Bangladesh Environment Network (BEN)

BEN Webinar on
Energy Future of Bangladesh?

Sustainable Renewable Energy for Buildings and Agriculture in Bangladesh

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Outline of the Presentation

- Background and Motivation for Renewables
- Renewable Energy in Buildings
- Renewable Energy in Agriculture
- Findings on Different Renewable Energy System
  - Buildings, Green Roof with Renewable Energy
  - Agriculture with Agrivoltaics and other Renewables
- Environmental Challenges with Barriers for Renewables Adoption in Bangladesh

Reference: https://www.solaricglobal.com/blog/solar-for-rural-development

Renewable Energy: Global & Bangladesh

- Renewable energy should supply 70-85% of the world's electricity by 2050 to meet the goals of the Paris Agreement and limit global warming (IPCC)
- Renewable energy: 4.5% of Bangladesh's total power capacity (Bangladesh's ambitious goals of 15% by 2030, 40% by 2041, and 100% by 2050)
- Almost 90% of energy in Bangladesh is produced with fossil fuel!! (11.4% of $68 billion total to power and energy sector: approximately $7.752 billion)
- Developed Countries such as Sweden (56.4%), Finland (43.1%), and the USA (19.8%) have a significant share of renewable energy in their energy generation
- Developing countries such as India (17%), Brazil (45%) and Indonesia (11%) have a significant share of renewable energy in their energy generation

- Bangladesh's 2024-2025 budget ($68 billion total): $68 million investment plan to support renewable energy projects and expand off-grid solar (<1% investment of total power and energy budget)
- Bangladesh needs an annual investment of approximately $1.53–1.71 billion to achieve the ambitious 40 per cent renewable energy target by 2041 (approximately 19.5%~22.1% of power & energy sector budget which is 2.25~2.51% of total budget allocation)
- Bangladesh needs significant renewable energy investment to fight climate change effectively while meeting energy demand and ensuring sustainable development and economic growth

Renewable Energy: Global & Bangladesh

BUILDINGS SECTOR:

- Building sector account for over 30% of the world's total energy consumption (IEA)
- Around 15% of the energy used in buildings globally comes from renewable sources
- Building sector account for 35% of total electricity usage in Bangladesh
- A very small percentage of energy used in buildings comes from renewable sources like solar power (exact data not reported for Bangladesh)

AGRICULTURAL SECTOR:

- Agriculture sector accounted for 30% of world's total energy consumption (FAO)
- Agriculture sector accounted for 5.3% of total energy consumption in Bangladesh
- Renewable energy use for agriculture for Bangladesh is minimally reported
- Globally 15.4% of energy used in agriculture comes from renewable sources

Renewable Energy in Buildings

- Design of an integral and optimized system of renewables for buildings is possible to contribute to the grid when possible.
- Grid integration possible as per Bangladesh government's Net Metering Guideline 2018.
- Food/crop production under solar in buildings might provide additional benefit

- Systems Evaluted:

a) Green roofs with solar to promote water-energy-food-climate nexus and

b) Approaches to optimize and enable the usage of other renewables (solar, wind etc.) in buildings.

Table: Types of Energy with Steps Needed & Expected Outcomes in Bangladesh

No	Energy Type	Steps to be Adopted	Expected Outcomes
1	**Solar**	# Install intelligent solar panel on rooftop	# Electricity generation (day) # Replacement of cooking gas
2	**Wind**	# Use ducted wind turbine # Building augmented wind turbine (BAWT)	# Electricity generation to reduce grid consumption
3	**Biomass**	# Install bio waste collector with biomass energy generator	# Generate electricity and reduce grid consumption # Alternative to cooking gas
4	**Geothermal**	# Use geothermal to run HVAC system in buildings near geothermal sites	# Cooling (mostly) and heating demands will be met regardless of the supply of electricity.
5	**Green Roof with Renewable**	# Urban roof gardening	# Lower cooling demand and reduce air pollution # Production of vegetation and fruits with energy
6	**CCHP System with Renewables**	# Build a CCHP system using generators fueled by renewable energy	# Efficient and minimal energy consumption # Reduction of dependency on fossil fuel with energy production

Renewable Energy in Buildings

- Solar Photovoltaic (PV) module is a common practice in Bangladesh buildings but wide adoption needed.
- Building augmented wind turbine (BAWT) integration possible
- Combined Cooling, Heating and Power (CCHP) System or trigeneration: concept of using a generator to meet both electrical and thermal demand of a building.
- Electricity generated is supplied to the building and exhaust heat is recovered by heat exchanger.
- Internal Combustion Engine (ICE), Microturbine, Gas turbines, Fuel cells can be used.
- Biomass gasification or Biogas can be used as fuel.
- We evaluated innovative energy systems using solar, wind, biomass energy for buildings with Combined Cooling, Heating and Power (CCHP) system for increased energy efficiency

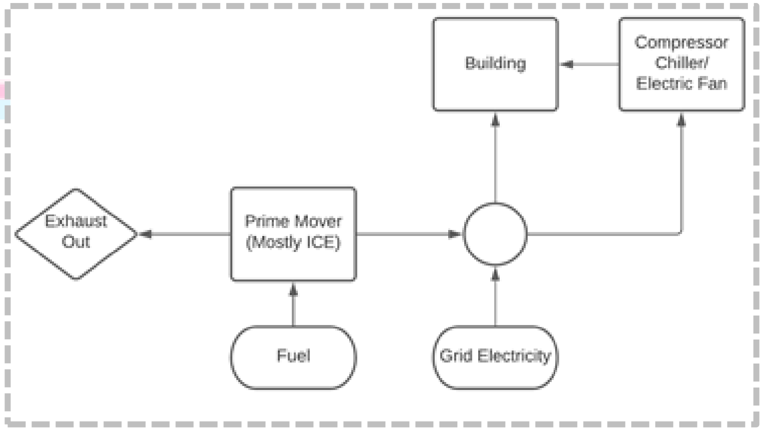


Figure: Current Energy Setup in Buildings

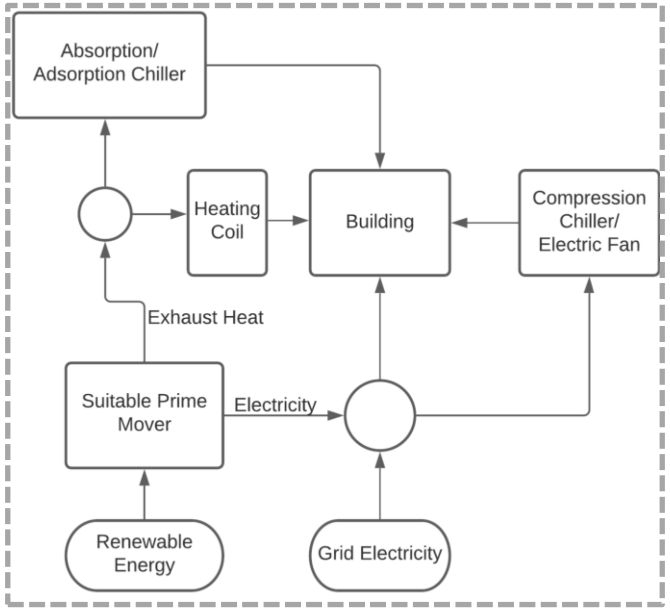
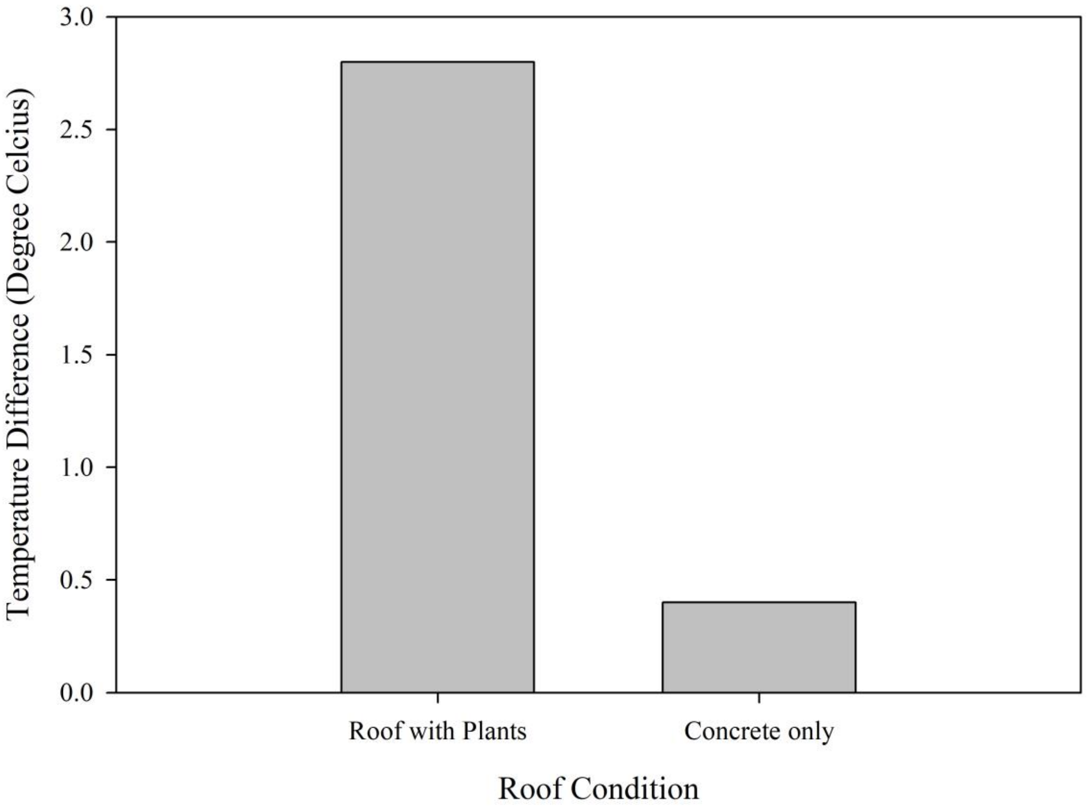


Figure: Proposed CCHP System

Effects of Green Roof

- Green Roof refers to structural integration of plants on roof for vegetation production, beautification and thermal comfort.
- Green roof substantially reduces cooling load of a building by lowering the top floor ceiling temperature contributing to reduce Urban Heat Island (UHI) effect.
- Generate revenue and ensure water-energy-food-climate nexus in buildings.
- Energy produced by solar can meet energy need of the buildings
- Optimization of space with growth of crops under solar
- Building code with retrofit of building with design evaluation needed

Indoor and Outdoor Temperature Difference

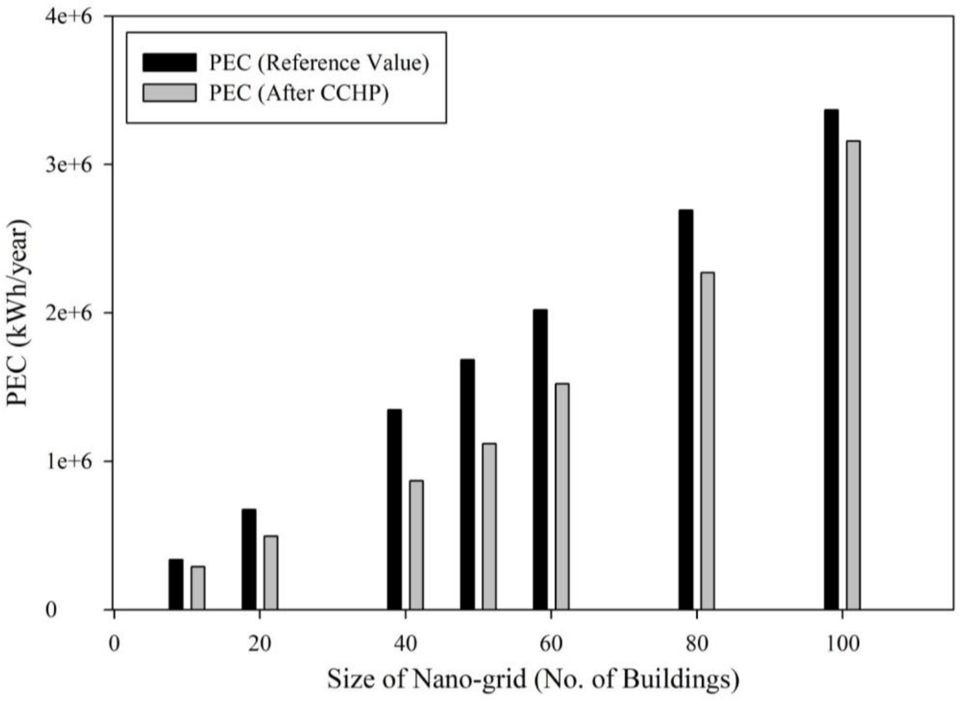


Ref.: Tabassum,2020

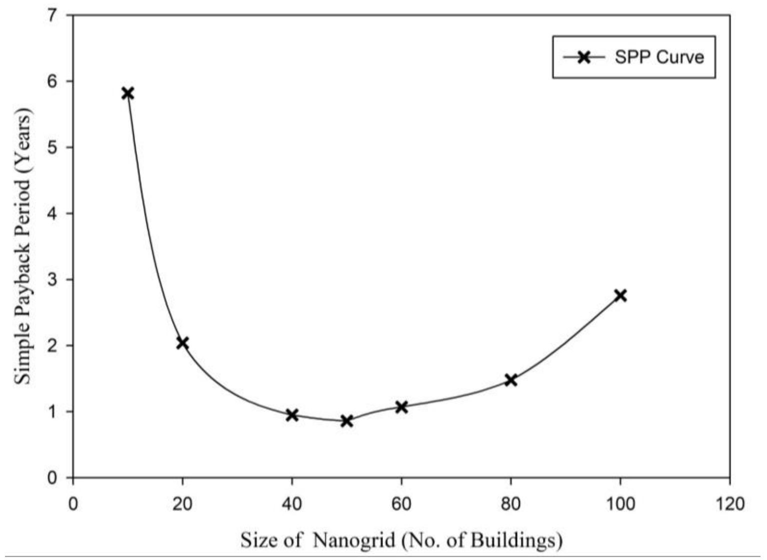
Results: CCHP System in Buildings

- CCHP system optimization showed very positive result in all aspects.

Primary Energy Consumption Comparison



Simple Payback Period (SPP)

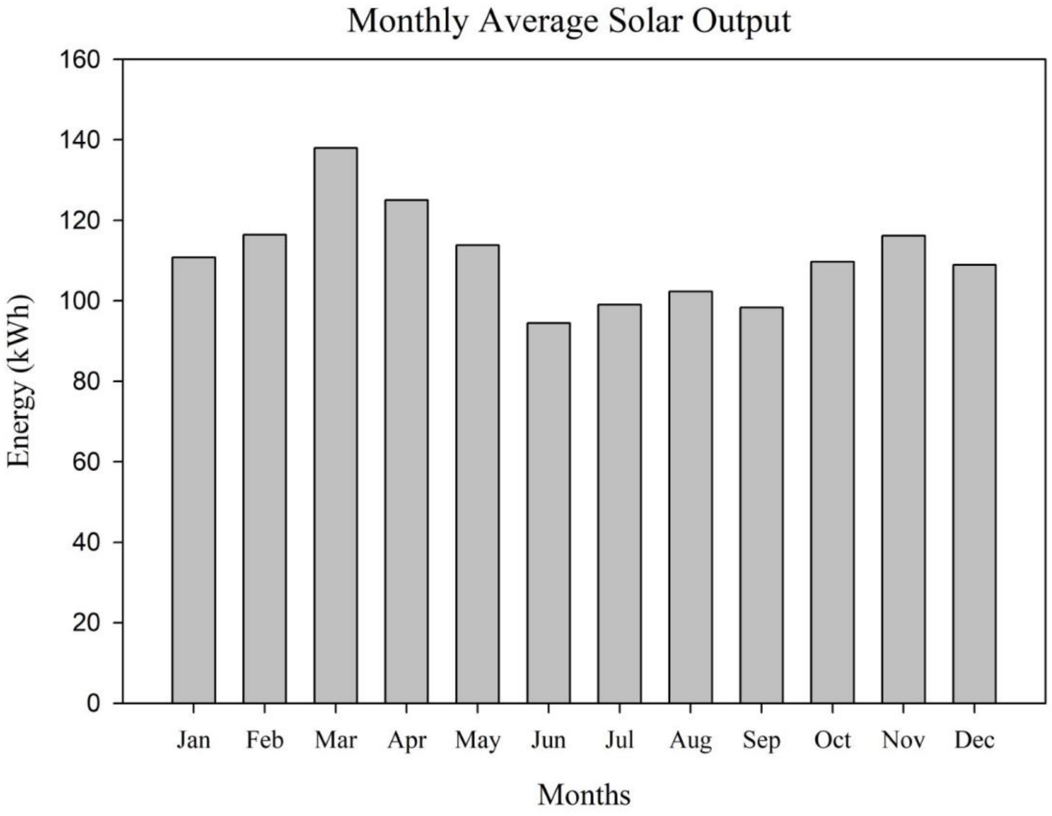


Size of Nano Grid (No. of Buildings)	10	20	40	50	60	80	100
SPP (Years)	5.8	2.0	0.95	0.86	1.1	1.48	2.76

Using Solar Energy in CCHP System (Buildings)

- Solar PV electricity generation will be calculated in detail as a continuation of the project. Preliminary studies still show positive output.

PV System Configuration	
Title	**Description/Value**
Small Residential	▪ PV mounted on a tilted roof of a building. ▪ Azimuth & tilt of PV modules are homogeneous, & modules do not shade each other. ▪ Modules are mounted on rails attached to a tilted roof (allows back-side ventilation) ▪ PV system is usually directly connected to a low-voltage grid through an inverter. ▪ No electricity storage is considered.
System Size	1kWp
Tilt	23 Degree
Azimuth	180 Degree



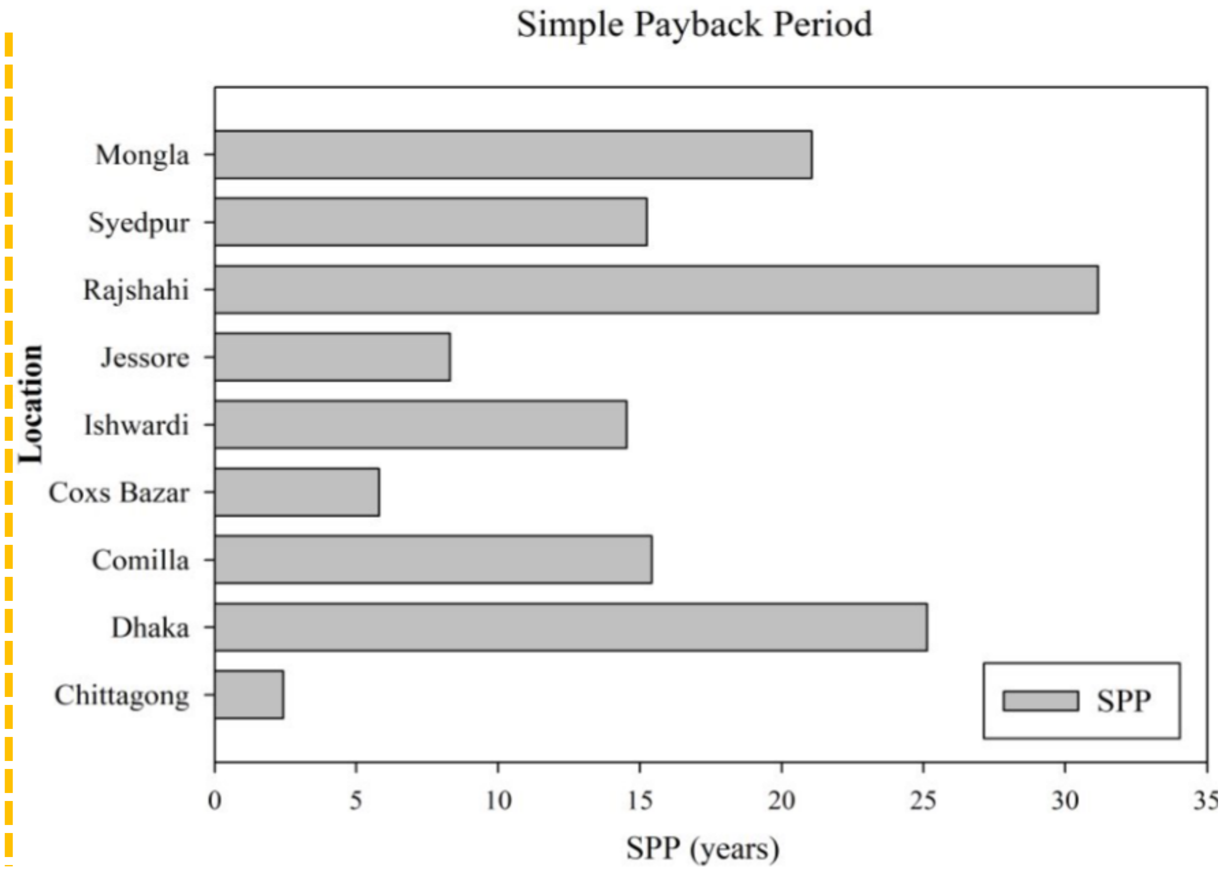
Reference: Global Solar Atlas

Using Wind Energy in CCHP System (Buildings)

- Roof Mounted Ducted Wind Turbine is promising in energy generation

Location	Total Energy Generated	Annual Savings	SPP
	(kWh)	(Taka)	(years)
Chittagong	10973.00	61890.00	2.42
Dhaka	1058.10	5967.90	25.13
Comilla	1725.00	9728.70	15.42
Cox's Bazar	4582.30	25844.00	5.80
Ishwardi	1828.80	10315.00	14.54
Jessore	3199.10	18043.00	8.31
Rajshahi	853.54	4814.00	31.16
Syedpur	1745.50	9844.90	15.24
Mongla	1262.40	7119.90	21.07

Assumed Turbine Blade Model: NACA series 63415 turbine blade, blade length-1.1 m, Duration of Daily Operation = 15 hours, Initial Cost= £1500 (~Tk. 1,75,000)

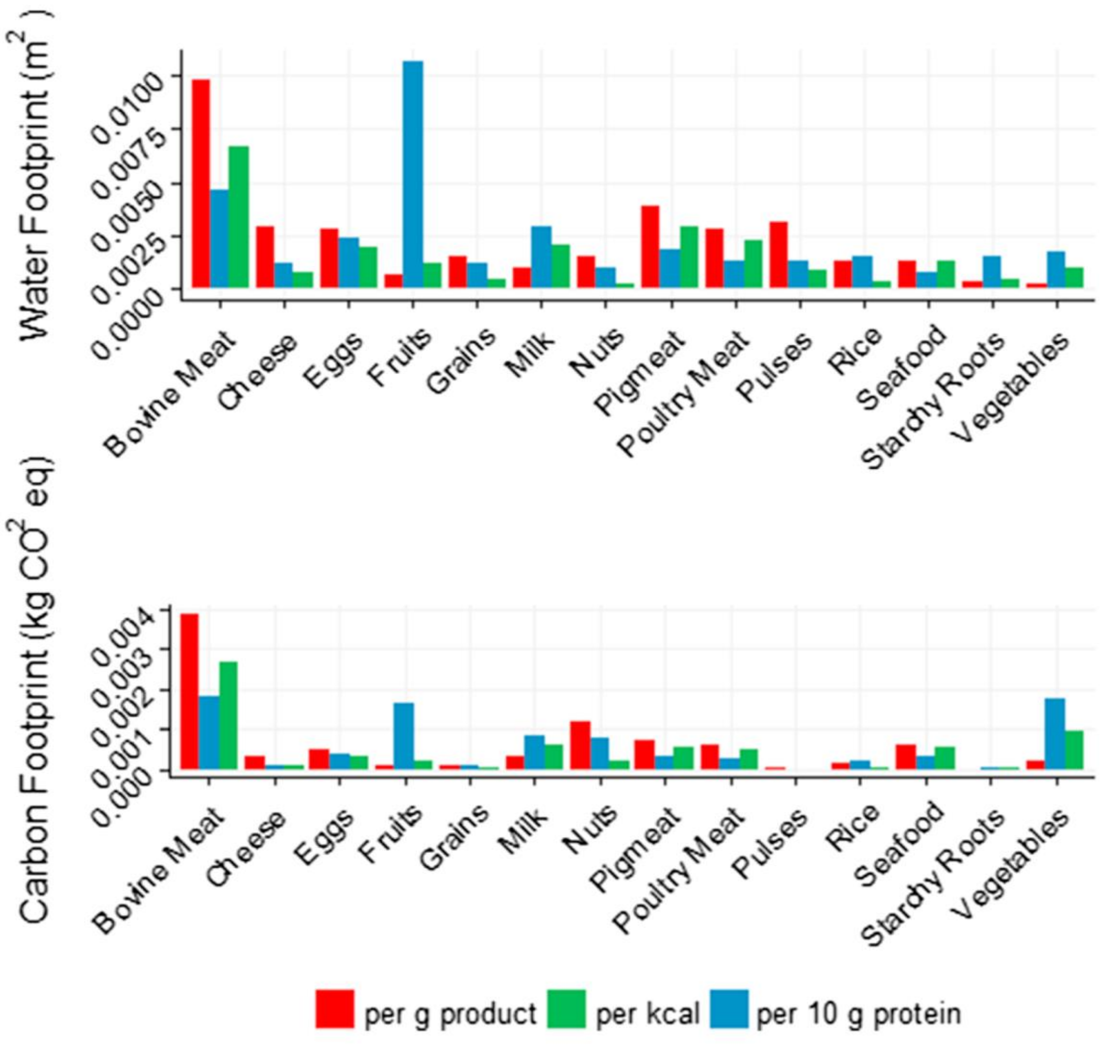


Renewable Energy in Agriculture

- An agro-based country, agriculture sector is one of the dominant energy sinks consuming almost 1800 million KWh annually.
- Solar, Wind, Geothermal, Biomass, Hydro etc. sources are utilized to harness energy and can be effective for agriculture with surplus energy for the main grid.
- Renewable energy allows farmers to generate the energy they need for farming and additional energy can be utilized at homes as straight-forward, sustainable, and cost-effective alternative
- Growing crops under solar or wind eliminate the competition for space for food and energy

Energy source	Description	End Product
Biomass	Burning of plant materials and animal wastes	Heat and gas
Hydropower	Water owing from higher to lower elevations through dams	Electricity
Wind	Capture of wind by turbines	Electricity
Geothermal	Capping stream and hot water from the earth's mantle	Heat and electricity
Solar	Absorbing and storing heat from the sun	Heat and electricity

Reference:
https://www.researchgate.net/publication/328631588_Renewable_Energy_Usage_for_Agricultural_Practices_A_review



The water and carbon footprints of food products (based on Gephart, Davis, et al., 2016).

- **Water-energy-food-climate nexus** issues demand renewable energy use to achieve sustainable agriculture
- Most farm machines are driven by fossil fuels, which contribute to greenhouse gas emissions and, in turn, accelerate climate change.

Table 1. Water Productivity Gains from Shifting to Drip from Conventional Surface Irrigation in India[1]

Change in Crop	*Change in Yield (%)*	*Change in Water Use (%)*	*Water Productivity[2] Gain (%)*
Banana	+52	-45	+173
Cabbage	+ 2	-60	+150
Cotton	+27	-3	+169
Cotton	+25	-60	+255
Grapes	+23	-48	+134
Potato	+46	~0	+ 46
Sugarcane	+6	-60	+163
Sugarcane	+20	-30	+70
Sugarcane	+29	-47	+91
Sugarcane	+33	-65	+205
Sweet potato	+39	-60	+243
Tomato	+5	-27	+49
Tomato	+50	-39	+145

Application of Solar Energy in Agriculture

Types of Crops	Total Energy Required (kWh)	Excess Generation (kWh)
Wheat	156	414
Maize	202.8	367.2
Tomato	218.4	351.6
Potato	187.2	382.8
Rice	468	102
Cabbage	140.4	429.6
Bean	124.8	445.2

** Assumed PV Model: Q-CELLS (mono-Si-Q6LM-1600), % Efficiency-16%, watt per sq.m = 190, PV module rating-3.8, 10% shaded area of the farm, irrigation pumps ranges from 250 to 1100 W, Average farm size-0.5 hectare, yearly output, Avg. sunshine hours-6 hours,

Type of Crops	% of Area Shaded	Excess Generation (kWh)
Wheat	10	414
	20	984
	30	1554
	40	2124
	50	2694

**Wheat, Total Energy Required 156 kWh, Assumed PV Model: Q-CELLS (mono-Si-Q6LM-1600), % Efficiency-16%, watt per sq.m = 190, PV module rating-3.8, irrigation pumps ranges from 250 to 1100 W, Average farm size-0.5 hectare, yearly output, Avg. sunshine hours-6 hours

Application of Wind Energy in Agriculture

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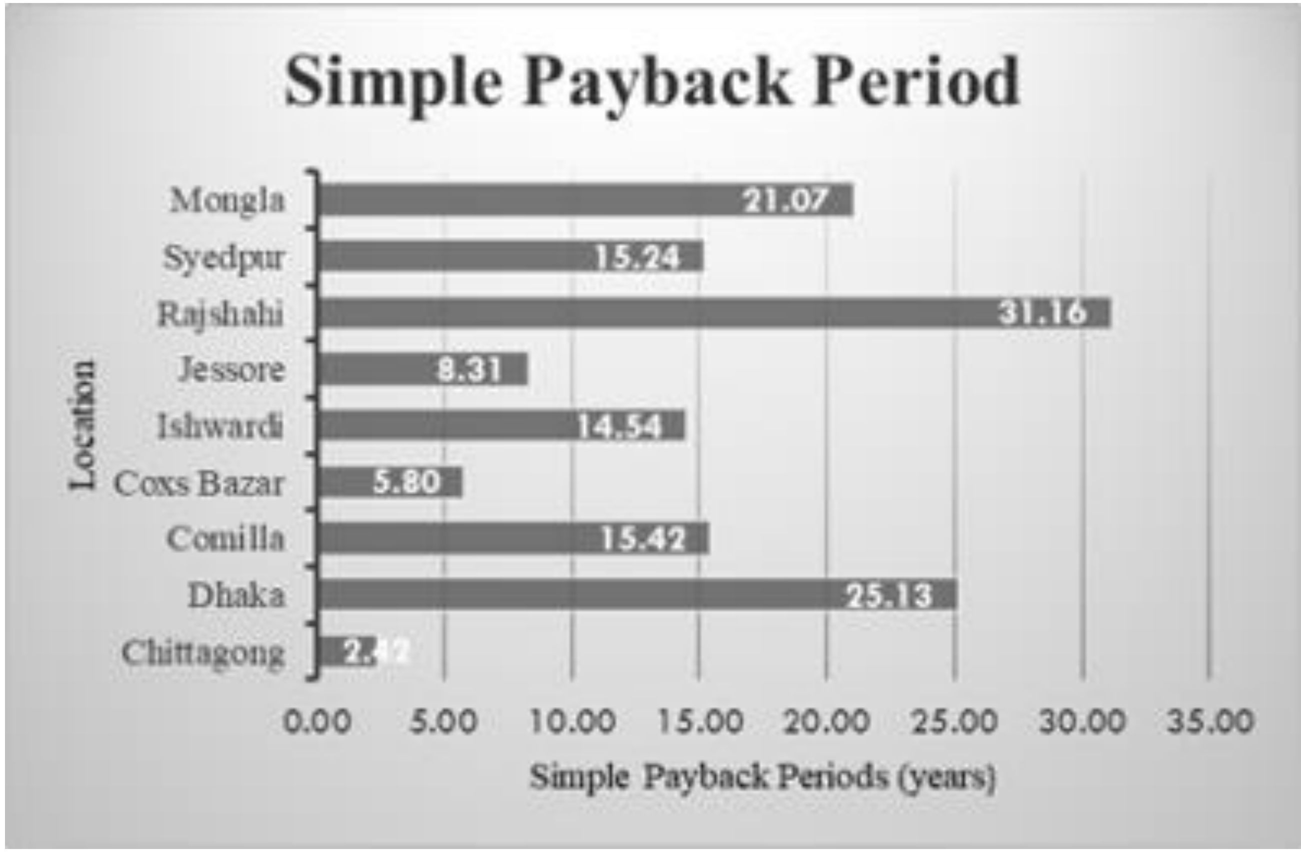

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Geothermal Energy for Greenhouse Heating

Location	Month	Soil Temp. at 1 km depth	Location Temperature	Pipe Length
		°C	°C	m
Cox's Bazar	Dec	43	17	429
	Jan	41	15	670
	Feb	43	18	360
Sylhet	Dec	35	15	2683
	Jan	32	12	764
	Feb	35	16	2181
Dinajpur	Dec	61	12	260
	Jan	58	9	353
	Feb	63	14	213
Bogra	Dec	43	13	614
	Jan	40	10	1119
	Feb	44	15	480

- Geothermal heat production can be done for greenhouse in the months of December, January, and February.
- We can use geothermal energy to heat water for further use in boilers and power plants
- Gaibandha, Rangpur, Dinajpur, Nilphamari has near surface high temp i.e., potential source of geothermal energy
- Flash steam power plant and Binary cycle power plant might be possible to get integrated with geothermal energy.

Assumed, Crop-maize, Optimum temperature-25° Pipe Burial Depth, H - 40 cm, Pipe Dia, d - 2.54 inch, H/d = 1.6, Geothermal Water enters and exits at 8°C temperature difference, Greenhouse cover material (Polyethene), Heat transfer Co-efficient, u - 1.15, Greenhouse Size = 80ft *30ft, Pipe cost will be incorporated

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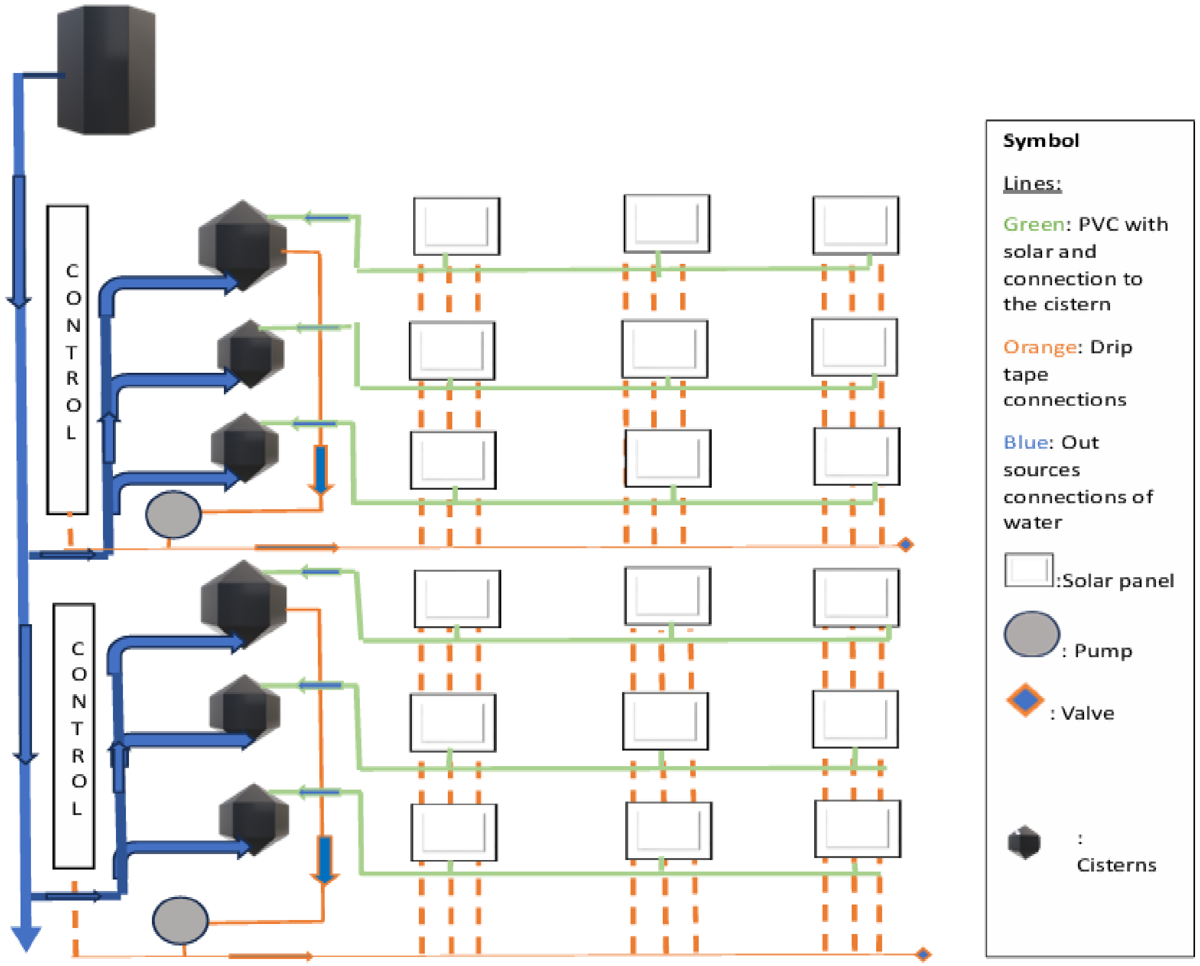
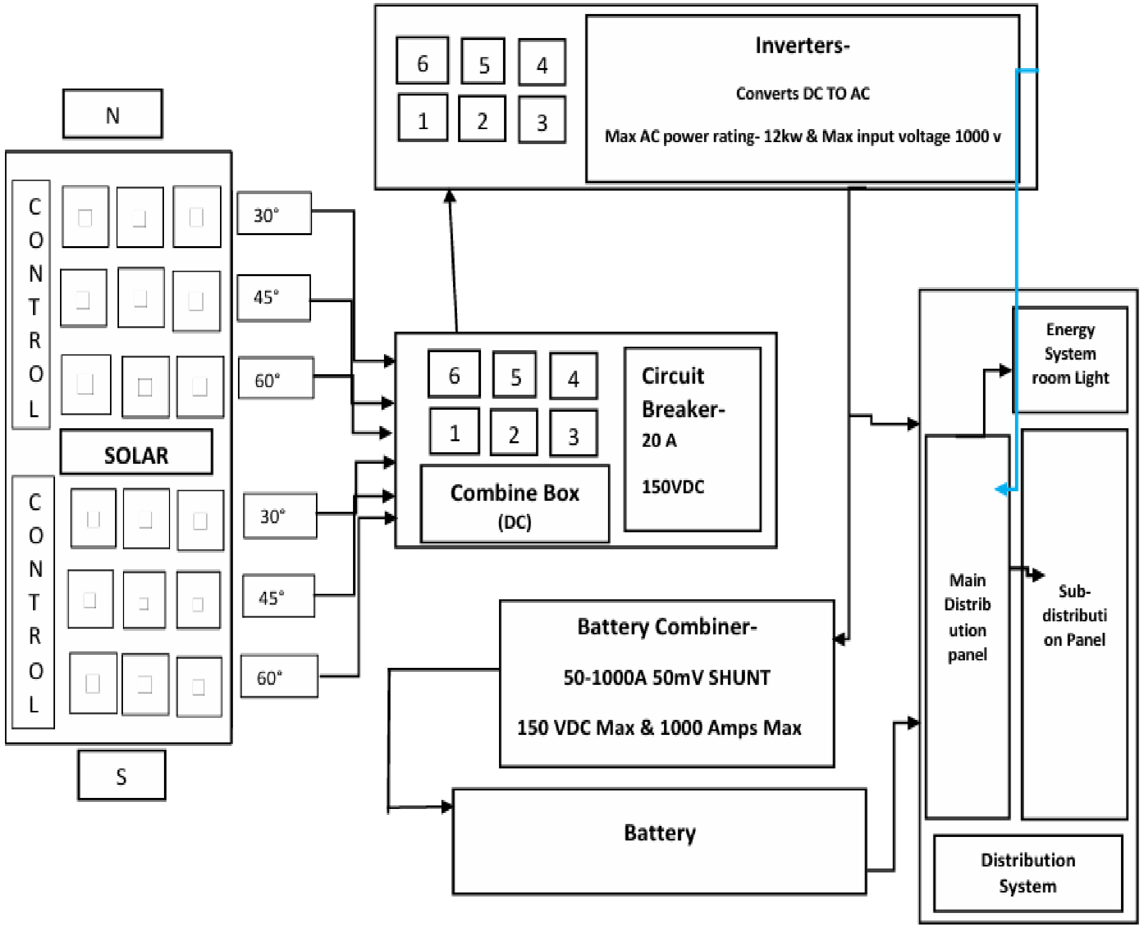
Agrivoltaics Systems at University of the District of Columbia





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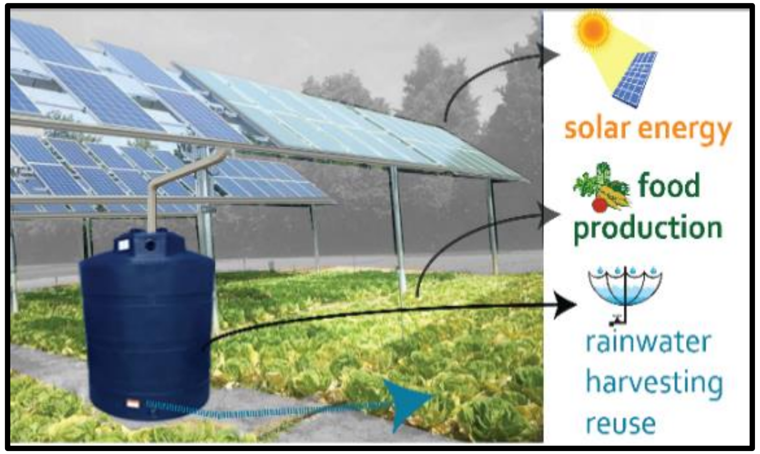

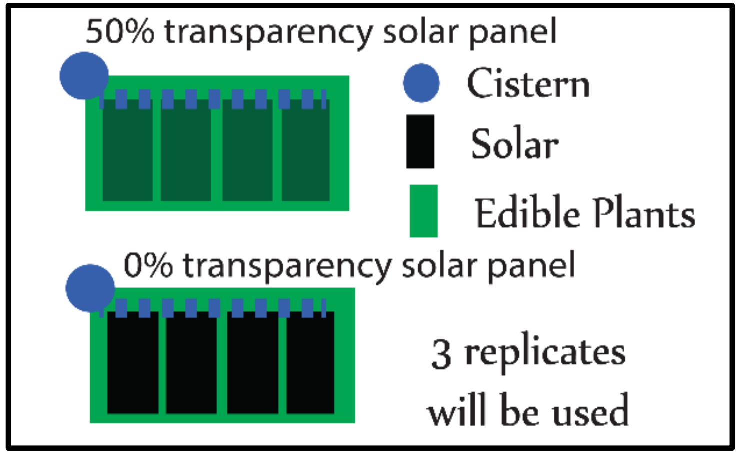

Simultaneous production of Solar Energy and Crops is known as Agrivoltaics

	Spring			Summer			Fall		
Solar Angle	Kale	Swiss Chard	Arugula	Bush tomato	basil	Hot Pepper	Winter Radishes	Spinanch	Mustard Green
Angle 01 (30º)	x	x	x	x	x	x	x	x	x
Angle 02 (45º)	x	x	x	x	x	x	x	x	x
Angle 03 (60º)	x	x	x	x	x	x	x	x	x
Open/No solar panel	x	x	x	x	x	x	x	x	x

- Preliminary results suggest (Fall: Sept-Dec growth season) that plants grown under 45° solar angle might have better effects on plant growth and yield (e.g. highest avg. height, highest avg. leaf area etc)

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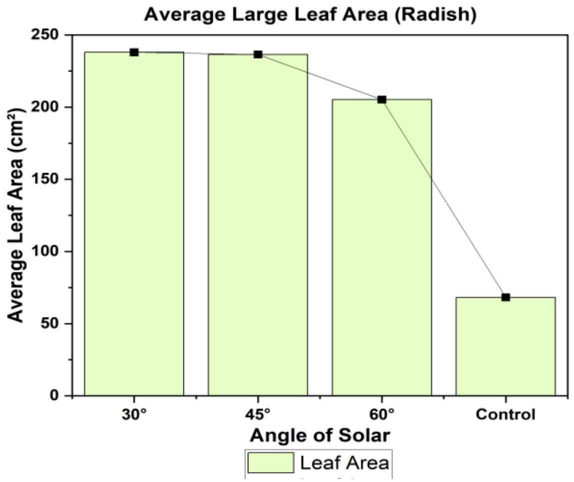
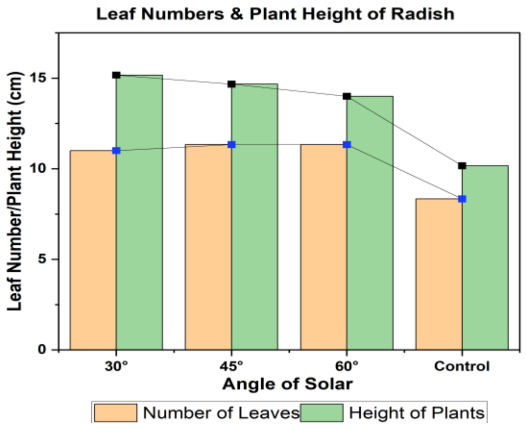
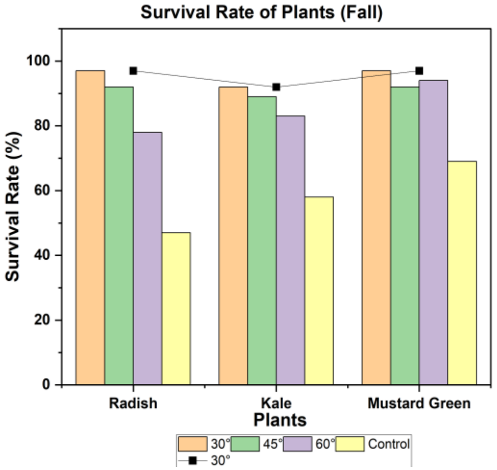
Findings of Agrivoltaics Systems at UDC

- **Rainwater Harvesting**: Best for rainwater collection angle 45°, outperformed 30° and 60° angles significantly.
- **Energy Production**: 45-degree angle yielded 40% more energy than 30° and 7% more than 60°; overall energy efficiency at 79%.
- **Crop Growth**: 30-degree angle showed best crop growth in spring and fall; moderate shading increased yields of shade-tolerant crops (Radish, Kale, Mustard Green, Swiss Chard, Lettuce, Arugula)







Renewable Energy Waste

- The amount of solar panel waste alone is projected to be 78 million metric tons in 30 years in developing countries (IRENA, 2018).
- The number reported does not count waste from wind turbines, battery storage units, and off-grid products with shorter lifetimes.
- It can further expose people to toxic waste as constituent materials of renewable energy technologies are similar to those in many electronics (e.g. cadmium byproducts, copper byproducts, lead, hexafluoroethane, polyvinyl fluoride, tin, lithium, and silicon tetrachloride) which can be highly toxic to humans and the environment.
- Without a strategy for their end-of-life management, so-called green technologies like solar panels, electric vehicle batteries, and windmills will ultimately place the same unintended burdens on our planet and economy as traditional commodities (US EPA Administrator, 2022)
- Appropriate and effective preparations need to occur along with the expanded use of renewable energy so that recycling systems and appropriate waste management infrastructures are in place when they are needed

Barriers to Renewable Energy Adoption in Bangladesh

- **Economic Barriers**:

~high initial cost of renewable energy installations

~Inadequate access to institutional finance

~Fossil fuel subsidies create significant distortions making non-renewable energy sources artificially inexpensive

~Renewable energy projects carries inherent financial risks and uncertainties

- **Technical Barriers:**

~Intermittent nature of solar and wind leading to challenges with reliable and stable power grid

~Effective energy storage systems

~Integrating renewable energy into existing power grids

~Lack of skilled labor

- **Political and Regulatory Barriers**:

~Stable and consistent policy frameworks including changes in government, shifting political priorities

~Complex regulatory hurdles, permitting process

~Influence of fossil fuel industry

- **Social and Cultural Barriers:**

~Misconceptions about the reliability, cost, and environmental impact

~Cultural resistance to change can impede the adoption of renewable energy

- **Environmental and Geographical Barriers:**

~Availability of renewable resources is geographically variable

~Renewable energy projects has environmental impacts with renewable waste challenges

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