EDU MATERIALS

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SUSTENANCE

SUSTENANCE INTRODUCES ASPECTS OF THE ENERGY TRANSITION

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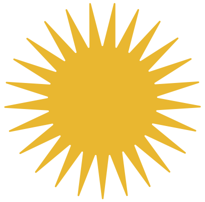
The role of citizens and local energy communities in the energy transition



Citizens are important players in the energy transition. They are the end-users of energy which they consume in their homes and through other activities like travelling. Their choices directly affect energy consumption through their energy use and energy-saving habits. They also indirectly influence energy consumption by buying energy-efficient appliances and equipment, which can help to reduce their energy consumption.

In general, citizens can influence the energy transition in a democracy in their capacity as voters. They can for instance support political parties and policies that promote renewable energy. They are also economic market actors who can choose to buy renewable energy or invest in their own renewable energy production, like their own solar panels, or decide to invest in renewable energy projects, such as solar or wind farms. They can also influence the energy transition by contributing to decarbonization through green electrification of house heating and mobility by investing in batteries, heat pumps, and electric vehicles (EV).

Particularly the transition from a centralised to a more decentralised energy system involves a new role for citizens. Centralized energy supply involves the large-scale generation of electricity at a central power plant which is then transported over a distance to consumers through an electric power grid. In a decentralised local energy system, the role of citizens can change from mere consumers to active energy citizens that are more actively involved in producing energy or by organizing themselves in local community initiatives.

Besides making changes in their own lives, there are many ways for citizens to cooperate together in the energy transition. Citizens can join a local energy community (LEC), which is a group of people who come together to generate, share, and manage their own energy. These local energy communities can play a particularly important role in decentralised distributed energy systems (DES), that allow citizens to deploy their own energy systems like small-scale renewables and storage, which can complement grid-scale electricity decarbonisation. DES can help cut emissions, increase energy security and reduce the need to reinforce grids.

Such LEC's can generate renewable energy by installing and operating renewable energy projects, such as solar panels or wind turbines. The investments in these projects would come from the community members. The LECs can also support individual members in producing their own renewable energy. Further, they can provide energy services, such as energy efficiency advice and web tools, that can help to reduce their member's energy costs.

The European Union legislation introduced two definitions of the local energy community. The Citizen Energy Community (CEC), which is contained in Electricity Directive, and the Renewable Energy Community (REC), which is contained in the Renewable Energy Directive. They are similar but have some different characteristics. In the transposition of these directives to national legislation across the EU, we find several different labels, but some important common characteristics arethat they are open and voluntary and combine non-commercial aims with environmental and social community objectives. This means a particular form of governance with the participation of the members in the decision-making. Ownership and control are reserved for citizens, local authorities and smaller businesses whose primary economic activity is not the energy sector, and whose primary purpose is to generate social and environmental benefits rather than focus on financial profits

A particular form of local energy communities is the juridical form of a cooperative. Like other cooperatives, energy cooperatives follow a number of the basic principles set by the International Cooperative Alliance (ICA). Next to the general local energy community elements of voluntary and open membership and democratic member control, particular ways of proceeding for energy cooperatives' are economic participation by members, autonomy and independence and concern for the community.

CECs and RECs can undertake similar activities includingenergy generation, storage, energy distribution and energy sharing. However local energy communities and community members must comply with the same obligations as other market participants. This means that for instance energy sharing by members or grid distribution by the community is only possible when there are explicit legal provisions. ■

> “BESIDES MAKING CHANGES IN THEIR OWN LIVES, THERE ARE MANY WAYS FOR CITIZENS TO COOPERATE TOGETHER IN THE ENERGY TRANSITION.

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Power system flexibility and its potential/ advantages

A large share of electricity production from variable renewable energy sources in electric power systems requires flexibility. Power system flexibility refers to the ability of the electricity system to always balance the fluctuation in generation and consumption of electricity in real-time, while maintaining the security of supply and efficient utilisation of existing grid infrastructure.

The illustration of the balance between generation and consumption is shown in Figure 1. To achieve power system flexibility for system balance, the electricity market structure and electricity grid operation play a crucial role. Flexible power systems promote sector coupling of renewable generation and consumption, allowing accommodation of variable renewable energy sources, such as solar and wind. Sector coupling is defined as the integration of various energy systems (electricity, heat, gas, and transportation), with the objective to gain mutual benefits to support their stable and secure operation.Flexibility in the power system is a critical aspect for transforming the energy system into carbon neutral economies.

To attain flexibility, the electricity market is considered as a key driver. Global market structure allows flexibility in import and export of renewable energy, between countries, during its shortage and excessive production respectively. The market structure is based

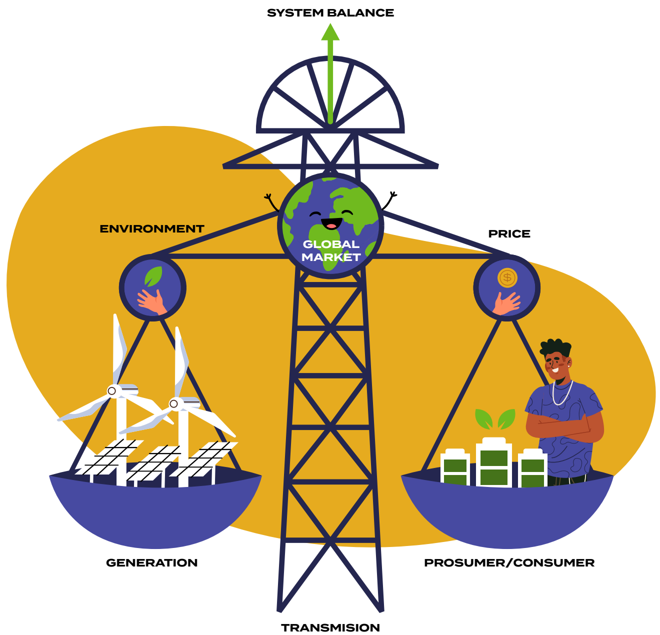

Figure 1: Synergies between generation technologies, market structure, transmission system, and loads (Power System Flexibility) (R.Sinha, 2023)

on the system's requirement to balance and maintain a secure supply of electricity. This requirement is achieved through flexible price signals to end-consumers as an economic incentive for participation, to effect demand-side flexibility.

The market is further enhanced by the engagement of energy communities. The application of demand side flexibility enhances active participation of energy communities in balancing the system with local energy production, consumption, storage and aggregation. This demand side flexibility is attained by shifting the operation of flexible loads (dishwasher, washing machine, dryer, heat pump, electric vehicle charging, energy storage systems etc.) and storing energy (battery, thermal storage, etc.) to match the electricity generation in the grid (Figure 2). An electric

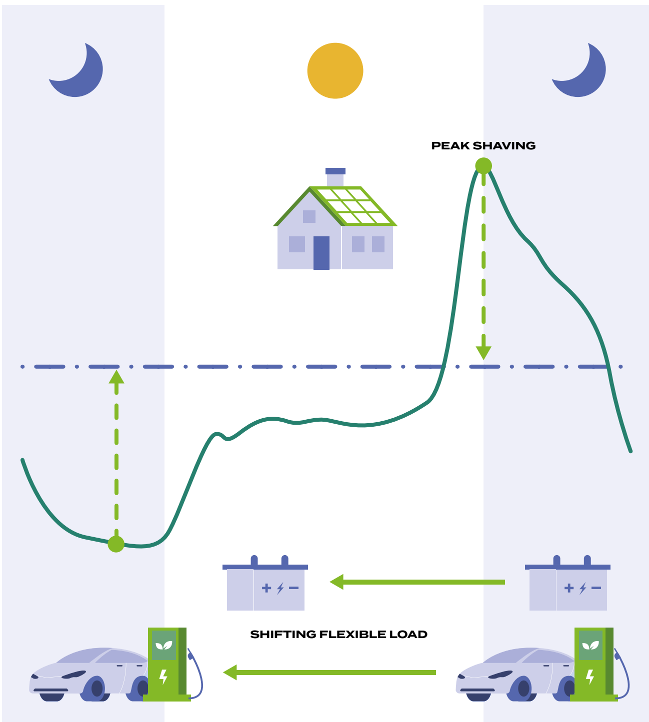

Figure 2: Demand Side Flexibility (Source: R.Sinha, 2023)

vehicle can be charged during the night when electricity demand and the electricity price are low and heat pumps can be operated during day time, to store thermal energy, when PV generation is high. Demand-side flexibility ensures power system reliability and optimal cost of electricity consumption benefiting both the energy utilities and end-consumers.

Potential advantages of power system flexibility:

- Ability to accommodate greater share of variable renewable energy sources.
- Increased requirement for sector coupling, (in the form of Power-to-X, where X stands for: heat/cool, hydrogen, and/or vehicles-to-grid, etc.) is relevant to the utilisation of renewable energy in various energy sectors and promotion of a carbon neutral society.
- Reduction in power loss, secure supply of power, and cost effectiveness is achieved from decentralised power system. Such advantages stem from the use of decentralised power generation rather than conventional and centralised fossil fuel based power units for power system balancing. This is realised by active participation and aggregation of decentralised energy production and local demand side flexibility.
- Efficient utilisation of existing grid infrastructure can be ensured with the support of demand response. Also, it facilitates congestion management and postponement of grid reinforcement in the present transmission and distribution network to accommodate increased renewable generation and new sizeable loads (EVs, HPs, etc) through shifting peak demand. As a consequence, reliability and quality of electricity supply and economic benefits are supported.
- Possibility of self-sustainable mode (island mode) of electricity grid operation: during the event of faults, power system can be divided into smaller self-sustainable and flexible islanded systems, operating independently, ensuring energy security. ■

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Smart charging of electric vehicles to support the sustainable power grid

Day by day, we see more electric vehicles entering the roads with the promise that this means of transport is much more sustainable. Without the noise, it is a convenient and comfortable method of mobility. However, this growing group of electric vehicles need to charge somewhere in our electric grid. It is often overlooked how much energy is required to fully charge an electric vehicle with a range of say 385km (70kWh of energy). The battery can hold enough energy to power an average European household for more than a week! Furthermore, current home chargers draw an amount of power from the grid that is roughly equal to 10 households. Fast chargers along the highway are even more crazy, with the equivalent of more than 100 households per charger.

Many of the electric grids in our neighbourhood were never designed to supply these amounts of power. Furthermore, it is hard to get a feeling for electricity use, but it can be compared to water pipes. Now imagine, that many water (electric) vehicles are charging in your neighbourhood, the amount of water (electricity) that needs to flow is so high that the pipes would burst. In an electricity grid, this is no different: too much power flow will lead to circuit breakers tripping and a local blackout is the result.

In some areas, the electric grid will be overloaded already nowadays if many electric vehicles charge at full capacity. The solution to this is Smart Charging (Figure 1). In essence, this means that charging stations communicate and negotiate with each other over who gets how much power at which time to avoid a grid overload. And yes, this means that cars will charge a little bit slower and will be completely “topped off” later as well. This is what you also will experience in the (near) future. But look at it from the positive side, if all cars would be charging at full power, then you would suffer a power outtage, which also results in your car not being charged, but even worse, all other devices such as your fridge, would not receive power. It is also not such a significant problem since cars are generally parked for 95% of the time!

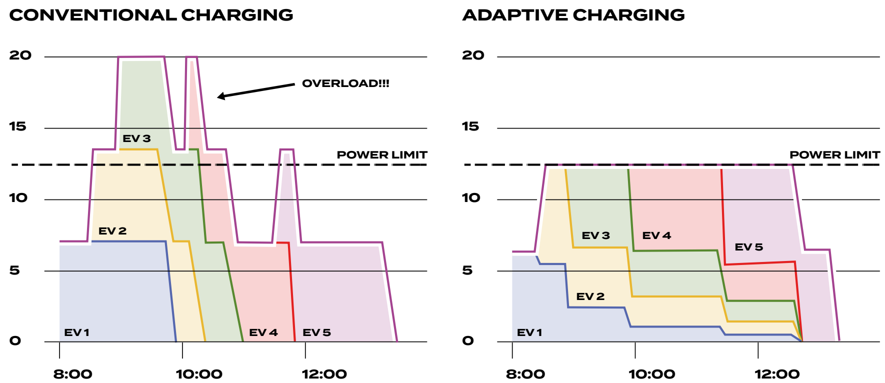

Figure 1: Resolving grid overload through smart charging (adapted from ev.caltech.edu/info).

Looking at it from the sunny side, this 95% means that, even with smart charging, we still have a lot of flexibility left. Which means we could delay the charging even further, which opens up a lot of possibilities to use electric vehicles to support the grid by providing demand response. Demand response is the act of changing the power draw of a load to assist the grid. This could for instance be to provide balancing services to ensure the security of power supply. Consider a moment when the electricity production from a large wind farm suddenly steeply reduces. Normally, another power plant, such as a gas or coal fired power plant will take over to balance the production. Instead, electric vehicles could now reduce their power consumption to balance the grid until the wind comes back again. This way, the vehicles can increase the use of renewables and reduce the emissions of greenhouse gases. Next to this, flexibility also has an economic value, since the electricity bill can also be signifcantly reduced.

Figure 2: Smart charging app showing charging schedule (University of Twente, 2023).

THE BATTERY CAN HOLD ENOUGH ENERGY TO POWER AN AVERAGE EUROPEAN HOUSEHOLD FOR MORE THAN A WEEK!

Another option is to synchronize the charging with the production of sustainable energy from solar panels and wind turbines. Preferably, these are local sources of electricity, which means that the electrons do not need to travel vast distances. By directly using local energy, for example from your own PV panels or those of your neighbours, you can also reduce the load on the grid.

Still, it is important to make sure that an electric vehicle is charged on time. This can be done through an app, in which departure time, energy requirement, and prefered mode of charging can be selected (Figure 2). In the future, such information screens will also be displayed in the vehicles themselves and directly communicated to the charging station. In this way, the charging system knows exactly how you would like to charge your car. More and more charging operators willl offer the option to charge differently. Of course, by knowing your preferences, they can provide you a better service, but also at a lower price through electricity market integration.

So, let go of the petrol-head mindset of recharging an electric vehicle as fast as possible. Instead, make use of offered smart charging solutions and the fact that the car is parked for 95% of the time and help the grid. You will be rewarded with a lower charging bill and a battery that is mostly, if not completely, filled up with sustainable energy. And, don't forget to smile when you're driving on sunshine! ■

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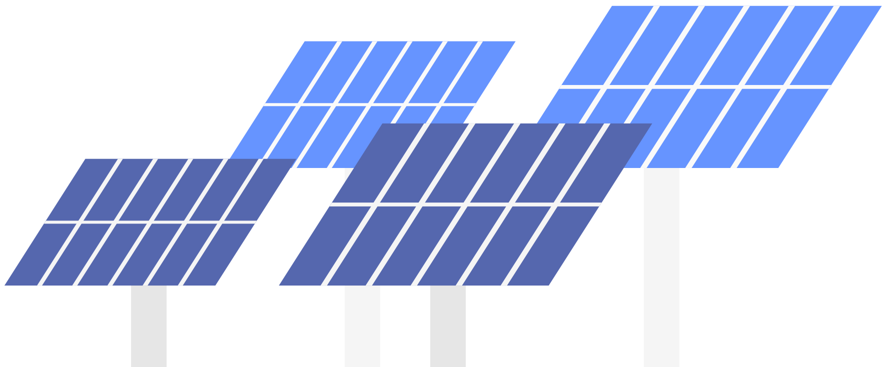
Microgrids for rural villages in India



India is a growing country with a population of around 1.4 billion [1], which has an ever-increasing demand for energy. In this regard, the grid has evolved significantly over the years to enhance its installed capacity. However, we are still facing a few challenges, as it is impractical and uneconomical to expand the main grid to some of the remotely located regions of India. Even though it is asserted that India has achieved 100% electrification, a village is declared to be 100% electrified even if only 10% of all homes and public offices have access to electricity. In that regard, around 15% of the population is still devoid of access to electricity [2].

In addition, blackouts have been observed in many areas and several villages around the country continue to experience power cuts for long periods. Also, villages in India face problems like low voltages at their supply terminal, flickers, and other power quality issues due to their location being almost at the end of feeders. With most Indians living in villages, the primary requirement lies in providing access to a reliable and round-the-clock electricity supply for households as well as for cultivation purposes.

To mitigate these issues, several microgrids are in the process of being installed [3]. A microgrid is defined as [4] the group of controllable sources (typically renewable energy sources), loads and energy storage systems, which can collectively operate either in a grid connected or isolated mode (Figure 1).

One of the first instances of a microgrid in India was a 65-kW hydropower plant commissioned in 1897 at 3600 ft. above sea level at the base of Arya tea Estate, around 12 km from Darjeeling, West Bengal [5]. However, with the current shift in focus towards integrating more renewable energy sources (RES) in the generation mix, especially solar and wind, due to their abundance and environment-friendly nature, the concept of microgrids is especially beneficial for villages which are sparsely connected to the main grid, experience frequent power cuts and irregular power supply.

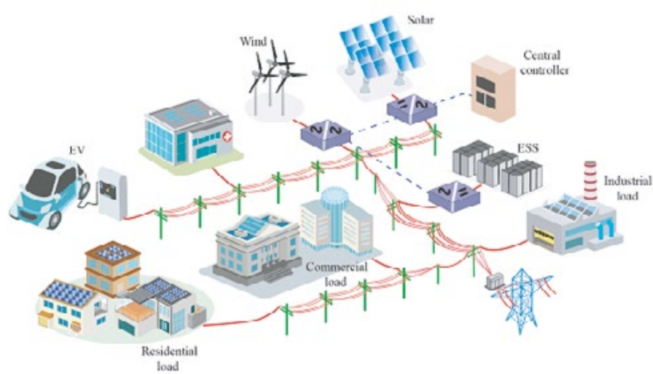


Figure 1: Diagram of a Sample Microgrid

Solar energy-based generation has made a visible impact on the lives of residents in the rural areas in recent years, by helping them meet their lightning, cooking and other needs in an eco-friendly manner. The solar based microgrids were pioneered in India in the 1990s by the West Bengal Renewable Energy Development Agency (WBREDA) in the Sundarban delta region with an installation of a 25-kWp solar PV system [6]. Subsequently, various microgrids have been installed all over the country under the Government of India initiatives including the Remote Village Electrification Program (RVEP), Decentralized Distributed generation (DDG) scheme, Village Energy Security Program (VESP) etc. The Government issued a National Electricity Policy (NEP) in 2021, emphasizing the promotion of RES-based mini and microgrids and establishing up to500 MW of generation with around 10,000 microgrid projects [7]. In February 2021, a team of Global Himalayan Expedition introduced electricity to a village in the union territory of Ladakh by harnessing solar energy, which had no access to it for the last 60 years [8]. Globally, India stands as 4th in cumulative installed solar power capacity with 61.97 GW of active installations at the end of 2022 [9].

SYSTEM	NO. OF UNITS \ CAPACITY INSTALLED
Solar Lamps/Lanterns	75,29,365
Solar Pumps	2,56,156
Solar Street Lights	7,15,029
Solar Home Lightning Systems	17,21,343
Solar Power Plants	214.57 MW

Table I: Application-wise status of the installations under Solar PV Applications Program till November 2022 [9]

> **SOLAR ENERGY-BASED GENERATION HAS MADE A VISIBLE IMPACT ON THE LIVES OF RESIDENTS IN THE RURAL AREAS IN RECENT YEARS, BY HELPING THEM MEET THEIR LIGHTNING, COOKING AND OTHER NEEDS IN AN ECOFRIENDLY MANNER.**

Under the solar power application program of Ministry of New and Renewable Energy, till 30 November 2022, end-use applications such as solar pumps, lamps, streetlights, and home lightnings are installed as per the number mentioned in Table I. The details of the few installed microgrids with their capacity are presented in Table II [3].

With the ongoing research on improving the efficiency of the PV modules, battery storage and inverter controllers, along with the incentives provided by Governmental policies, every remote location in the country is expected to be electrified very soon. The SUSTENANCE project in this regard focuses on development of smart technology concepts enabling a "green transition" of the energy systems, thereby aiming to provide clean energy to the regional communities to meet their local needs. Additionally, the project goes beyond just helping in the electricity sector. Other aspects such as local transportation, energy, heating and cooling are being locally integrated into "energy islands" or "integrated community energy systems". The collective effort will enhance the local economy, create new employment and business, and bring about positive environmental changes, such as improving air quality. Besides, community empowerment and capacity development for smart solutions along with improved infrastructure in both the energy and transport sectors are some of the added advantages. ■

PROJECT/ DEVELOPER	LOCATION	CAPACITY	NO. OF VILLAGES
Dharnai solar city	Dharnai, Bihar	100 kW	1
Sagar Island microgrid	Sagar Island, Sundarbans	26 kW	1
Palm Meadows project (urban)	Hyderabad	30 kW	1
CREDA	Chhattisgarh	500 PV systems	6
DESI Power	Bihar (4), Madhya Pradesh (1)	260-kW PV systems	4
HPS microgrids	Bihar	82 systems (32 kW each)	48
OREDA	Orissa	2-4.5 kW each	27
WBREDA	West Bengal	25-500 kW each	22
UPNEDA	Uttar Pradesh	1.2 kWp	27 districts
MGP	Uttar Pradesh	240 Wp systems	8
SREDA	Sikkim	10-25 kW systems	-
Garam Oorja Projects	Maharashtra, Karnataka	5-30 kWp systems	30-40
Alamprabhu Pathar: MEDA	Maharashtra	12,000 kW	50 households + 40 commercials
SELCO foundation microgrids	Karnataka	1-14 kWp systems	5
Amrita self-reliant villages	Kerala	8 kW mini hydro	1
Biomass energy for rural India project	Karnataka	500 kW	3

Table II: Details of some Indian microgrid projects [3]

REFERENCES

[1] India population (2023) - worldometer, Worldometers. [Online]. Available: https://www.worldometers.info/world-population/india- population/ (accessed 22/07/2023)

[2] Renewableenergyworld.com. [Online]. Available: https://www.renewableenergyworld.com/solar/the-role-of-microgrids-in-india/ (ac- cessed 22/07/2023)

[3] Vijay A. S., S. Doolla and M. Chandorkar, “Microgrids in India: Possibilities and Challenges,” in IEEE Electrification Magazine, vol. 5, no. 2, pp. 4755, Jun. 2017

[4] M. H. Saeed, W. Fangzong, B. A. Kalwar and S. Iqbal,” A Review on Microgrids Challenges & Perspectives,” in IEEE Access, vol. 9, pp. 166502-166517, Dec. 2021.

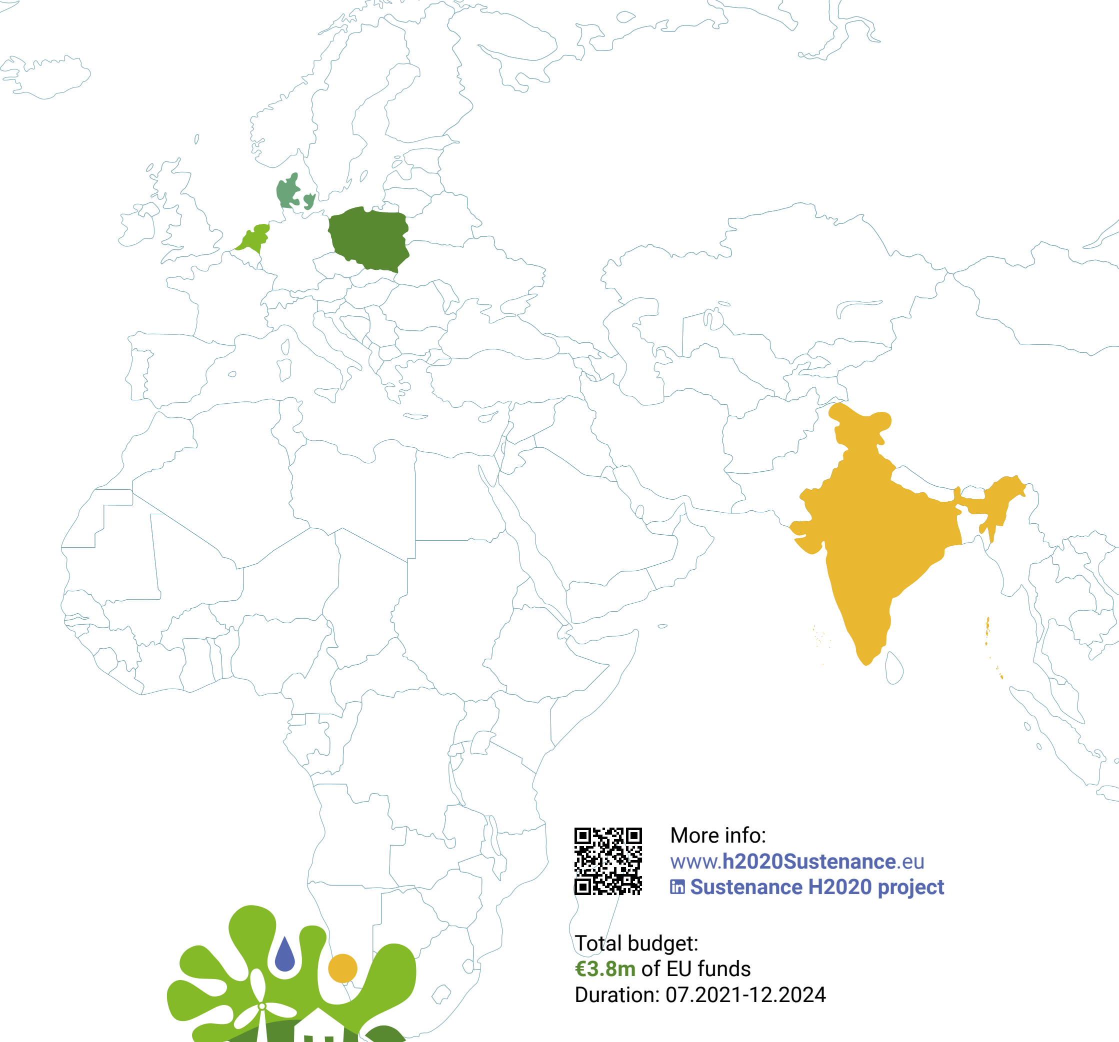
[5] The DC News Desk. (2019, March 4). HERITAGE DARJEELING: Sidrapong - Asia’s oldest hydro project. The Darjeeling Chronicle. [Online]. Available: https://thedarjeelingchronicle.com/heritage-darjeeling-sidrapong-asias-oldest-hydro-project/ (accessed 21/07/2023)

[6] Solar Microgrids in India, [Online]. Available: https://www.yellowhaze.in/solar-microgrids-in-india/ (accessed 20/07/2023)

[7] NEP 2021, A roadmap for sustainable development of electricity in India [Online]. Available: https://energy.economictimes.indiatimes.com/news/power/nep-2021-a-roadmap-for-sustainable-development-of-electricity-in-india/ (accessed 20/07/2023)

[8] Ladakh Renewable Energy [Online]. Available: https://www.thebetterindia.com/249931/solar-electrification-tibetan-refugee-border- village-dungti-ladakh-engineers-india-inspiring-nor41/ (accessed 21/07/2023)

[9] Current Status Solar [Online]. Available: https://mnre.gov.in/solar/current-status/ (accessed 22/07/2023)



More info:
www.**h2020Sustenance**.eu
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