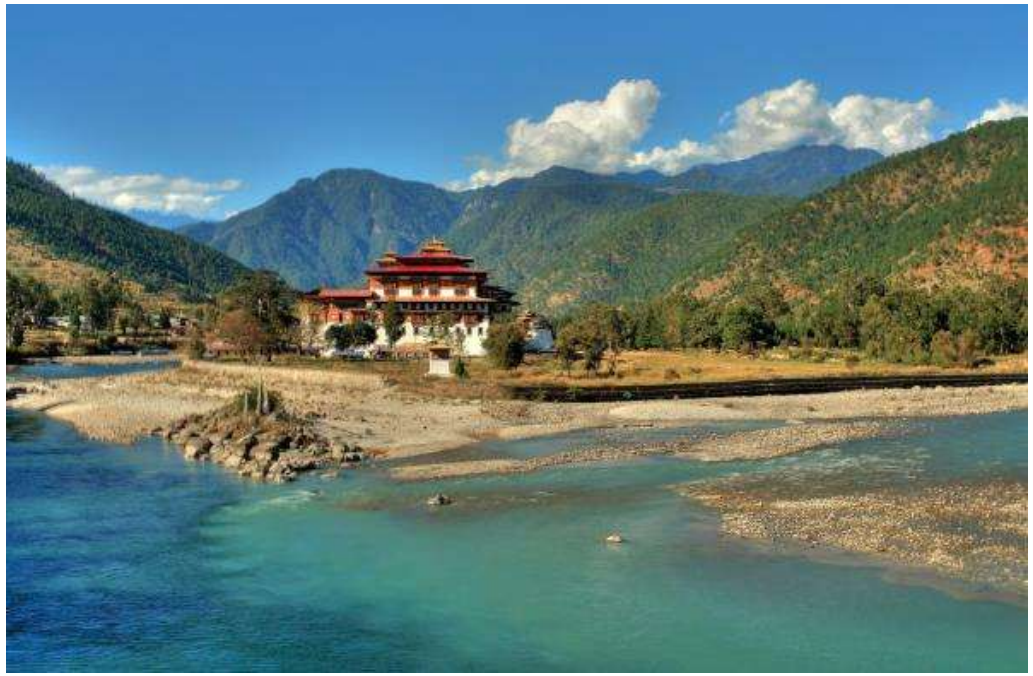
Monthly trend of Hydro-power generation in Bhutan (in GWh)



An energy system which constitutes a healthy mix of **renewable energy technologies** including **hydropower, solar PV, wind and bioenergy** can be more resilient to the **seasonal variation in rainfall patterns.**

Climate change impacts

Changing river flows



Climate change may result in overall more erratic river flow. Higher during rainy season and dry just before.

Catastrophic events, GLOFs

*The Bhote Koshi hydropower 45 MW **Nepal** damaged by a flood.*
*The Dig Tsho GLOF washed away a new hydropower plant in **Bhutan***

An energy system which constitutes a healthy mix of **renewable energy technologies** including **hydropower, solar PV, wind and bioenergy** can be more resilient to the impacts of **climate change**

Environmental impacts

The hydropower sector of Bhutan is driven by run-of-the-river (ROR) installations, which avoid a lot of the environmental and climate impacts.

But some impacts are unavoidable

- Drying up of the river bed
- Loss of forest and disturbance to wildlife
- Dust pollution and noise pollution during construction
- Damage to water bodies and stress on water resources in the region

Shift towards reservoir based hydropower may mean more severe impacts on environment

- Methane emissions
- Displacement
- Drying up of the river bed
- Loss of forest and disturbance to wildlife
- Dust pollution and noise pollution during construction
- Damage to water bodies and stress on water resources in the region

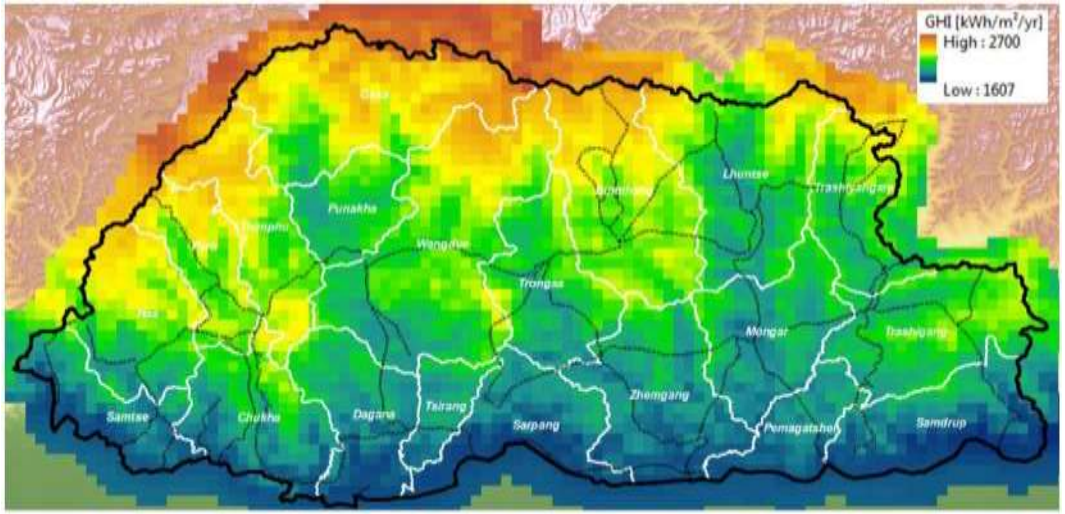
Renewable energy technologies such as solar PV, wind and bioenergy, if implemented in a sustainable way, can have minimal impacts on the environment.

Renewables offer opportunities for diversification

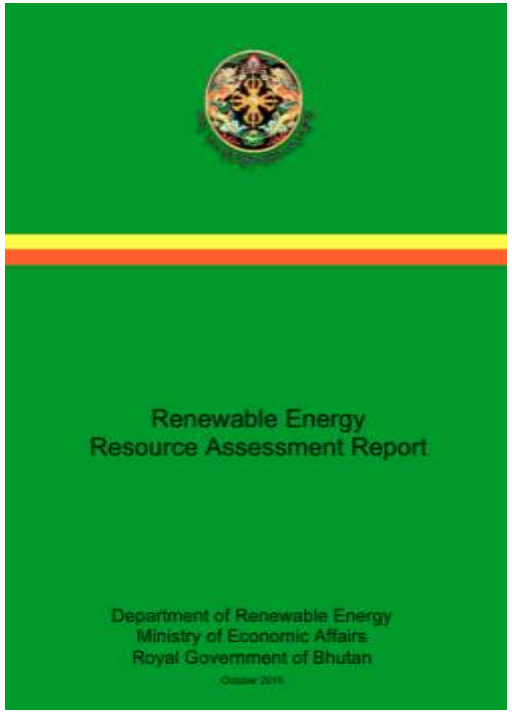
Promising renewable energy resources

6 TW *Theoretical potential*

12 GW *Restricted **technical** potential*

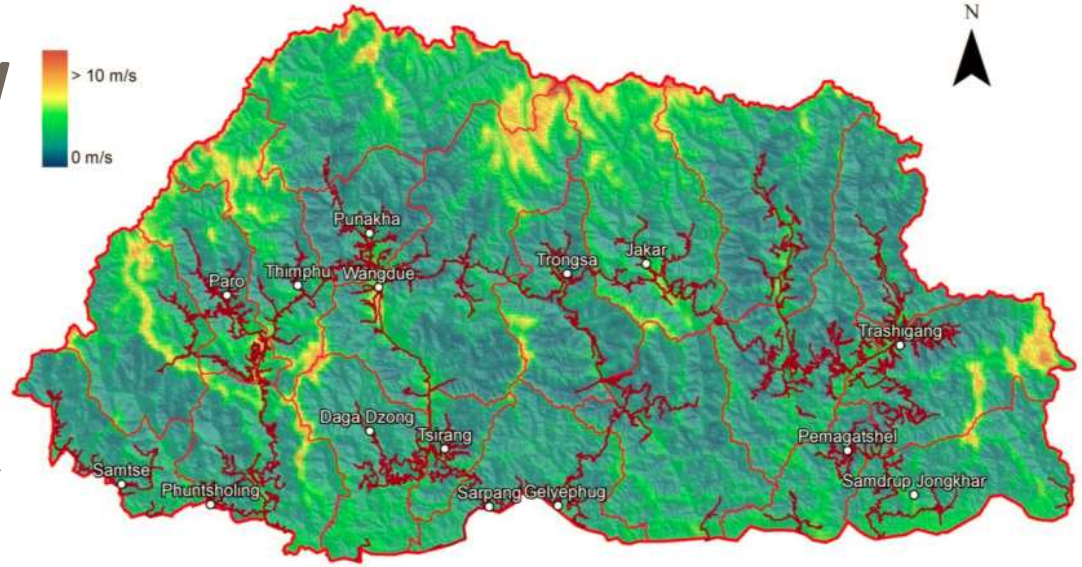


Solar map from 3Tier in original resolution, values in kWh/m² including districts and major national road network (DRE MOEA, 2016b)



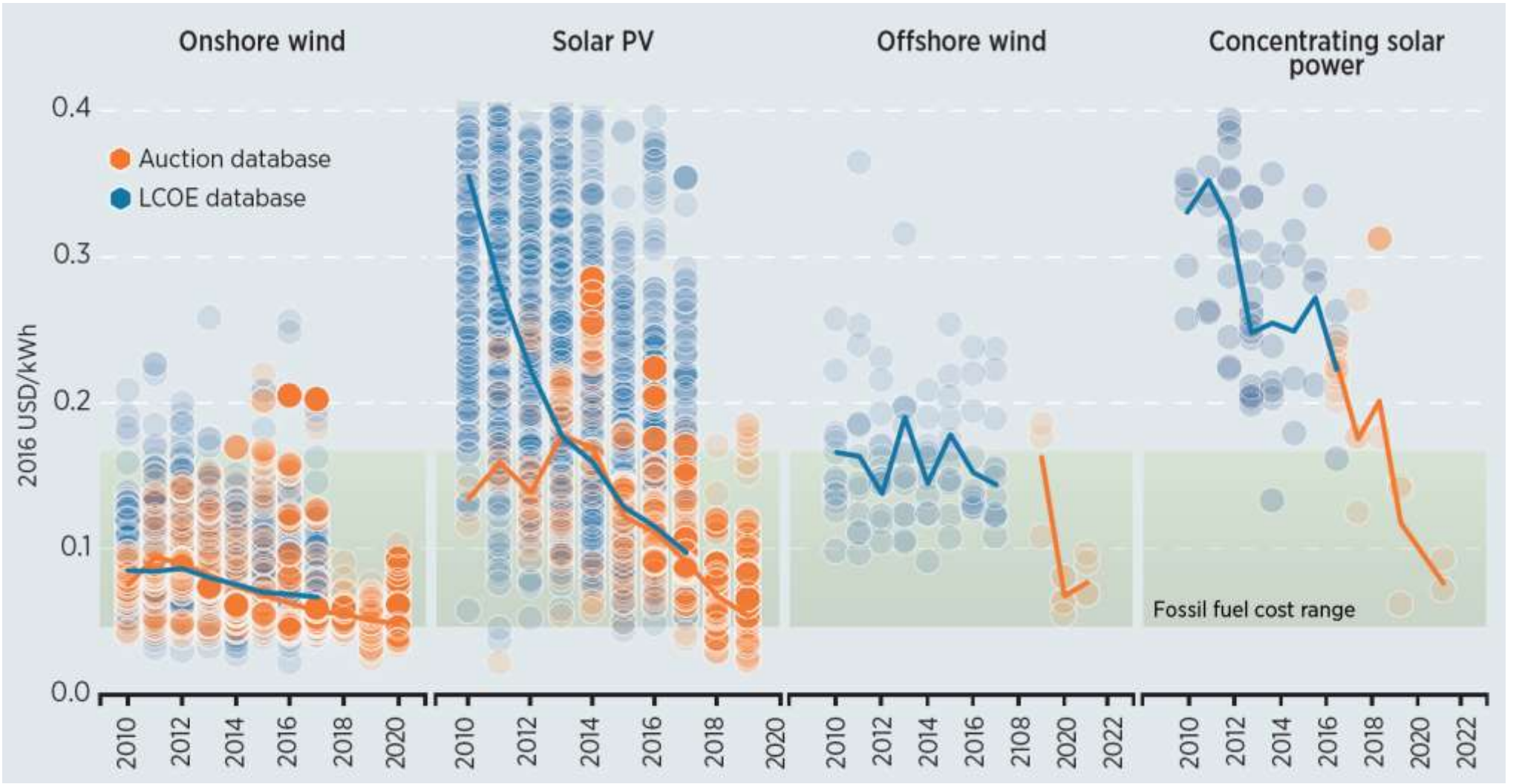
64 GW *Theoretical potential*

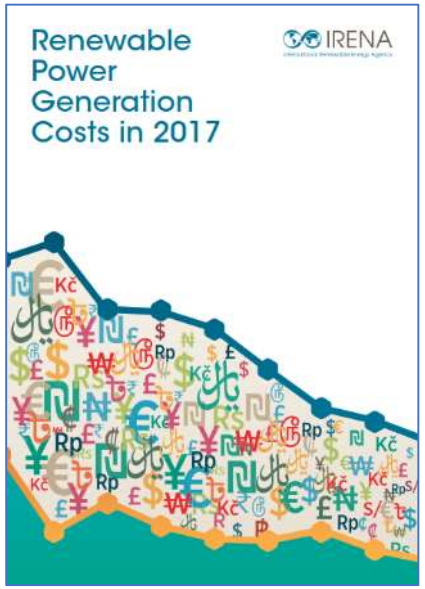
760 MW *Restricted **technical** potential*



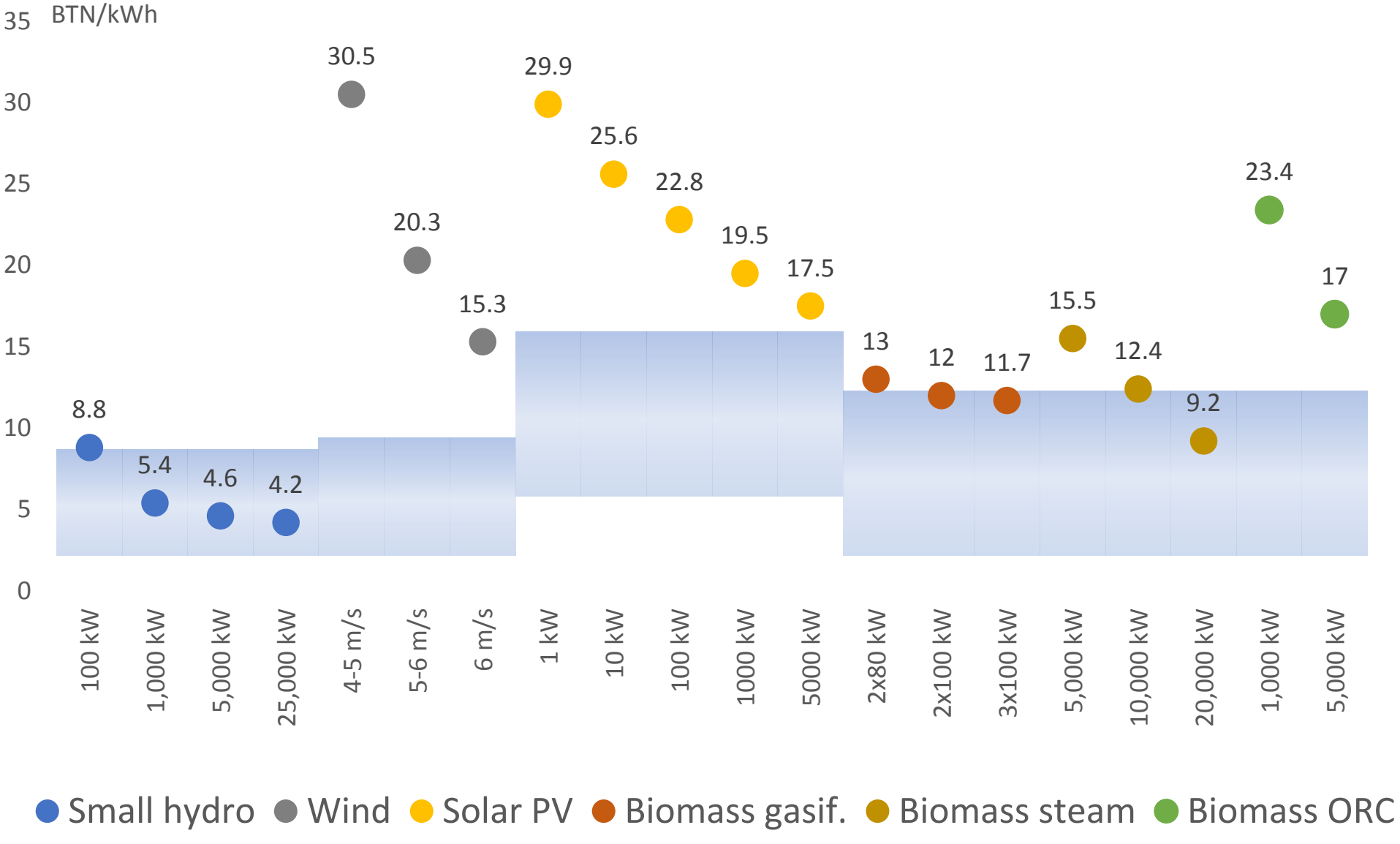
Map of annual average wind speeds at a height of 60 m from 1 km x 1 km model (DRE MOEA, 2016b)

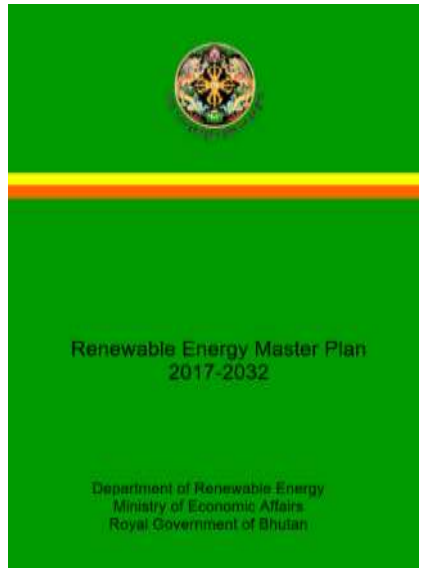
Declining costs: Global trends

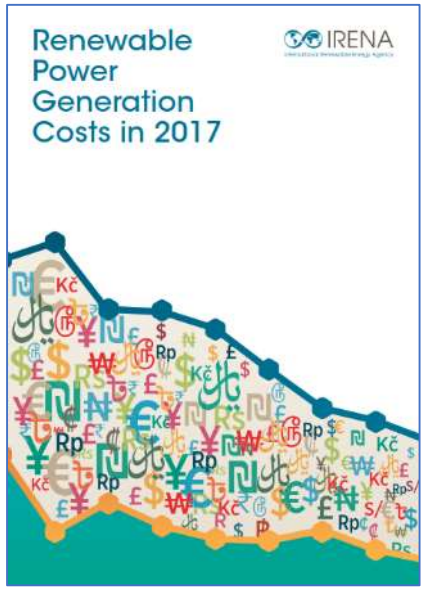




Declining costs: Estimates for Bhutan







Energy access and quality of life

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Solar home systems

Agrifood processing (and other productive uses)

Healthcare solutions

Short construction periods

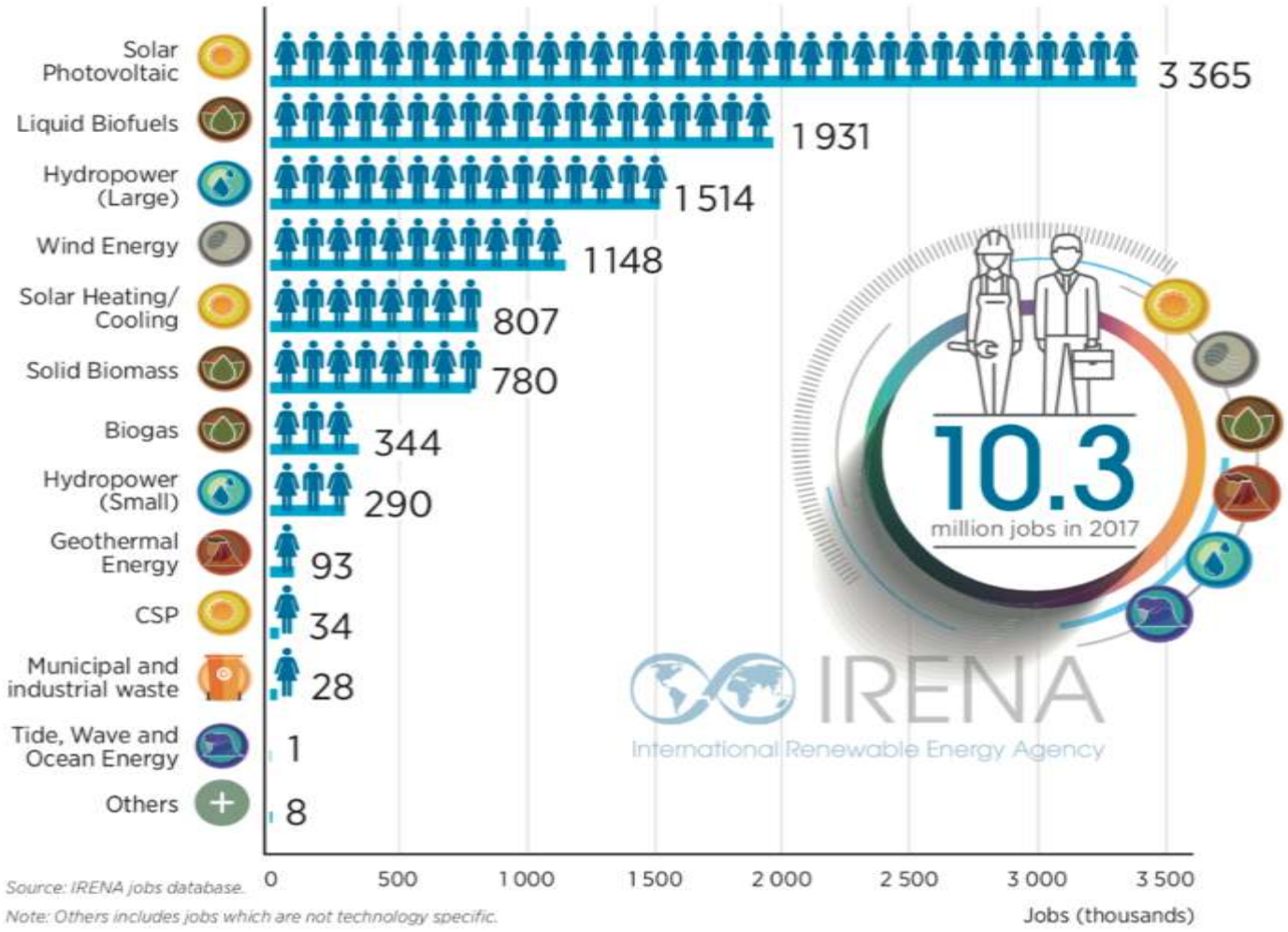
Large solar PV projects (100 MW) can be completed in **less than year**.

Construction time of **six months** reported for 50 MW wind parks.

Large hydro **longer construction time**, potential delays, cost overruns.

Industrial development and job creation

Renewable energy jobs by technology, 2017



2050

28.8

million

Leveraging Local Capacity: Solar PV and wind value chains

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50 MW solar PV:
229 055 person-days

Procurement | Manufacturing | Transport | Installation | Grid Connection | Operation and Maintenance | Decommis-sioning

Project Planning 1% | 22% | 2% | 17% | 56% | 2%

50 MW onshore wind:
144 420 person-days

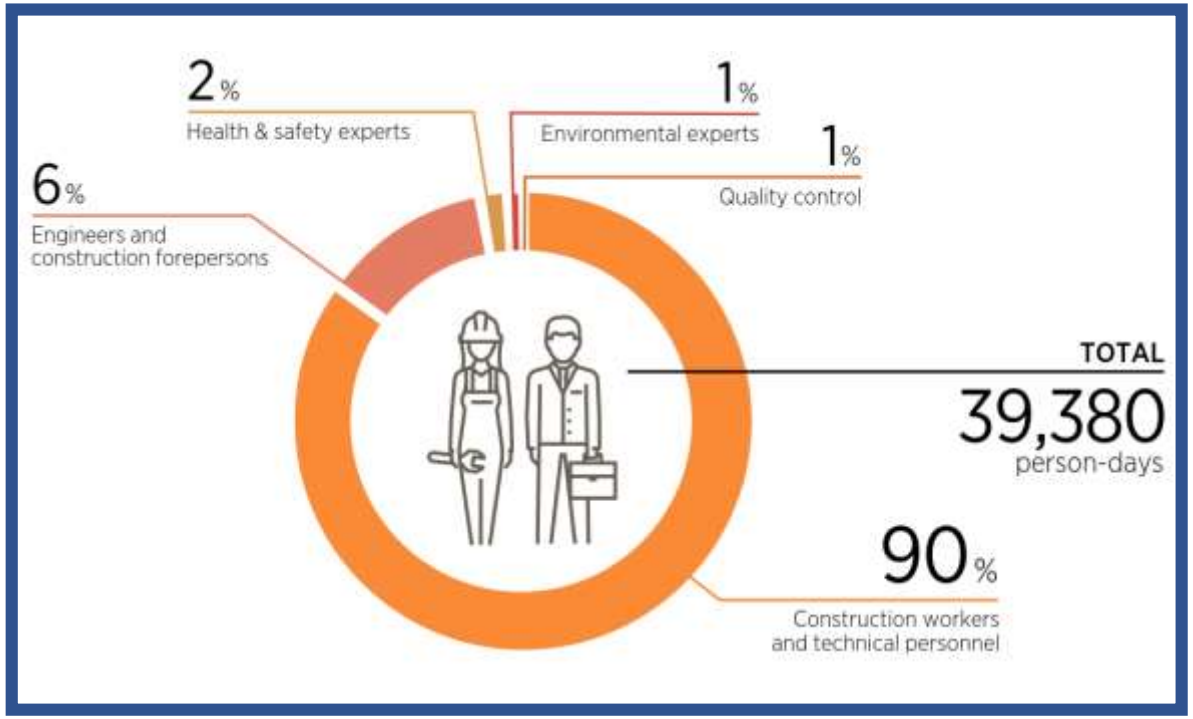
Project Planning 2% | 17% | 1% | 30% | 43% | 7%

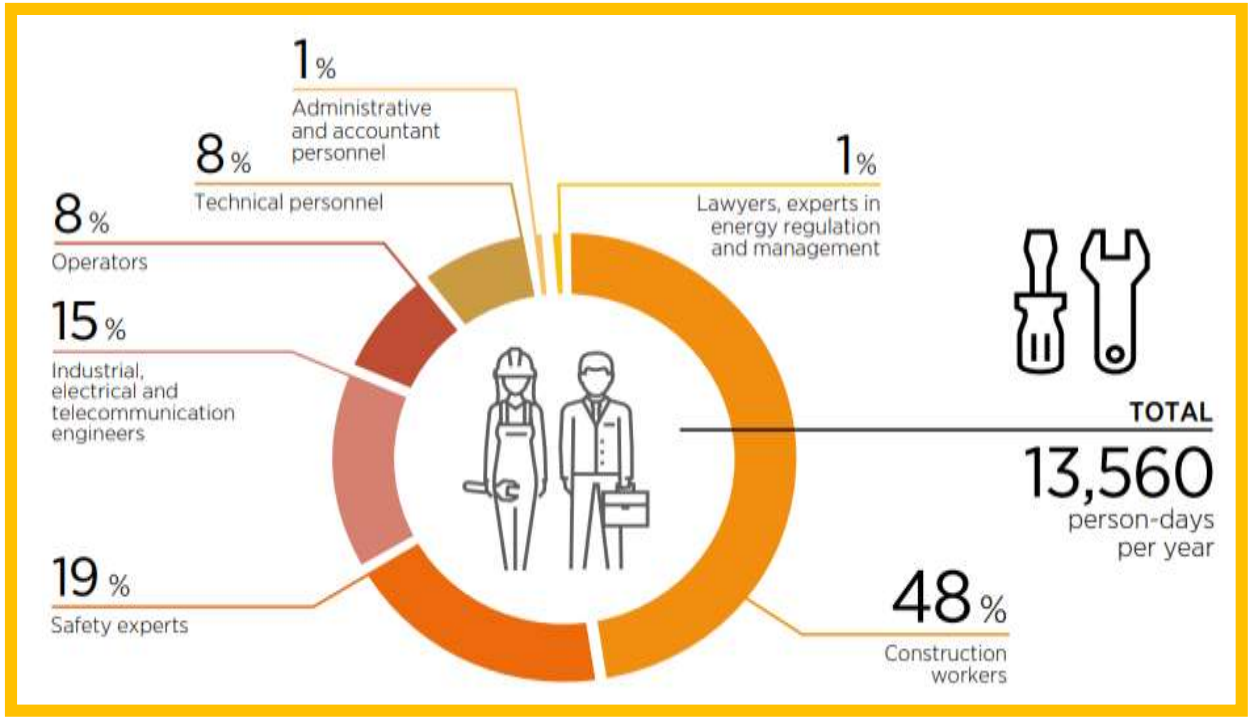
Solar PV value chain

Project Planning 1%

50 MW Solar PV: 229 055 person days

Procurement	Manufacturing	Transport	Installation	Grid Connection	Operation and Maintenance	Decommissioning
22%		2%	17%		56%	2%





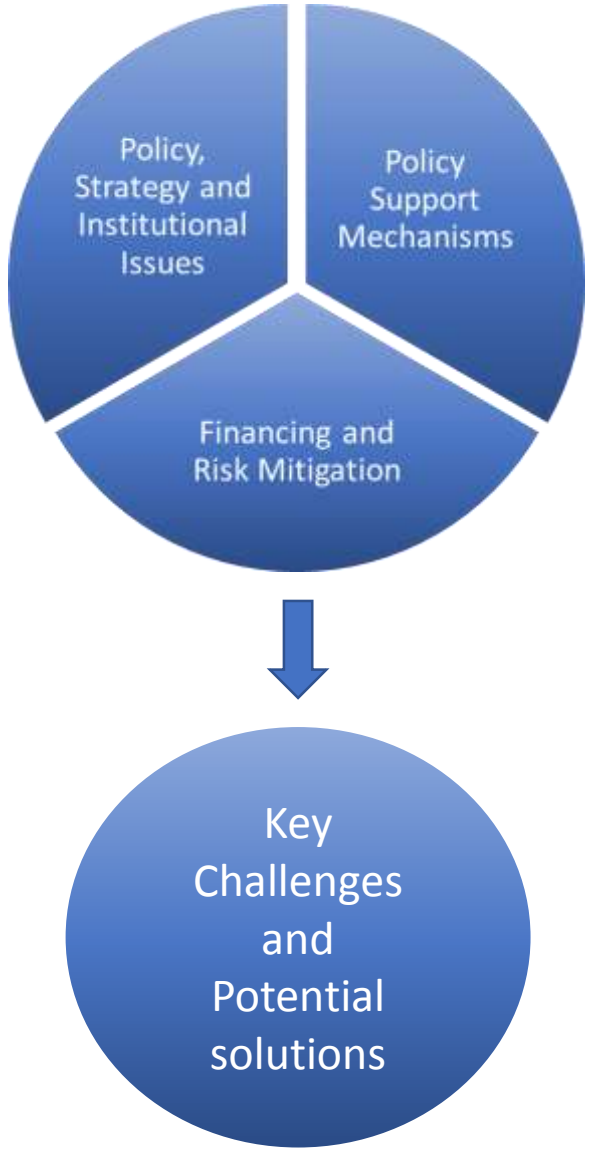
RRA Resource-Service Pairs

SERVICE	RENEWABLE ENERGY RESOURCE					
	Hydro	Wind	Solar	Bioenergy	Geothermal	Marine
On grid – electricity	x	x	x	x	x	x
Off grid – electricity	x	x	x	x	x	
Thermal energy (heating & Cooling)			x	x	x	
Transport*				x		

* incl. electrification of transport

RRA Service-Resource Pairs (Bhutan)

Service/ Resource	Elements					
	Policy & strategy	Institutional, Regulatory & Market Structure	Resource, Technology & Infrastructure	Business model	Capacity Building	Energy Efficiency
Off grid – electricity (solar, small hydro, wind, bioenergy)	❑ Gaps and barriers ❑ Preliminary proposals for action					
Thermal energy - heating & cooling – solar, bioenergy						
On grid – electricity (hydro, wind, solar, bioenergy, geothermal)						
Transport - electrification						

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