Solar organic Rankine cycle technology for electricity generation, heating and cooling: A new pathway for sustainable development in Himalayas and Terai regions of Nepal

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## **Clean Energy in Nepal**

Almost all the generated electricity comes from the hydropower plant in Nepal

In 2000, access to electricity was only 19%

In 2019, access
without electricity is
6% of the remaining
population

✓ Residential use in urban areas

✓ Business Enterprises

## ✓ Industrial use

People still do not have grid connection: 1740000

Number of households: 290000 (assuming 6 people)

Difficult terrain for grid connection

Economically infeasible due to sparse households

## Total primary energy supply (TPES) by source, Nepal 1990-2017



Coal Hydro Biofuels and waste Oil Wind, solar, etc.

#### Source: IEA, https://www.iea.org/countries/nepal

## **Heating of Rural Household in Himalayan Region**



a) Firewood room heater

b) Improved cook stove

Firewood is used for cooking and heating purpose in all regions
 After cooking meal, firewood is used for boiling water and improving the thermal environment of the houses

Ram, Pokharel Tika, Rijal Hom Bahadur. and Masanori Shukuva. "Rural Household Energy Use and Thermal Environment in Three Climatic Regions of Nepal." IOP Conference Series: Earth and Environmental Science, Vol. 294. No. 1. IOP Publishing, 2019.



Bhandari, Ramchandra, and Surendra Pandit. "Electricity as a Cooking Means in Nepal—A Modelling Tool Approach." *Sustainability* 10.8 (2018): 2841.

> Energy demand (a) By sub-sectors (b) By fuel types



Ranabhat, Chhabi Lal, et al. "Consequence of indoor air pollution in rural area of Nepal: a simplified measurement approach." Frontiers in public health 3 (2015): 5.

## Solar Organic Rankine Cycle Technology



#### **Heating and Cooling Unit**

Hong, Xiaoqiang, and Feng Shi. "Comparative Analysis of Small-Scale Integrated Solar ORC-Absorption Based Cogeneration Systems." Energies 13.4

Specific entropy, kJ/kg.K

(2020): 946. Baral, S.; Kim, D.; Yun, E.; Kim, K.C. Energy, Exergy and Performance Analysis of Small-Scale Organic Rankine Cycle Systems for Electrical Power Generation Applicable in Rural Areas of Developing Countries. *Energies* 2015, *8*, 684-713

## Geographic and Technical potential of solar ORC for various countries

		Area	Irradiance	GP(TWh)/ye	TP(TWh)/ye	
	Country	(Sq.km²)	(kWh/m²day)	ar	ar	
	Afghanistan	33163	6.5	1983	159	
	Bangladesh	7652	5.4	380	30	
<	Bhutan	2340	5	107	9	
	India	<del>188391</del>	5.7	<u>-98</u> 77	790	
	Nepal	2791	5.3	466	37	>
	Pakistan	62946	5.2	3010	241	
		3678	5.6	189	15	



Theoretical potentialGeographic potentialTechnical potential





## **Economic Analysis of the system**

## **Emission Calculation**



## CO<sub>2</sub> emission saving by the Solar **ORC** system throughout the lifetime

•Technological barriers Lack of technical human for

**Obstacles of solar ORC** 



## **Investment-based**

The capital subsidy for ORC of 3.5 kW shall be60-80 % of total investment.

## **Connection-based**

In this system, 30-50 households can be benefited and each of them should invest \$ 300 from the subsidy rate of government.

## **Output-based**

- The limit of electricity supply for each household shall be 50kWh.
- The households pay a monthly electricity fee to the utility company.
- The installers cost and households electricity cost shall be subsidized by the government.

# Thank you for your kind attention !

## Any queries and suggestions?