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Renewables Powered Smart City: A Case Study

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Abstract : Energy is the heart of the development of any city. But the conventional sources of energy generation like coal, oil or natural gases are in limited quantity which can serve for another 30 -40 years. So, in this situation it is highly needed to do some research on the self-energy reliant cities [1,2] or may be energy independent country. In this article one city of the Nadia District namely Kalyani where a few industries, lot of educational hubs, many marketplaces, football and cricket stadium are present, and it is well connected by bus, train and flight is considered for this study. In this article, it has been shown that around 70% of total energy requirements of the city can be generated from different renewable energy sources without increasing the cost of generation.

***IndexTerms* – Solar Energy, Wind Turbine, Hydro Energy, Biowaste, Smart City, Self-energy Reliant City**

I. INTRODUCTION

Clean power [3] is an essential part of our future, driving a thriving, sustainable global economy [4]. Clean power has been growing, thanks to technology and cost improvements as well as various forms of financial, policy, and regulatory support. In some countries clean power already makes up a high percentage of the electricity mix, using a range of flexibility tools to deliver reliable electricity to customers.

The time to expand clean power [5,6] is now. It is cheaper, healthier [7, 8], and critical to stopping climate change. What is needed is political support and an understanding of the tools necessary to make it happen. Fortunately, tools for supporting the expansion of clean power suitable for different local contexts are already available. As variable output renewables like wind turbines and solar panels increase their share of overall electricity generation, system operators must manage the increase in variability.

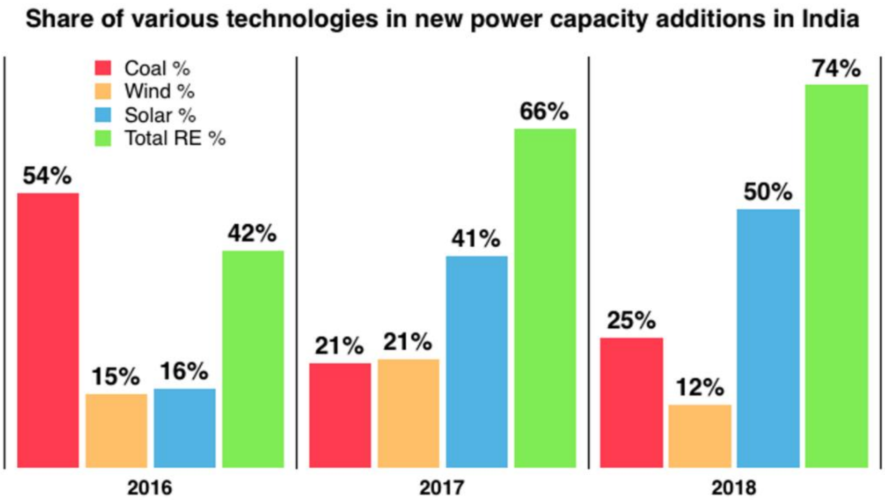


Fig.1 Share of various technologies in new power capacity addition in India

There is a broad range of tools available to further enhance the already significant flexibility in electricity systems, enabling high penetrations of renewables in many countries. And a range of additional flexibility tools will become available in the future. The trends of capacity addition of the different kind of energy generation in India is presented in figure.2.

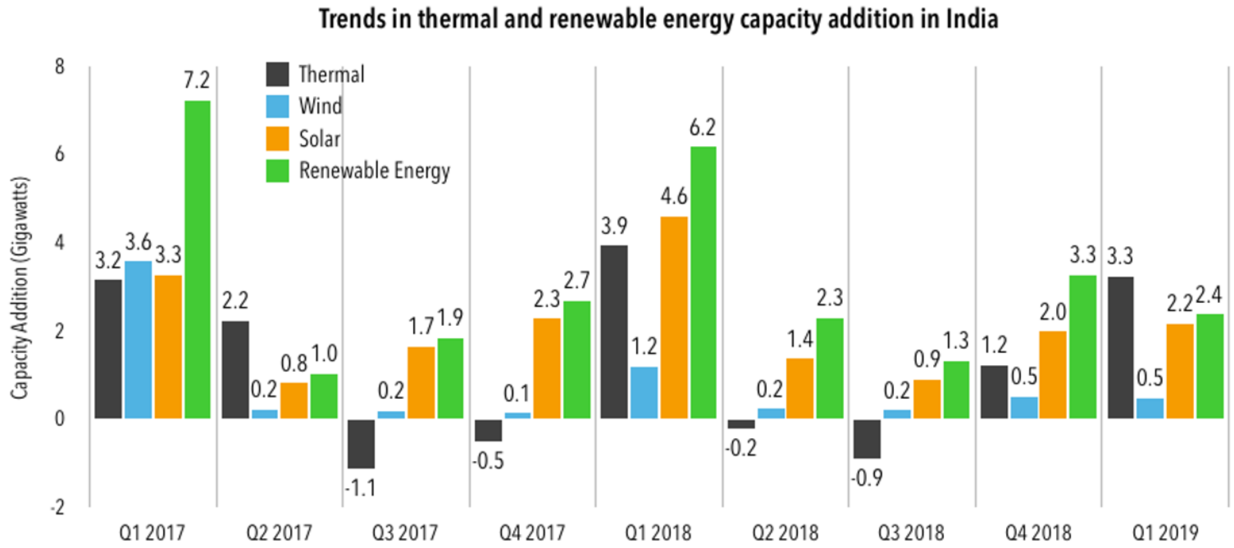


Fig.2 Trends in Electrical Energy capacity addition in India

Renewable power can be supported in a variety of ways to grow as a new industry and achieve its potential to deliver a sustainable future. Delivering renewable power involves a wide range of actors, and it helps to understand their roles and needs.

Increase of renewable energy generation, specially the capacity enhancement in solar energy generation is giving us a new opportunity to develop an energy independent self-sustainable city to full-fill all its energy requirements.

Year	Renewable Energy Capacity	Solar Energy Capacity
2009	1,136.226	23.371
2010	1,224.050	40.871
2011	1,329.202	72.683
2012	1,441.393	102.871
2013	1,563.122	139.602
2014	1,693.254	177.496
2015	1,848.157	225.820
2016	2,007.996	297.293
2017	2,179.448	391.063
2018	2,350.755	485.826

In this article it has been proposed that a complete city in the state of West Bengal, Namely Kalyani can be a model of energy independent city.

II. Renewable Energy Sources

Four following areas of renewable energy sources have ben consider in this article:

a. Solar energy
b. Hydro energy
c. Wind energy
d. Biogas

A. Solar Energy

- Choose a location that receives high sun radiation (kW/m^2) all the year around and many sunny hours per day.
- Less rain and cloudy days all the year around.
- Lost of land as these plants require large footprint.
- Access to raw material needed for the concentrated solar power plant.
-

What we can do using solar power?

a. Water heating and other processes
   - Solar cookers
   - Solar heater
   - Solar still

b. Solar space heating systems
   - Solar air heaters
   - Solar hybrid space heating systems
   - Solar assisted systems for space heating
   - Solar driven absorption heat pumps

Generate electricity

- In a nutshell, a solar panel works by generating electricity when particles of sunlight, or photons, knock electrons free from atoms, setting them in motion. This flow of electrons is electricity, and solar panels are designed to capture this flow, turning it into a usable electric current.

B. Hydro Energy

As demand for electricity has increased it has become necessary to generate electricity at home or agriculture. Rooftop Rainwater Harvesting is the Techniquethroughwhichrainwateriscapturedfromtheroofcatchmentsand Stored in reservoirs. By using rainwater, we will generate electricity by using turbine. And, we will generate electricity by using solar energy. Harvested rainwater can be stored in sub-surface ground water reservoir to meet the household needs through storage in tanks. The Main Objective of roof top rainwater harvesting is to make water available for future use.

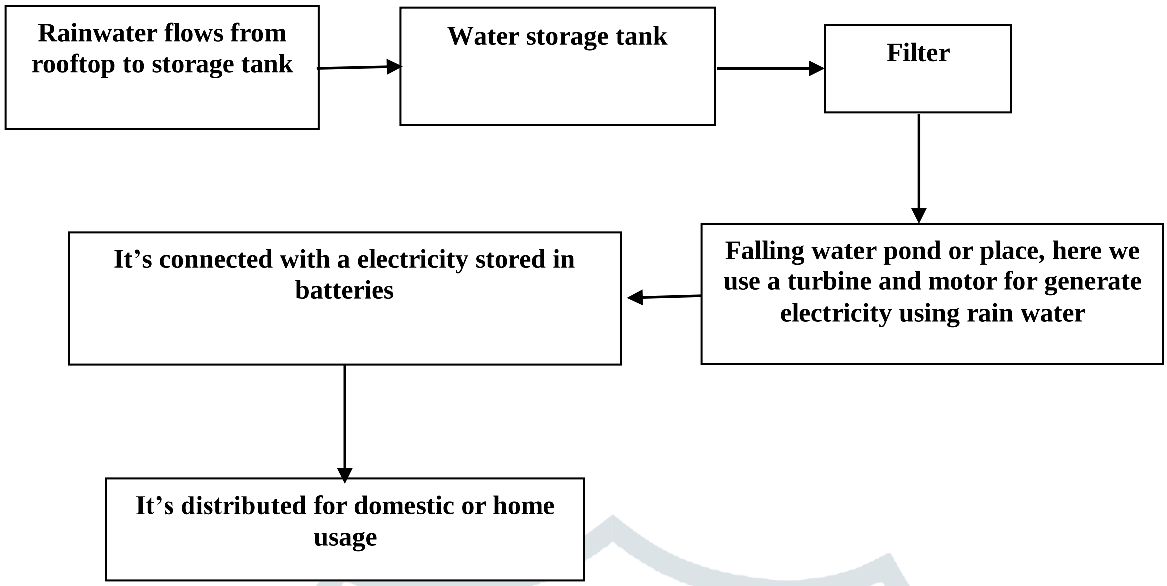
District rain fall mean, variability and trend:

Table 1 Rainfall Statistics of Nadia District

District	Average Rainfall (mm)	Average Pre-monsoon water level (m bgl)			Average Post-monsoon water level (m bgl)			Average Fluctuation (m)		
		Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
Maldah	1453	3.99	17.54	7.36	2.07	12.54	4.62	1.20	5.55	3.05
Nadia	1474	4.38	6.90	5.33	2.23	3.93	2.86	1.87	2.97	2.47
Koch Bihar	3608	3.12	4.27	3.91	2.41	3.63	2.85	0.55	1.50	1.06
North 24 Parganas	1523	3.77	8.56	5.39	1.61	6.13	2.99	-0.25	4.06	2.40
Dakhin Dinajpur	1690	6.00	12.15	8.39	1.87	4.73	3.74	2.24	8.09	4.59
Uttar Dinajpur	2087	3.19	5.63	4.38	1.74	3.29	2.56	0.77	3.40	1.83
Bankura	1422	3.70	12.14	6.58	2.54	5.89	3.40	1.01	8.05	3.24
Puruliya	1276	5.41	11.39	6.94	2.61	4.55	3.24	1.78	6.84	3.69
Jalpaiguri	3319	3.41	4.85	3.98	1.90	3.93	3.12	0.04	1.76	0.86
Barddhaman	1496	2.89	16.57	8.83	0.00	12.95	5.54	-1.0	15.00	3.28
Murshidabad	1417	4.18	16.93	8.27	1.53	15.12	4.94	0.20	6.02	2.95
Birbhum	1289	4.12	14.57	8.52	2.08	9.98	5.21	0.83	5.26	3.30
Haora	1625	8.77	12.83	10.39	5.38	6.94	5.96	3.04	5.89	4.42
Darjiling	2829	4.32	4.52	4.42	2.45	2.53	2.49	1.87	1.99	1.93
Hugli	1523	7.17	17.13	12.48	4.68	9.31	6.58	1.96	8.72	5.90
Purba Medinipur	1629	11.90	15.06	13.27	4.23	8.68	6.83	4.49	7.67	6.43
Paschim Medinipur	1560	1.83	15.07	9.30	2.84	6.39	4.72	-2.80	9.57	4.59

Source: CGWB and SWID, 2011

Block Diagram:



C. Wind Energy

- **How we use wind power:**
  Wind turbine produce more electricity but it depends on geographical area but we are working on Kalyani city but there no mountain or high places are but having some open place there we can use wind turbine .A minimum wind speed is needed (12-14kmph) to being turning and generate electricity. Here the wind speed is not so much to turn the turbine so we can place the wind outstation.

  But all time we can't generate wind power so we can get the wind in the month of June –July here we are using variable speed wind turbine.

Area calculation:

In 15kw wind turbine has a rotor diameter of 11.5m and a rated power of 15 kw the hub height of the wind turbine is about 20m and the highest point of the wind turbine including rotor blade with 26.6m.

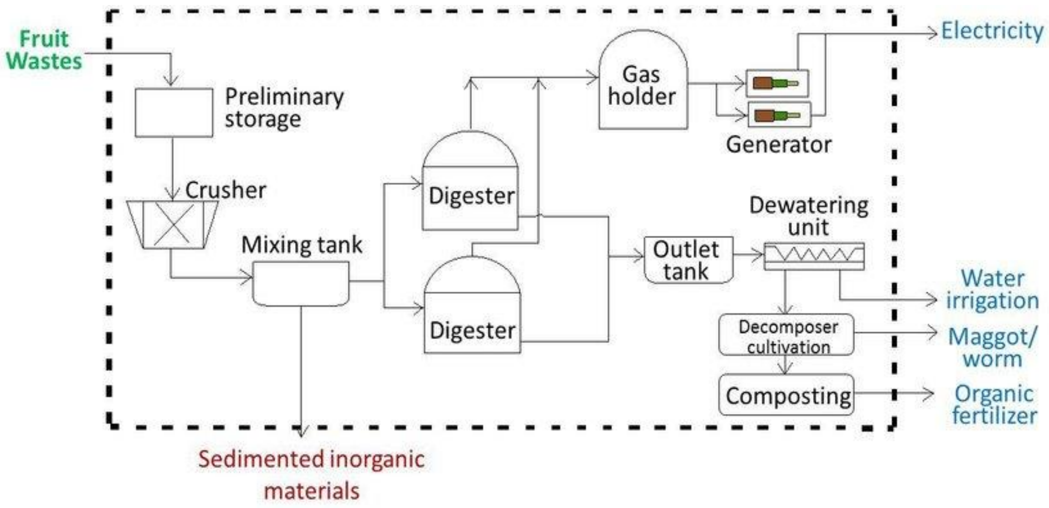
One wind turbine can require up to 75 acres of land, and each turbine will generate around 2.5 MW. Because wind turbines are spaced so far apart, surface activities like farming can still take place on much of the land.

D. Biogas Plant

Biogas is produced from organic wastes like kitchen wastes by concerted action of various groups of anaerobic bacteria. An attempt has been made in this review on the work done by our scientists in understanding the microbial diversity in biogas digesters, their interactions, and factors affecting biogas production, alternate feedstocks, and uses of spent slurry.

The present work provides a process for the production of electric power, using a biogas as a fuel in an electric power producing turbine, wherein the biogas produced from a biomass in a gas generator is not subjected to a wet scrubbing step; and the biogas, after treatment according to the process, may be directly charged to an electric power producing combustion turbine.

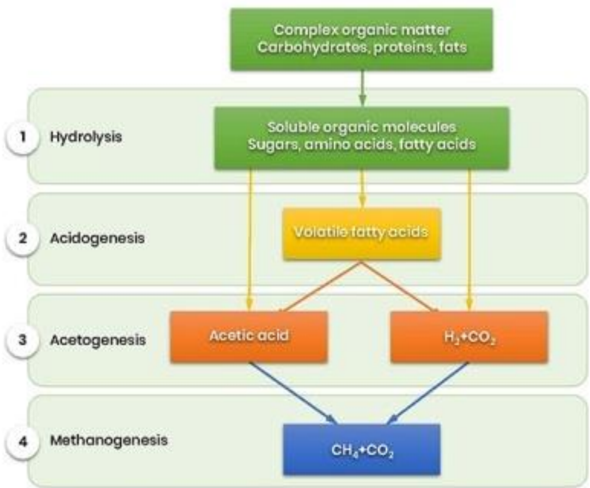
Flow diagram of biogas plant:



Four Phases of Digestion of Bio Wastes:

The process consists of four steps, each of which carried out by different groups of bacteria:

- Hydrolysis.
- Acidogenesis.
- Acetogenesis.
- Methanogenesis



III. DETAILED SURVEY AND EXECUTION PLAN

A. Solar Module Selection in Kalyani:

In kalyani city monthly electricity consumed is 144 MW (as per daily log sheet of WBSEDCL)
In this project we have planned to use 200 WT solar panel
So, the requirement of solar panel for generating 144WT is 144*200=28800 units

Area required for solar panel:

So far, land has been allotted in the solar park for projects worth 176MW to 16 companies from thefirst and second phases. The total capacity of the solar park is 500MW with 30,000 sq. m per MW land allotted.

As per this work we have calculated the area required:
If we target 100% generation from solar plant, total area requirement is as follows:

- 144*30000/500=8640 sq.m

B. Hydro-energy proposal for Kalyani

The area of reserve tank,

30ft * 30ft =900ft^2 * (144/1ft^2) in^2=1296000in^2

Moderate rain fall = 0.2/hr

Gallons/hr=129600in^{2}y 2.2 in/hr*1GAL/231in^3 =112GAL/hr

Gallons/main=(112Gal/hr)*(1hr/60min)=1.87GAL/min

Then,

Flow=(1.82 GAL/min)*(3.78L/GAL)*(1min/60sec) =118L/S

Height=1.8M

Density= 997kg/l

Gravity=9.8m/s

=(118l/s)*1.8m*(997kg/K)*(9.8m/s^2)
=2.08N.M/S
=2.08Watt

Here, we get rainwater from one house =1.87 GAL/MIN

The population of the area = 1000575

Suppose per house number of member =5

Then, total house in this area= 200115

If we take a particular area, then we get 374215.05 GAL/MIN

Other side,
Electricity we get from one house is =2.08 watts
Then total electricity from this area we get= 179911.08173076 watts

C. Wind-energy at Kalyani

Area calculation:

In 15kw wind turbine has a rotor diameter of 11.5m and a rated power of 15 kw the hub height of the wind turbine is about 20m and the highest point of the wind turbine including rotor blade with 26.6m.
One wind turbine can require up to 75 acres of land, and each turbine will generate around 2.5 MW. Because wind turbines are spaced so far apart, surface activities like farming can still take place on much of the land.

○Example calculation:

- WINDMILL EFFICIENCY = 42%
- AVERAGE WIND SPEED = 10 M/S (20 MPH)
- POWER = 0.0006 X 0.42 X 1000 = 250 WATTS PER SQUARE METER
- ELECTRICITY GENERATED IS THEN .25 KWH PER SQ. METER

Respective to our project wind energy will provide about 20 MW of electricity per month. As a wind turbine with above mentioned criteria can produce 2.5-3 MW. IN this case we need to install about 10 wind turbines to fulfill our project requirement.

How much Biogas is needed for Kalyani?

By remembering the city demand ,
We need,

- Plant size = 300M^3

- We need to fill (primary level) : 4000kg cow dunk+200kg other organic waste
- To fill (daily basis) : 2000kg bio waste(cowdunk+food waste +market released bio waste+other bio waste)
- From 1kg of bio waste with cowdunk we are able to produce 35kg of bio gas
- So, from about 43200kg(permanent)+2000kg(daily) bio waste we will be able to produce about 151200lit of gas in a month.

By which we can be able to provide city demand.

Can we make electricity From Biogas?

- The present project provides a process for the production of electric power, using a biogas as a fuel in an electric power producing turbine, wherein the biogas produced from a biomass in a gas generator is not subjected to a wet scrubbing step; and the biogas, after treatment according to the process, may be directly charged to an electric power producing combustion turbine.

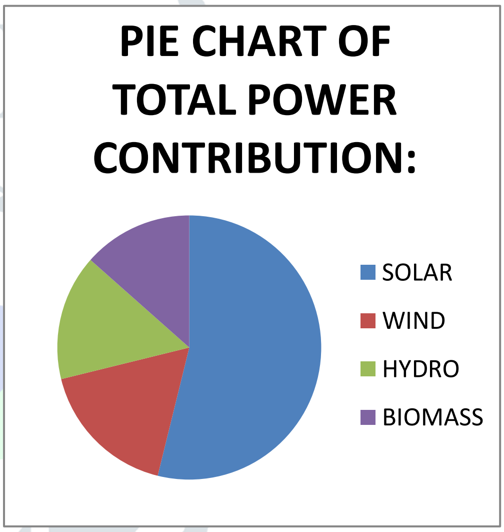
Planning:

We can help the society by using the biogas and can contribute electricity average of 5-6percent but other gases like used domestic purpose for cooking etc in the we having important criteria role in smart City .

TOTAL POWER CONTRIBUTION:

City demand=144MW
solar =30MW we can contribute 28%
Wind= 20 MW we can contribute 9%
Hydro =12MW. We can contribute 8%
Biomass =10.08MW we can contribute 6%

If we step up this generating power we can contribute 65-70% of demand .



IV. CONCLUSIONS

In this article, through the detailed calculations it has been established that the energy independent smart city [9, 10] is not far away. Just a little bit of technical modifications and proper selection of renewable sources can serve the purpose. But a lot of challenges ahead are in terms of selection of proper mix, availability of sun, air, and rain at a particular city etc.

References:

[1] Property Design.pl. The Transformation of Cities into Smart Cities Is Accelerating Due to the Pandemic. Available online: https://www.propertydesign.pl/architektura/104/transformacja_miast_w_smart_cities_przyspiesza_za_sprawa_pandemii,30838.html (accessed on 20 June 2021).
[2] Standard ISO 37120:2014. In Sustainable Development of Communities–Indicators for City Services and Quality of Life–DS./ISO 37120, 1st ed.; International Organization for Standardization: Geneva, Switzerland, 2014.
[3] Yeh, H. The effects of successful ICT-based smart city services: From citizens' perspectives. Gov. Inf. Q. 2017, 34, 556–565.
[4] Hoffman, I.M.; Goldman, C.A.; Rybka, G.; Leventis, G.; Schwartz, L.; Sanstad, A.H.; Schiller, S. Estimating the cost of saving electricity through U.S. utility customer-funded energy efficiency programs. Energy Policy 2017, 104, 1–12.
[5] How Smart City Technologies Improve the Quality of Life. Available online: https://www.copadata.com/pl/przemyslowa/inteligentne-miasto/smart-city-insights/jak-technologie-smart-city-poprawiaja-jakosc-zycia-copa-data/ (accessed on 12 June 2021).
[6] Smart City—Solutions for Institutions. Buildings and Transport in Smart Cities. Available online: https://www.copadata.com/pl/przemyslowa/inteligentne-miasto/ (accessed on 11 July 2021).
[7] Martínez, L.; Short, J.R. The Pandemic City: Urban Issues in the Time of COVID-19. Sustainability 2021, 13, 3295. [CrossRef]

[8] Hasija, S. Smart Cities Can Help Us Manage Post-COVID Life, but They'll Need Trust as Well as Tech. The Conversation. Available online: https://theconversation.com/smart-cities-can-help-us-manage-post-covid-life-but-theyll-need-trust-as-wellas-tech-138725 (accessed on 13 June 2021).
[9] Tosiek, D. Social Safety Management in Smart City; AGH: Kraków, Poland, 2017.
10] Public Transport Security in the Smart City Era, Challenges and Solutions for European Bus, Metro and Rail Companies, Make the World See. 2020. Available online: https://aspolska.pl/bezpieczenstwo-transportu-publicznego-w-erze-smart-city/ (accessed on 24 April 2021).