



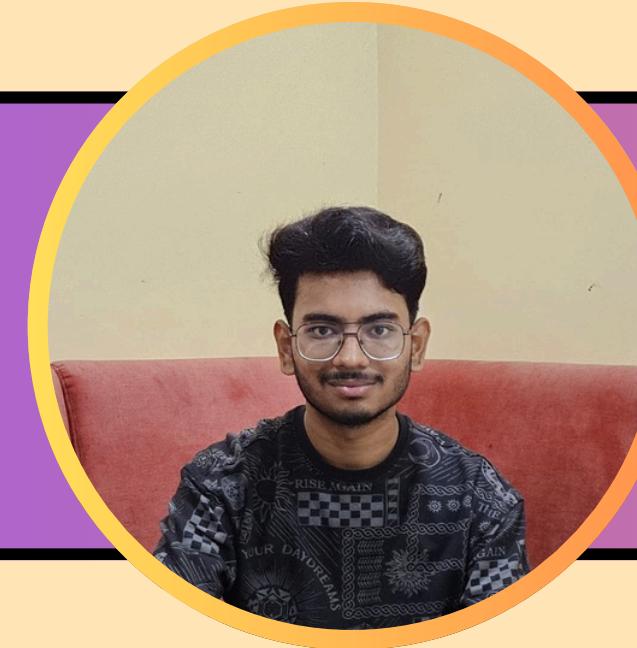
SOLAR NEXUS

Empowering Sustainable Development: Advancing Solar Energy Adoption in Developing Nations.

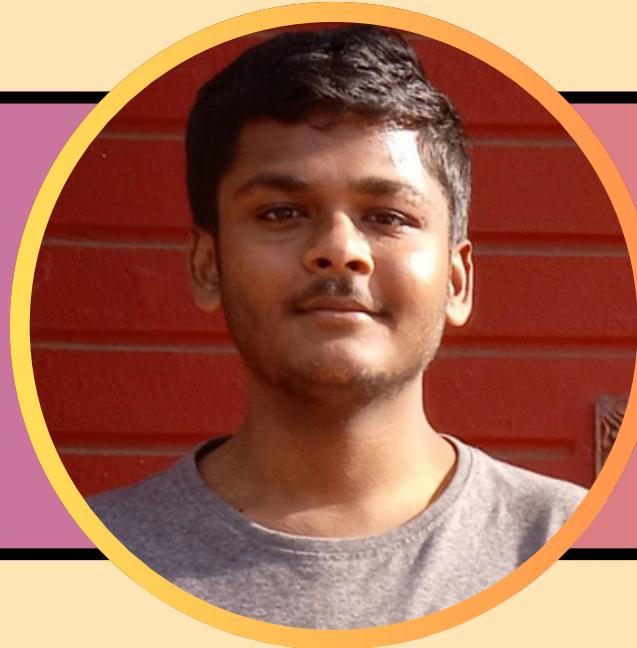
TEAM VISIONARY MINDS FROM NIT ROURKELA



Om Prakash Mallick



Subham Pradhan



Suvankar Prusty



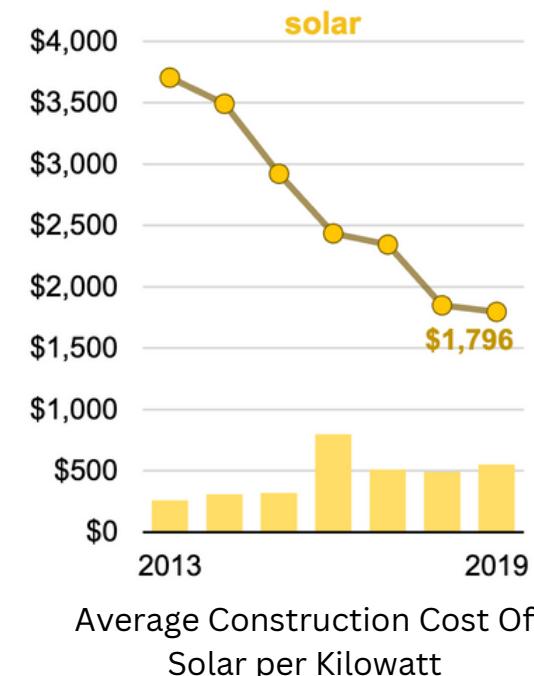
Swagat Mishra

INNOVATIVE FINANCING MODELS

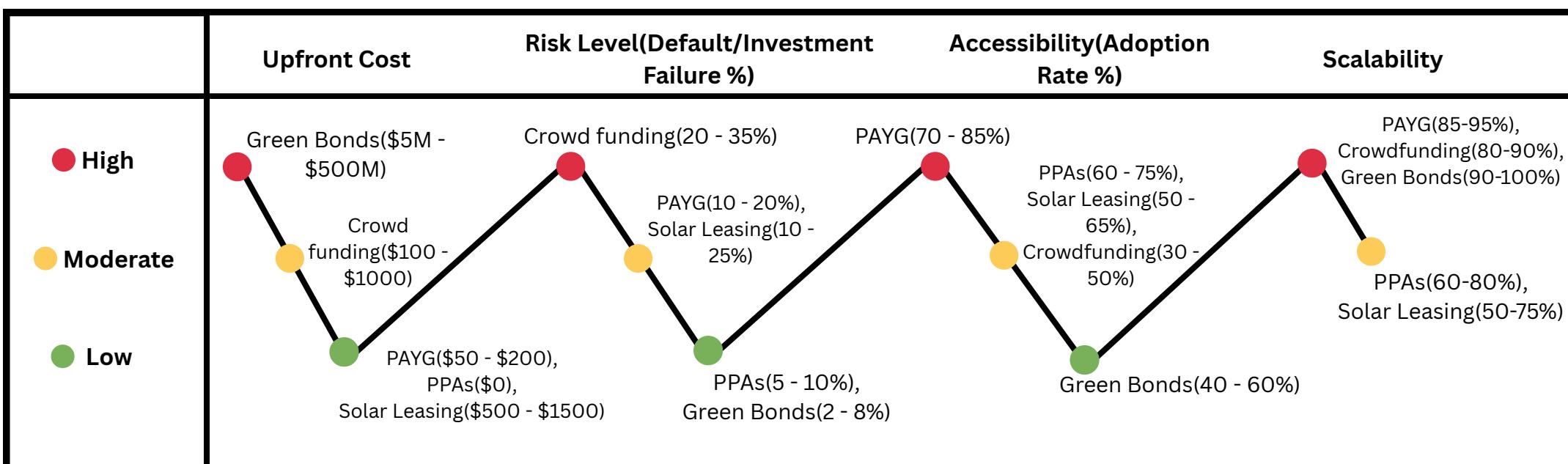


How Solar Financing Models Work

- Pay-As-You-Go (PAYG) Financing & Solar Leasing**
 - Install solar system → Make small payments via mobile or lease monthly → Own the system over time (PAYG) or keep leasing (Solar Leasing).
- Power Purchase Agreements (PPAs)**
 - Developer installs solar → Business/home pays for usage → Lower energy bills.
- Crowdfunding**
 - Investors contribute → Solar project launches → Profits generated for reinvestment.
- Green Bonds**
 - Institutions issue bonds → Funds raised for large solar projects → Investors receive financial returns.



Evaluating Solar Financing Models



Conclusion

- PAYG & Solar Leasing** = Best for low-income households & small businesses.
- PPAs & Green Bonds** = Best for industrial and commercial solar projects.
- Crowdfunding** = Effective for community solar projects and start-ups.

COST-EFFECTIVE STRATEGIES



SMART MANUFACTURING & DESIGN

1

Solution: Automate production & use lightweight materials to cut costs.

How It Helps: Speeds up manufacturing, reduces waste, boosts efficiency.

- Example:** HJT & thin-film solar panels lower material and energy costs.
- Impact:** Up to 20% cost reduction in solar panel production.

INCENTIVE-DRIVEN FINANCING

2

Solution: Expand tax credits, subsidies & incentives for solar adoption.

How It Helps: Cuts upfront costs, making solar affordable for homes & businesses.

- Example:** The U.S. ITC slashed costs by 30%, boosting adoption.
- Impact:** 30%-50% lower installation costs.

FASTER SOLAR INSTALLATION

3

Solution: Use pre-approved designs & digital permitting for quick approvals.

How It Helps: Cuts red tape, speeds up deployment, and lowers costs.

- Example:** SolarAPP+ (U.S.) slashes permit approval time from 20 days to a few hours.
- Impact:** 10%-20% cost reduction on installations.

SMART ENERGY STORAGE

4

Solution: Affordable battery storage (e.g., lithium-ion phosphate & sodium-ion).

How It Helps: Maximizes solar savings, reducing grid dependence.

- Example:** Tesla Powerwall & CATL sodium-ion batteries lower costs.
- Impact:** 40% energy cost reduction for industries with optimized storage.

LARGE-SCALE DEPLOYMENT & BULK PROCUREMENT

5

Solution: Promote bulk solar panel procurement for businesses & governments to cut costs.

How It Helps: Economies of scale reduce per-unit prices, making solar more affordable.

- Example:** India's Solar Park Initiative slashed solar power prices by 40%.
- Impact:** 25%-40% lower per-kWh costs for industrial use.

ECONOMIC VIABILITY OF SOLAR ENERGY

TECHNICAL CHALLENGES AND INNOVATIONS

POLICY AND GOVERNANCE

COMMUNITY INVOLVEMENT AND AWARENESS

ENERGY TRANSITION PLANNING



Dubai Solar Park, UAE – A Beacon of Renewable Ambition

Bhadla Solar Park, India – The Largest Solar Farm in the World

Noor Solar Complex, Morocco – Pioneering Africa's Clean Energy Future

Gandhinagar Solar Rooftop Program, Gujarat – Powering Cities from the Top Down

Vision:

Transform Dubai into a global **solar powerhouse** by leveraging PPPs to attract **international investments and expertise**.

Impact:

- Strengthens **energy security**, reducing dependence on fossil fuels.
- Establishes **Dubai** as a **leader in renewable energy innovation**.
- Significantly **cuts carbon emissions**, supporting UAE's **net-zero goals**.



Milestone: This visionary project has drawn **billions in investments**, proving that **large-scale solar is not just a dream—but a reality**.

Installed Base in Gigawatt
CAGR 35.48%

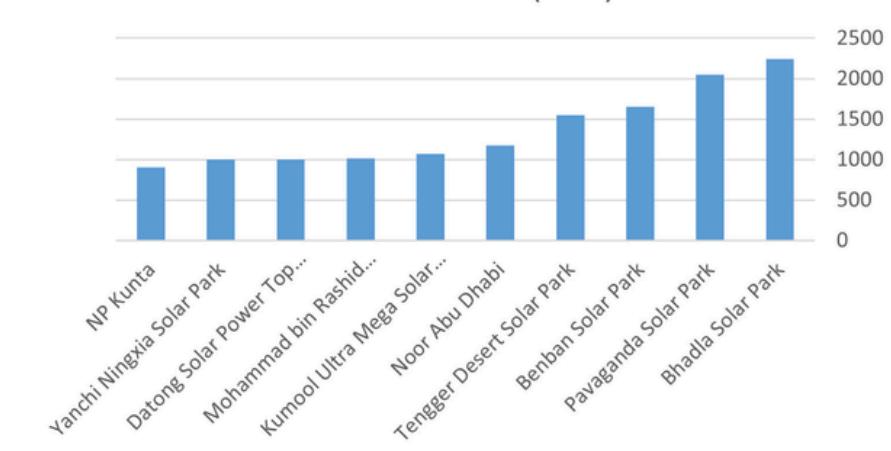
36.06

7.90

2024

2029

Power Generated(MW)



Global Recognition

A symbol of **India's clean energy future**, attracting investors worldwide.

Mission:

Establish the **world's largest solar park in Rajasthan's sun-drenched desert**, proving that even extreme climates can be energy assets.

Why It's a Game Changer:

- 2,245 MW capacity**, powering millions of homes.
- One of the **cheapest solar power producers** globally, with record-low tariffs.

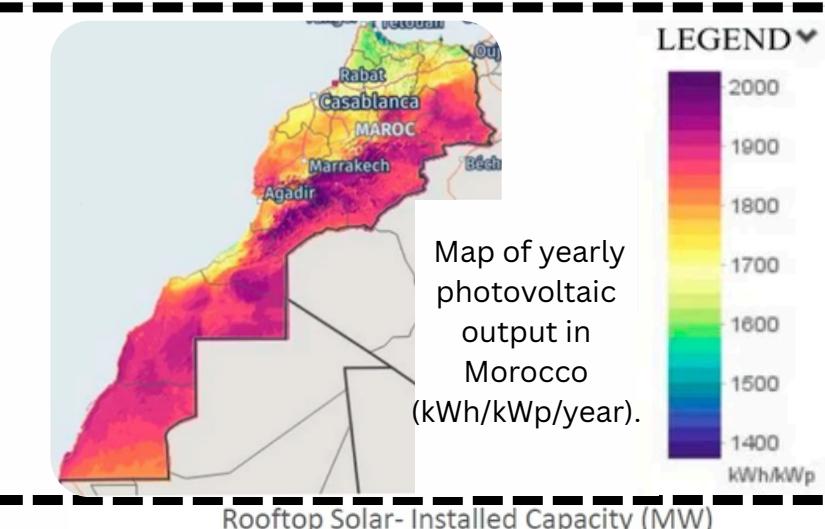
Vision: Establish Morocco as a global **renewable energy leader** by leveraging Public-Private Partnerships (PPPs) for large-scale solar investments.

Impact:

- Provides **580 MW** of clean energy, powering **1 million homes**.
- Reduces CO₂ emissions by **760,000 tons annually**.
- Strengthens **energy security** and reduces fossil fuel dependency.

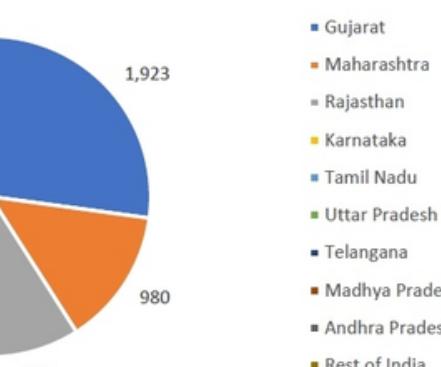


Milestone: One of the world's **largest concentrated solar power (CSP) projects**, featuring **molten salt storage** for night-time energy supply.

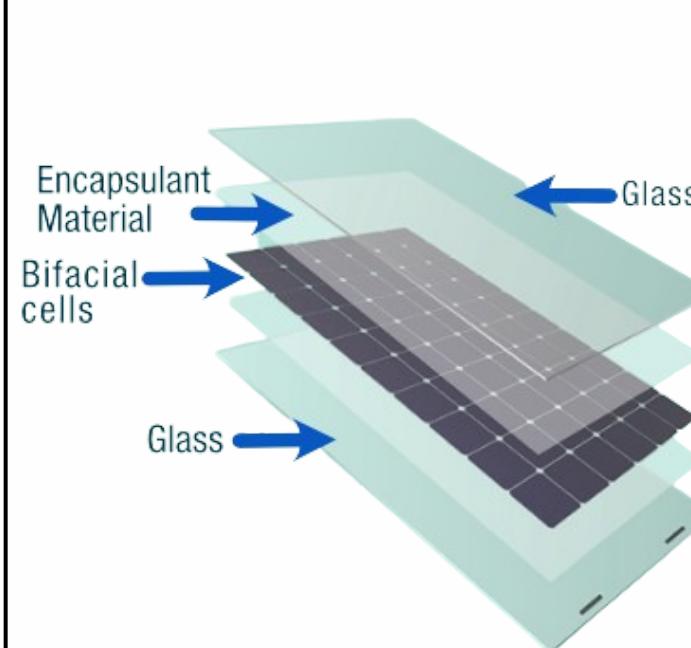
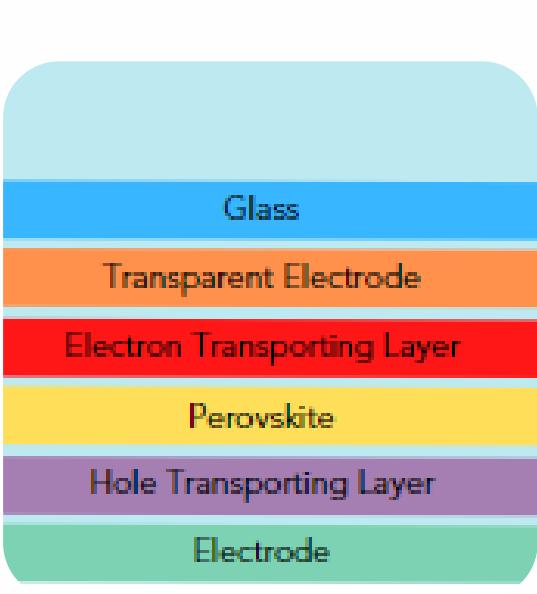
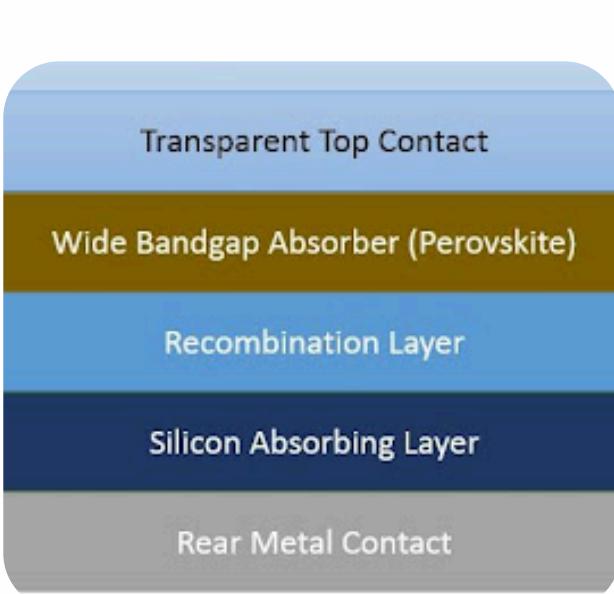
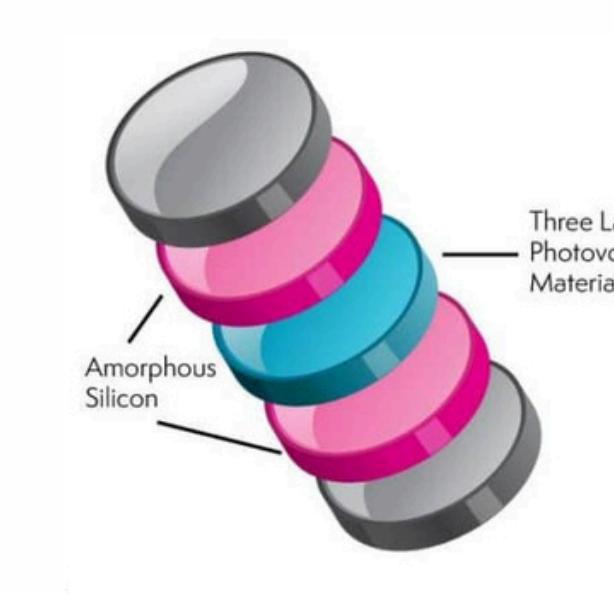
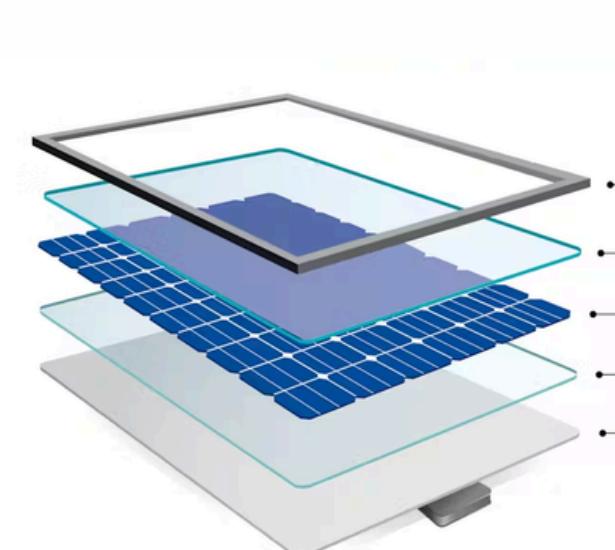


Why It's Revolutionary:

- Provides **financial incentives** to encourage private solar investment.
- Reduces **carbon footprint** while enhancing **energy efficiency**.
- Real-World Success:** With **rooftop solar spreading across state-owned buildings**, Gujarat has **turned its skyline into a clean energy asset**.



ADVANCEMENTS IN SOLAR PANEL EFFICIENCY

					
TYPES	BIFACIAL SOLAR PANELS <i>(Harnessing Reflected Light)</i>	PEROVSKITE SOLAR CELLS <i>(High Efficiency at Low Cost)</i>	TANDEM SOLAR CELLS <i>(Stacking Layers for Maximum Output)</i>	HETEROJUNCTION TECHNOLOGY SOLAR PANELS <i>(Improved Performance in Heat)</i>	MONOPERC SOLAR PANELS <i>(Enhanced Light Absorption)</i>
INNOVATION	Capture sunlight from both the front and rear sides, utilizing reflected light to enhance power output.	Use perovskite materials that absorb a broader light spectrum and can be produced at lower costs than silicon.	Combine perovskite and silicon layers to absorb different wavelengths of sunlight.	Merge crystalline silicon with thin-film technology to reduce energy losses in high temperatures.	Uses a passivated emitter and rear contact (PERC) layer to trap more sunlight and improve electron flow.
EFFICIENCY	Up to 25% more energy generation compared to traditional panels.	Lab efficiencies have exceeded 30% , surpassing conventional silicon cells.	Exceed 30% efficiency, higher than single-junction solar cells.	Up to 26% efficiency, superior to standard silicon panels.	Achieve up to 25% efficiency, higher than traditional polycrystalline panels.
CHALLENGES	Requires optimal ground surfaces (e.g., white sand, concrete) to maximize rear-side energy capture.	Stability and durability issues limit their commercial scalability.	High manufacturing complexity and production costs.	Higher production costs due to complex cell structure.	Higher initial costs, but greater long-term energy savings.
COMPANIES	 			 	

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ENERGY STORAGE SOLUTIONS

Lithium-Ion Batteries – High energy density, fast charging, and widely used in residential, commercial, and grid-scale storage.

Solid-State Batteries – Higher efficiency, longer lifespan, and improved safety over traditional lithium-ion batteries.

Flow Batteries – Store energy in liquid electrolytes, offering long-duration storage and scalable grid applications.

Hydrogen Fuel Cells – Convert hydrogen into electricity with zero emissions, ideal for large-scale and off-grid solutions.

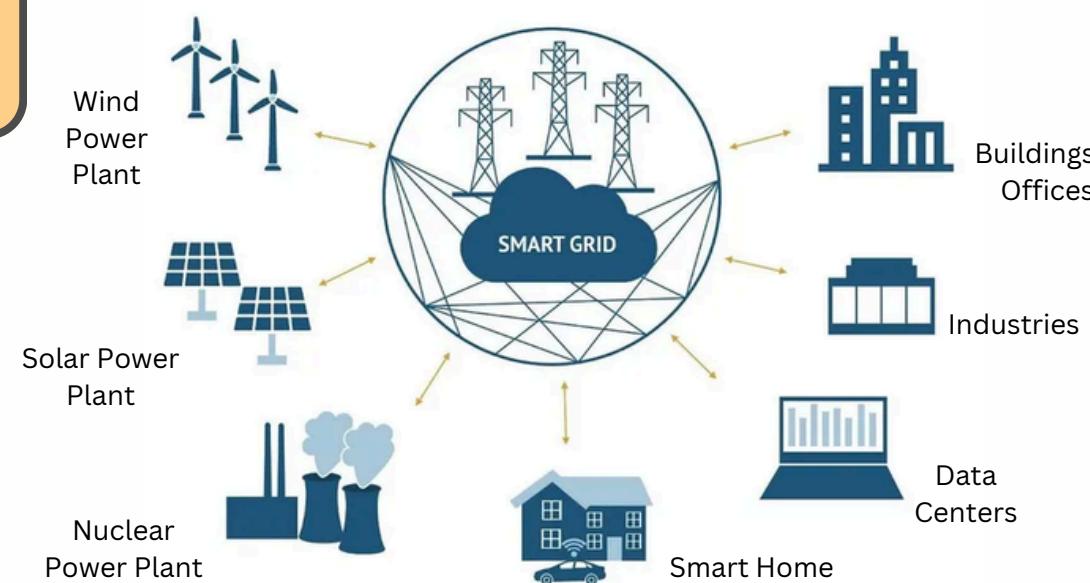
Gravity-Based Storage – Uses kinetic energy by lifting and lowering weights, offering a sustainable alternative to chemical batteries.

Smart Grids

- Benefits:** Optimize solar energy management, reduce congestion.
- Challenges:** High upfront costs, complex infrastructure.



- Solutions:** Smart meters, advanced analytics, demand-response systems.
- Lifespan:** 10-20 years.



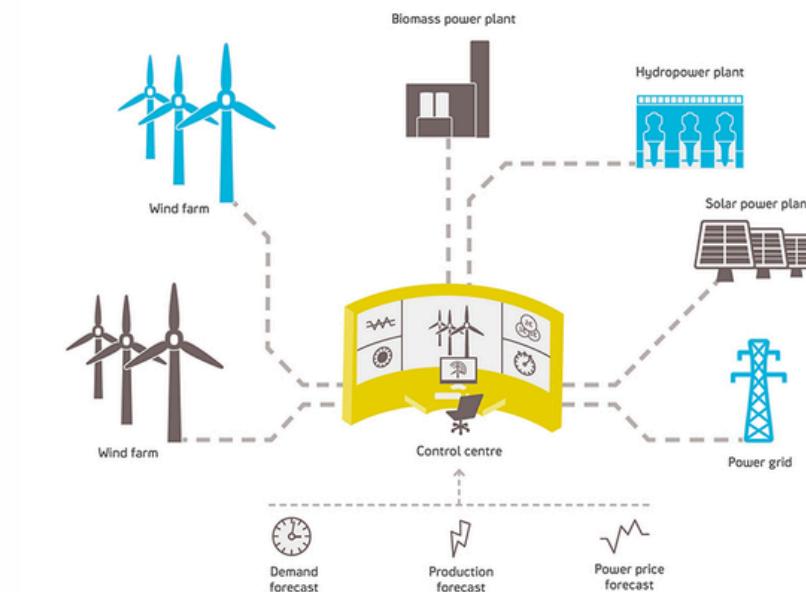
GRID INTEGRATION TECHNOLOGIES

Virtual Power Plants (VPPs)

- Benefits:** Enhance grid stability & cut energy costs by aggregating distributed resources.
- Challenges:** Complex management of diverse energy sources.



- Solutions:** Advanced software for real-time monitoring & control.
- Lifespan:** Software updates continuously; hardware lasts 10-20 years.

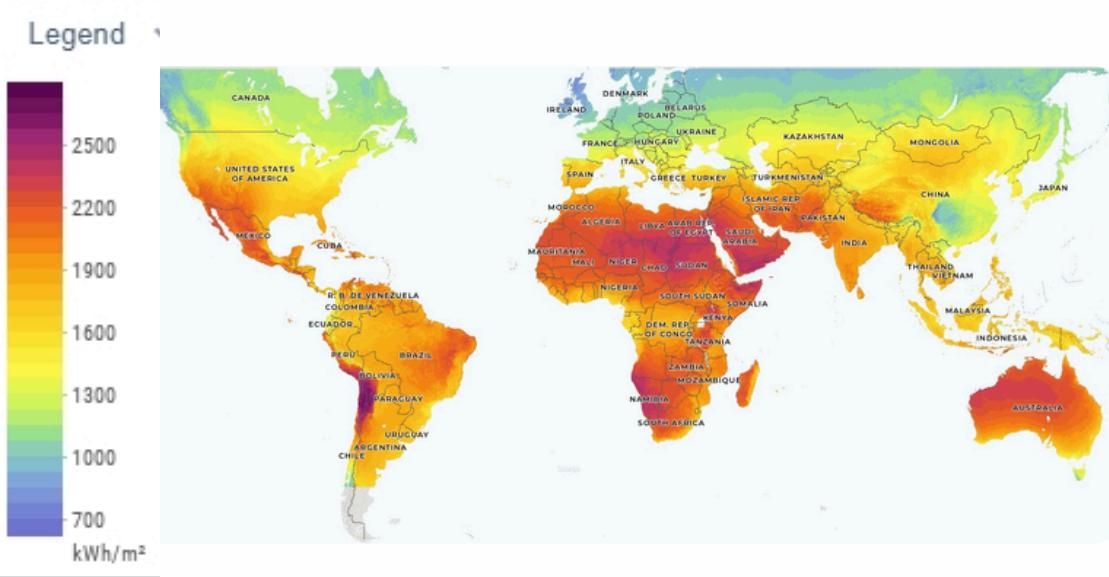


Artificial Intelligence & Machine Learning

- Benefits:** Enhances solar generation, grid operations & energy management with predictive analytics.
- Challenges:** Data quality & integration complexities.



- Solution:** AI-driven forecasting for solar irradiance & demand management.
- Lifespan:** Models update continuously; hardware lasts 5-10 years.



Economic Viability of Solar Energy		Technical Challenges and Innovations		Policy and Governance		Community Involvement and Awareness		Energy Transition Planning	
Factors	Cost-Efficiency and Affordability	Rapid Deployment and Scalability	Enhanced Energy Resilience	Environmental Sustainability	Economic and Social Empowerment	Energy Equity and Accessibility			
Buyer Actions & Solutions									
MINI-GRIDS:	<ul style="list-style-type: none">Action: Consider mini-grids but worry about the high initial cost.Solution: Offer community-based financing models and micro-loans.	<ul style="list-style-type: none">Action: Interested in future-proof solutions but worried about delays.Solution: Implement modular mini-grids that start small and scale over time.	<ul style="list-style-type: none">Action: Want reliability but concerned about system downtime.Solution: Use battery storage and hybrid models (solar + diesel backup).	<ul style="list-style-type: none">Action: Open to green energy but concerned about reliability.Solution: Educate on energy-efficient appliances and hybrid solutions.	<ul style="list-style-type: none">Action: Need power for productive activities like irrigation, welding, or cold storage.Solution: Provide higher-wattage connections for small businesses.	<ul style="list-style-type: none">Action: Interested in a community-wide solution but need financial support.Solution: Implement subsidized mini-grid projects in rural areas.			
STANDALONE HOME SOLUTIONS (SHS):	<ul style="list-style-type: none">Action: Look for a cheaper, immediate alternative.Solution: Provide pay-as-you-go (PAYG) financing to reduce upfront costs.	<ul style="list-style-type: none">Action: Choose SHS for fast access to power.Solution: Deploy plug-and-play kits that require minimal setup.	<ul style="list-style-type: none">Action: Worry about limited battery storage.Solution: Provide higher-capacity battery options and efficient appliances.	<ul style="list-style-type: none">Action: Want a simple renewable energy option.Solution: Provide solar-powered appliances and smart energy management tools.	<ul style="list-style-type: none">Action: Use SHS for personal lighting and phone charging but struggle to power larger appliances.Solution: Introduce solar-powered business kits (e.g., solar freezers).	<ul style="list-style-type: none">Action: Need an individual solution at an affordable price.Solution: Provide PAYG financing and bulk purchase discounts.			
THOUGHTS AND EMOTIONS	<p>“Mini-grids sound promising, but are they too expensive?”</p> <p>“This is way beyond my budget. I’ll stick to kerosene.”</p> <p>“I found an affordable energy solution that fits my budget.”</p> <p>“Mini-grids are scalable, but how long will installation take?”</p> <p>“I can get a solar home system today and have power immediately!”</p> <p>“I need power now, not months from now!”</p>	<p>“With this system, I no longer have to worry about blackouts.”</p> <p>“Solar sounds reliable, but what happens during rainy days?”</p> <p>“If my battery runs out, I’ll be left in the dark.”</p>	<p>“Renewable energy is good, but will it be enough for my needs?”</p> <p>“Solar is unreliable. I’d rather use a diesel generator.”</p> <p>“This solution reduces pollution and improves air quality.”</p>	<p>“This won’t work for my shop – I need a strong power source.”</p> <p>“Mini-grids can power businesses, but are they stable enough?”</p> <p>“I can use this system to start a small business!”</p>	<p>“Standalone systems work for me, but what about my neighbors?”</p> <p>“If I can’t afford it, this won’t help me at all.”</p> <p>“Now my entire community has access to reliable electricity!”</p>				
OPPORTUNITIES	Develop subsidy programs and micro-financing options to reduce upfront barriers.	Offer hybrid solutions, where SHS is used while mini-grids are under construction.	Promote integrated battery storage solutions to improve system reliability.	Encourage government policies supporting renewables over fossil fuels.	Develop micro-enterprise solutions using mini-grid power.	Establish public-private partnerships to expand decentralized energy access.			
WHAT'S THE ULTIMATE WINNER?	SHS is better for immediate affordability, but mini-grids are more cost-effective long-term when shared across multiple users.	SHS is better for immediate deployment, but mini-grids provide long-term scalability.	Mini-grids are better for long-term resilience, but SHS works well for individuals needing basic backup power.	Mini-grids are better for larger-scale sustainable impact, but SHS is a great entry point for clean energy adoption.	Mini-grids are better for business and economic development, while SHS supports basic needs but has limited income-generating potential.	Mini-grids offer a more sustainable, equitable solution for communities, while SHS provides quick access to energy for individual households.			

CURRENT SCHEMES



PM KUSUM
Scheme



SEIA
Solar Energy
Industries
Association®

STATE GRID
CORPORATION OF CHINA

Jawaharlal Nehru National Solar Mission

JNNSM



OBJECTIVE

- Purpose:** Promote decentralized solar power, reduce reliance on diesel pumps, and enhance farmer incomes.
- Subsidized Solar Pumps:** Farmers receive **60% subsidy + 30% loan**, covering **90% of costs**.
- Grid-Connected Solarization:** Farmers can **sell surplus power** back to the grid, creating an additional revenue stream.
- Target:** **30,800 MW solar capacity** with ₹34,422 crore investment.

- Purpose:** Accelerate solar adoption by reducing installation costs for residential and commercial projects.
- Tax Credits:** Offers a **30% federal tax credit** on solar system costs under the Inflation Reduction Act (2022).
- Impact:** Contributed to **160+ GW** of installed solar capacity, driving 25% annual growth in the U.S. solar market.

- Purpose:** Enhance grid reliability to accommodate China's goal of **500+ GW** solar capacity by **2030**.
- Smart Grid Investment:** Allocating \$550 billion by 2025 to deploy Ultra-High Voltage (UHV) transmission lines.
- Impact:** Enabled China to supply **450 TWh** of solar power (2023), contributing to its carbon neutrality target by **2060**.

- Purpose:** Establish India as a global leader in solar energy with a **280 GW solar target by 2030**.
- Large-Scale Solar Parks:** Facilitates utility-scale solar projects to attract domestic & foreign investments.
- Impact:** India's solar capacity surged 24x since 2014, reaching **72 GW by 2023**.



CHALLENGES AND ISSUES

- High upfront costs despite subsidies.
- Slow implementation due to bureaucratic hurdles.
- Limited awareness and accessibility for small & marginal farmers.

- Periodic reductions create policy uncertainty for investors.
- Complexity in claiming tax credits for lower-income households.
- ITC set to phase out for residential solar **by 2035**.

- Grid congestion led to **12% solar energy curtailment in 2018**.
- High dependence on coal-based backup power.
- Large-scale infrastructure development requires significant capital.

- Land acquisition difficulties slow large-scale project implementation.
- 55% of India's solar capacity** concentrated in five states, limiting national distribution.
- Financial constraints affect small-scale solar developers.



SOLUTIONS

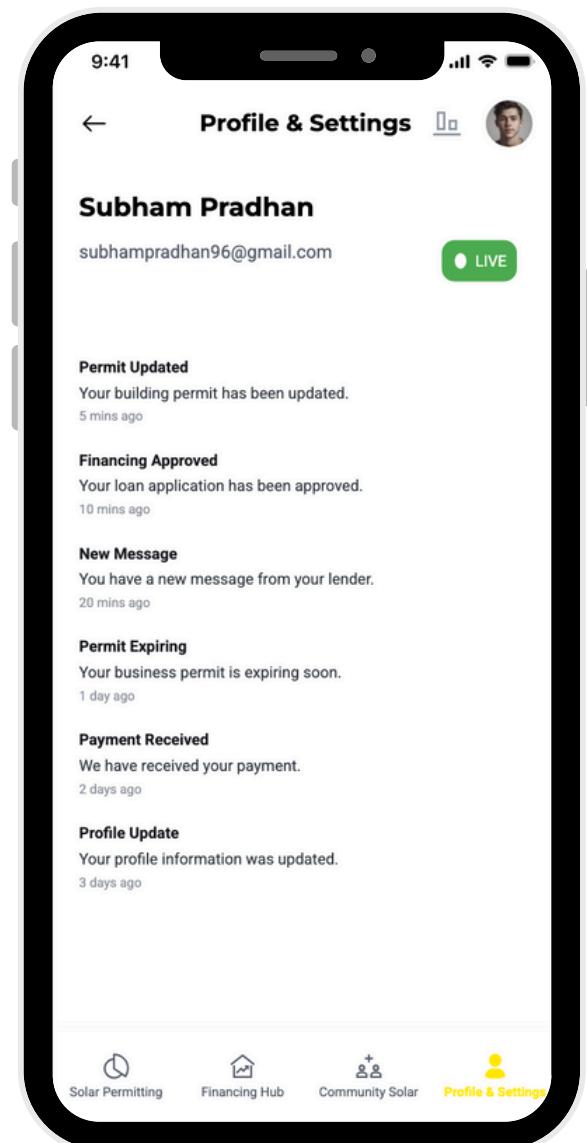
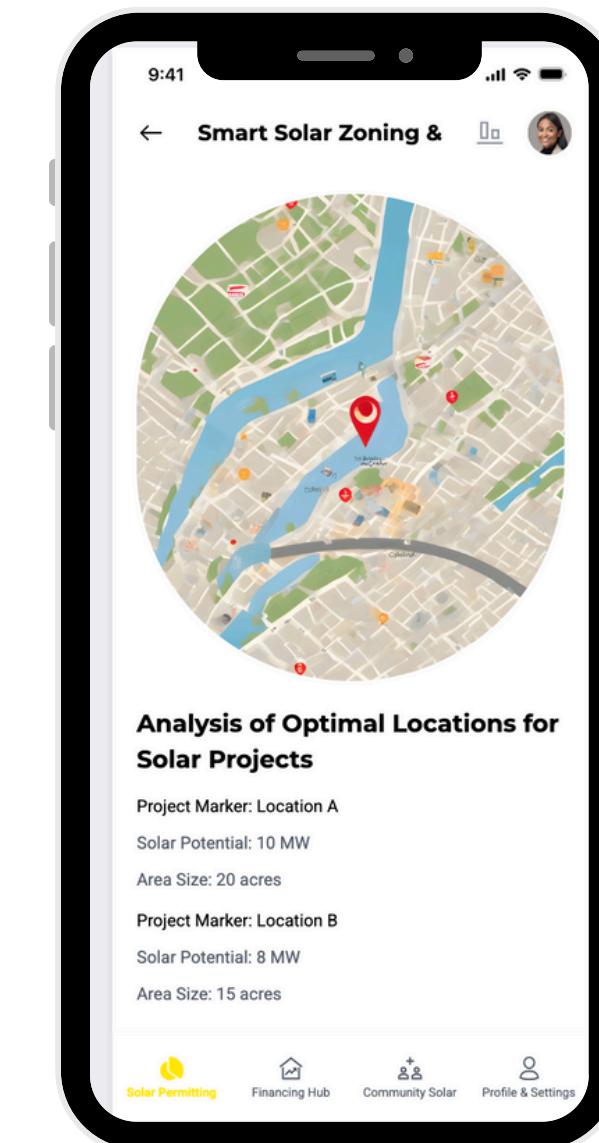
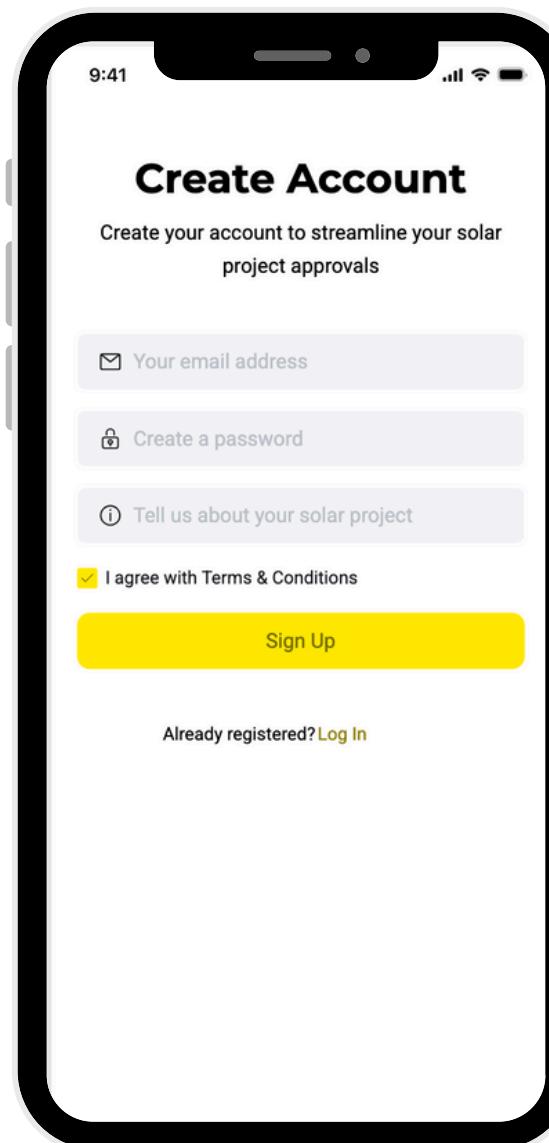
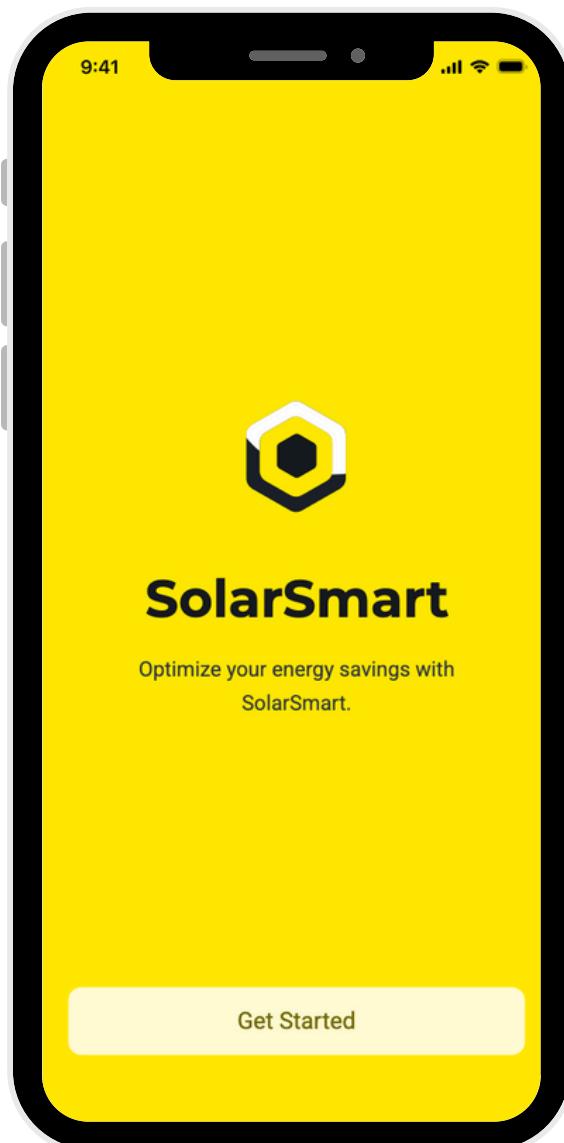
- Expand micro-financing options for small farmers.
- Streamline approval processes to speed up deployment.
- Awareness campaigns & local training for better adoption.

- Periodic reductions create policy uncertainty for investors.
- Complexity in claiming tax credits for lower-income households.
- ITC set to phase out for residential solar by 2035.

- Expand battery storage to reduce curtailment losses.
- Implement AI-based grid management to optimize energy distribution.
- Increase public-private partnerships to fund smart grid projects.

- Promote floating solar farms (e.g., **600 MW Omkareshwar Project**).
- Support rural micro-grids for decentralized solar adoption.
- Offer low-interest loans for small-scale solar businesses.

PROPOSED SOLUTION



LINK: [SOLAR SMART](#)

ECONOMIC VIABILITY OF SOLAR ENERGY

TECHNICAL CHALLENGES AND INNOVATIONS

POLICY AND GOVERNANCE

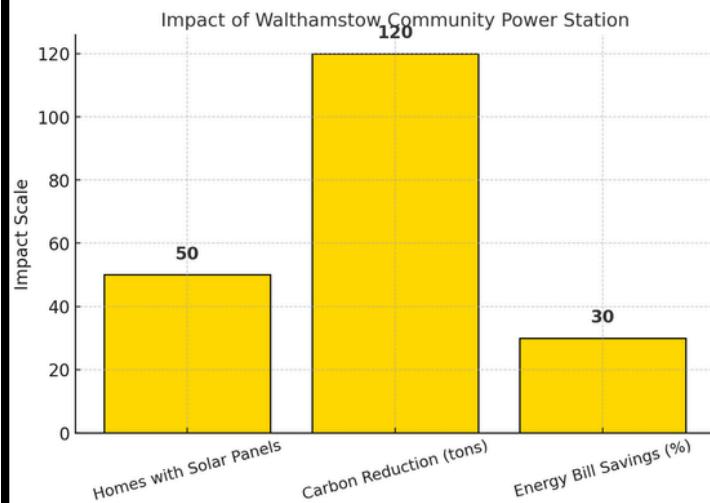
COMMUNITY INVOLVEMENT AND AWARENESS

ENERGY TRANSITION PLANNING

COMMUNITY INVOLVEMENT AND AWARENESS

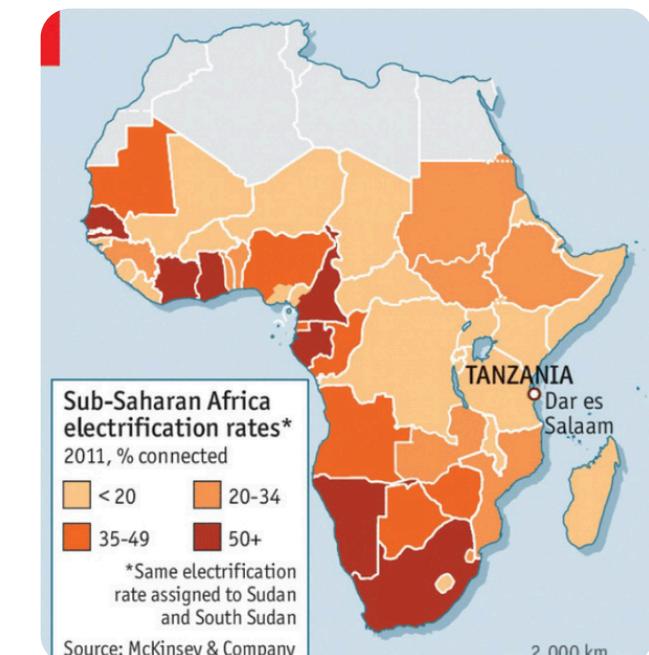
CO-OWNERSHIP & COMMUNITY SOLAR MODELS

- Community Solar Initiatives – Allow multiple residents to **share the benefits and costs** of a solar installation, making solar more accessible.
- Cooperative Ownership** – Community members collectively invest in solar projects, ensuring profits are distributed locally.
- Crowdfunding for Solar** – Residents can **financially support** solar installations through online platforms, fostering local ownership.
- Best For:** Expanding solar access to renters, low-income households, and urban areas.
- Example:** Walthamstow Community Power Station (London).



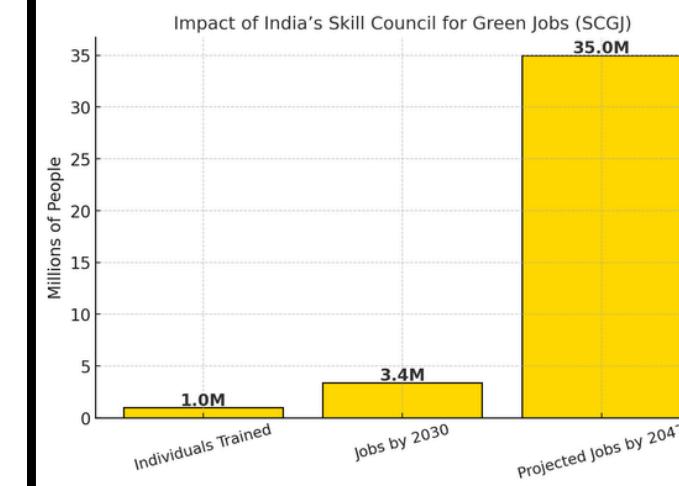
AWARENESS & COMMUNITY ENGAGEMENT

- Educational Programs** – Conduct workshops, training, and school partnerships to educate locals on solar benefits.
- Public Meetings & Consultations** – Involve communities early in the decision-making process to build trust and transparency.
- Community Visioning Exercises** – Align solar projects with local priorities by engaging residents in planning sessions.
- Best For:** Overcoming skepticism and ensuring community-driven solar adoption.
- Example:** Kenya's M-KOPA Solar – PAYG solar model promoted via door-to-door awareness campaigns.



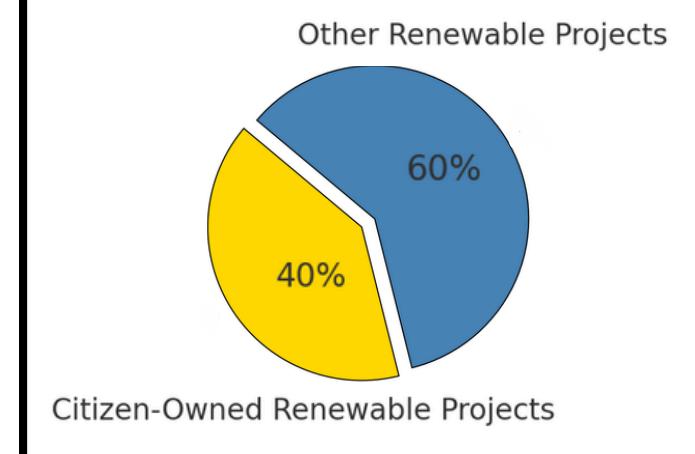
ECONOMIC & WORKFORCE DEVELOPMENT

- Solar Job Training Programs** – Equip local workers with skills in solar installation, maintenance, and operations.
- Microfinance for Solar Entrepreneurs** – Enable small businesses to **provide solar solutions in off-grid regions**.
- Public-Private Partnerships (PPPs)** – Governments and solar companies **collaborate to train and employ local labor**.
- Best For:** Creating sustainable jobs and boosting local economies.
- Example:** India's Skill Council for Green Jobs (SCGJ)



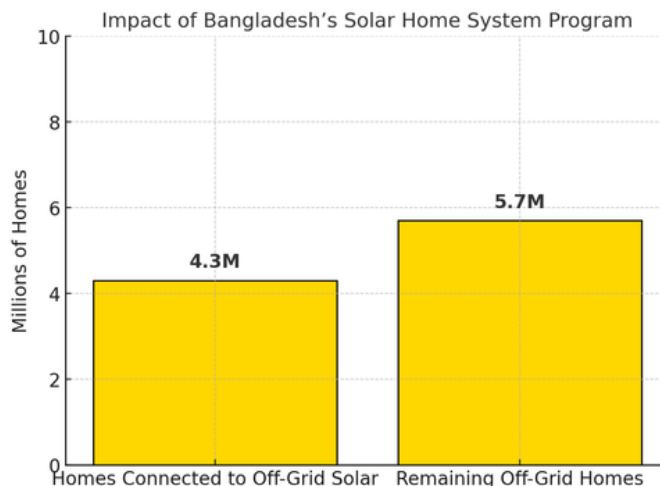
FINANCIAL INCENTIVES & POLICY SUPPORT

- Government Grants & Incentives** – Reduce **financial barriers** by leveraging public funds for community solar projects.
- Tax Breaks for Community Solar Investors** – Encourage local ownership and financial participation.
- Feed-in Tariffs (FiTs)** – Allow residents to **earn income by selling surplus solar energy** back to the grid.
- Best For:** Ensuring affordability and long-term sustainability of solar investments.
- Example:** Germany's FiT Program



SMART & INCLUSIVE INFRASTRUCTURE

- Solar-Powered Microgrids** – Provide **24/7 clean energy** to off-grid and rural communities.
- Smart Metering & Real-Time Data** – Enable residents to track and **optimize solar energy** usage.
- Women-Led Solar Initiatives** – Support female entrepreneurs in solar businesses to drive community-wide impact.
- Best For:** Expanding solar access to rural, low-income, and marginalized communities.
- Example:** Bangladesh's Solar Home System Program



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PHASE 1

PHASE 2

PHASE 3



FOSSIL FUEL DOMINANCE (1800S–2025)

- Industrial Boom: Coal, oil, and gas fueled rapid urbanization, transportation, and global trade.
- Energy Demand Surge: Cities expanded, factories thrived, and fossil fuels became the backbone of modern civilization.
- Environmental Fallout: CO₂ emissions soared, triggering climate crises, extreme weather, and oil dependency.
- Crisis Point: Rising temperatures, energy insecurity, and resource depletion demand urgent action.
- Early Socio-Economic Impact
- Fossil Fuel Job Boom: Millions employed in coal mining, oil drilling, and gas production.
- Regional Economic Powerhouses: Fossil-rich nations like the Middle East, U.S., and Russia thrived.

LAYING THE SOLAR FOUNDATION (2025–2030)

- Carbon Pricing & Subsidy Reallocation – Shift fossil fuel subsidies to solar energy.
- Green Bonds & Solar Tax Credits – Attract global investments for large-scale solar expansion.
- Decentralized Solar Networks – Promote community solar & microgrids for energy security.
- Breakthrough – Governments commit to 5X solar expansion worldwide.
- Ensuring a Just Transition
- Reskilling Programs – Train fossil fuel workers for solar panel manufacturing & battery tech.
- Equitable Solar Access – Financial incentives for low-income & rural households.

INFRASTRUCTURE EXPANSION & GRID MODERNIZATION (2030–2035)

- Smart Grids & AI Integration – Real-time, AI-driven grid management to balance solar supply.
- Hybrid Energy Systems – Combine solar + wind + hydro + battery for 24/7 power reliability.
- Solar-Ready Industrial Hubs – Convert former coal plants into solar and battery storage sites.
- Outcome – 40% of global electricity sourced from solar, reducing fossil fuel dependency.
- Addressing Socio-Economic Impact (2030–2035)
- Global Solar Investment Hubs – Advanced economies fund solar projects in developing nations.
- EV & Solar Charging Infrastructure – Nationwide solar-powered charging networks for transportation.

PHASE 5



THE SOLAR-DOMINANT FUTURE (2040–2050)

- Net-Zero Solar Grid – Solar, battery storage & green hydrogen power the world.
- AI-Managed Smart Grids – Decentralized energy networks optimize efficiency.
- Global Solar Trading – Cross-border solar power sharing ensures energy security.
- Socio-Economic Transformation
- Green Jobs Boom – Solar & clean energy industries become the backbone of global employment.
- Public-Private Innovation – Governments & companies collaborate for widespread solar access.
- Affordable Energy for All – Solar prices drop 40%, making clean energy universal & inclusive.

PHASE 4

SOLAR ECONOMY & UNIVERSAL ENERGY ACCESS (2035–2040)

- Universal Rooftop Solar – Homes, industries & public buildings run on solar energy. 🏠
- Fossil Fuel Workforce Shift – Transition into solar construction, smart grids & EV tech. 🚗
- Mass Energy Storage – Batteries & hydrogen ensure 24/7 power stability.
- Economic Impact: 🌎
 - Solar jobs outnumber fossil fuel jobs 3:1.
 - Energy resilience & price stability for all.
- Social Equity & Workforce Protection
- Job Training & Financial Aid – Support for displaced fossil fuel workers.
- Global Solar Electrification – Expanding clean energy to remote regions.
- AI-Optimized Smart Grids – Self-adjusting energy flow for max efficiency.

Illuminating Insights: Key References Powering This Case Study

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**THANK
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