Switch Energy Case Competition 2023

Bangladesh & Kenya

Team 106: RoarEEE

Hanif Adzmir, Malaysia
Uta Konishi, Japan
Justin Tee, USA
Karly Timko-Ruiz, USA

Mentor: Mrs. Kathy Aulstead

Table of Contents

Bangladesh

Rural Population

60.29% of population

Climate

High humidity, 7 flooding and cyclones events a year

Poverty

13.5% of the population living below the poverty line ($2.15/day)

Largest Sector

Agricultural Sector, with 37.6% of total workforce

Population & GDP

169 million people
$2620/capita

Air Quality

The Air Quality Index is 182, which is the fourth worst in the world.

Energy Poverty Factors

1 Affordability

Are energy services affordable?
→ % income

2 Reliability

Are energy services provided consistently?
→ Average outage length

3 Security

Are energy supply dependent on other countries?
→ Amount of energy import

4 Safety

Are cooking fuels impacting health?
→ % access to clean cooking fuel

5 Accessibility

Do people have energy access?
→ % electricity access

6 Potential for Roadblock

Are there hurdles that could impede the improvements?
→ Political rights and civil liberties

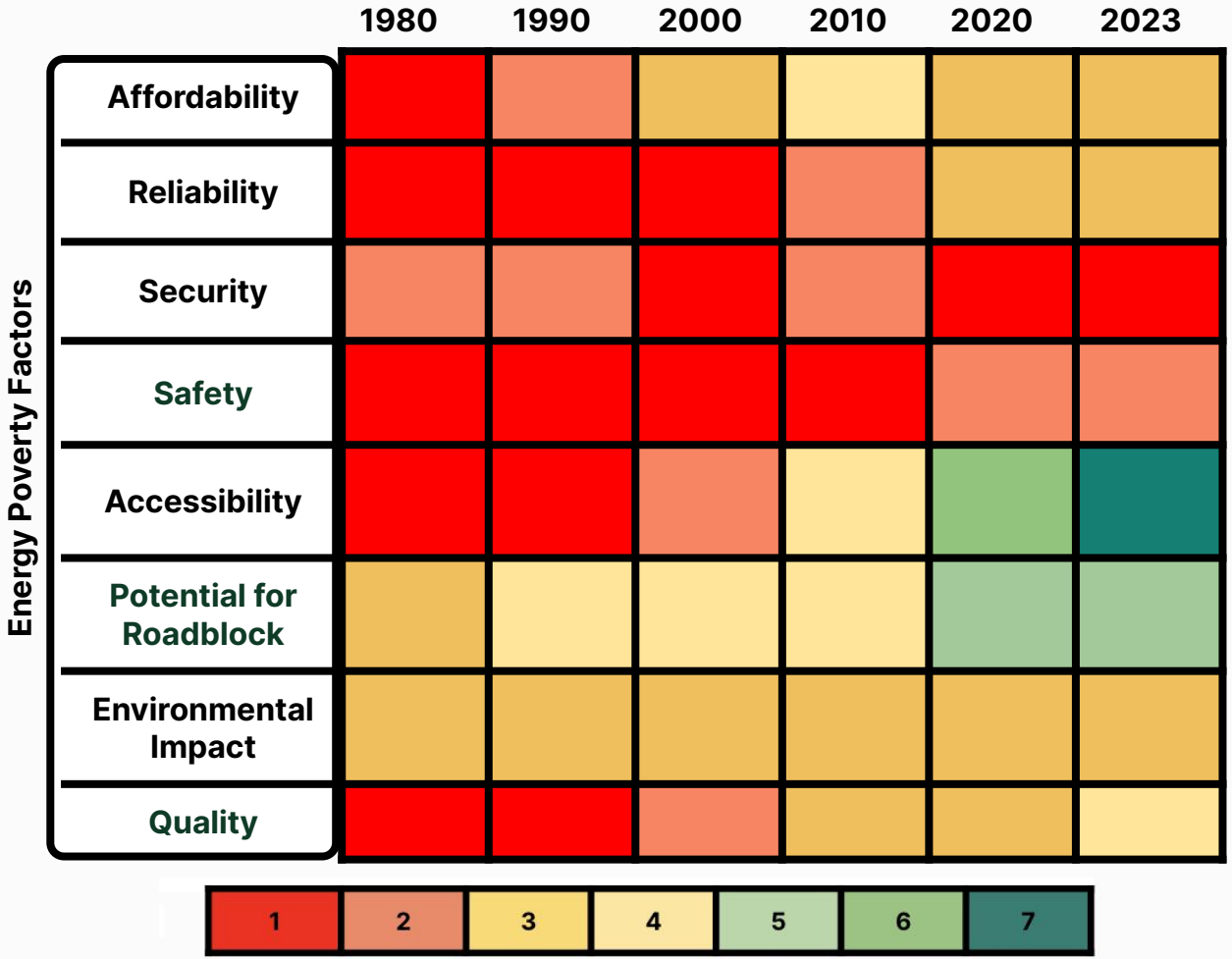
7 Environmental Impact

How does energy impact the environment ?
→ CO_2 emission

8 Quality

How reliable, safe, and affordable are the country's energy services?
→ Progression of the grid

Energy Poverty Analysis: Bangladesh



Main Problems in Bangladesh

Affordability

Rapid decarbonization in power system will Increase the cost by 30%.

Security

84% of energy demand is covered by import.

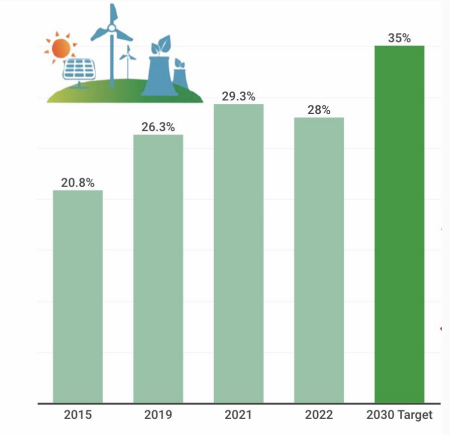
Environmental Impact

Current energy consumption from clean sources is only 3.5%.

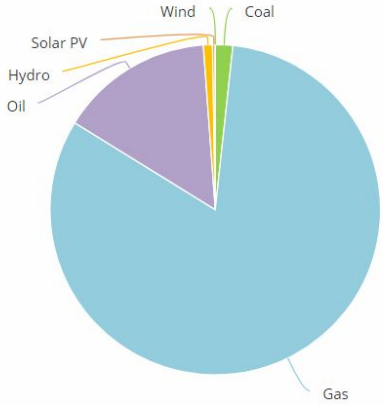
Safety

Only 28% of population has access to clean cooking fuel.

Clean cooking fuel access %→



Access to clean energy for cooking in Bangladesh drops to 28% in 2022: BBS. The Business Standard. (2023a, June 13). https://www.tbsnews.net/bangladesh/access-power-clean-energy-bangladesh-drops-28-2022-bbs-648858



←Energy Supply by Source

Bangladesh - Countries & Regions. IEA. (n.d.-a). https://www.iea.org/countries/bangladesh

Objectives and Targets

Reduce environmental impact — **Reach 15% renewables by 2041 (Government Goal)**

Government Goal

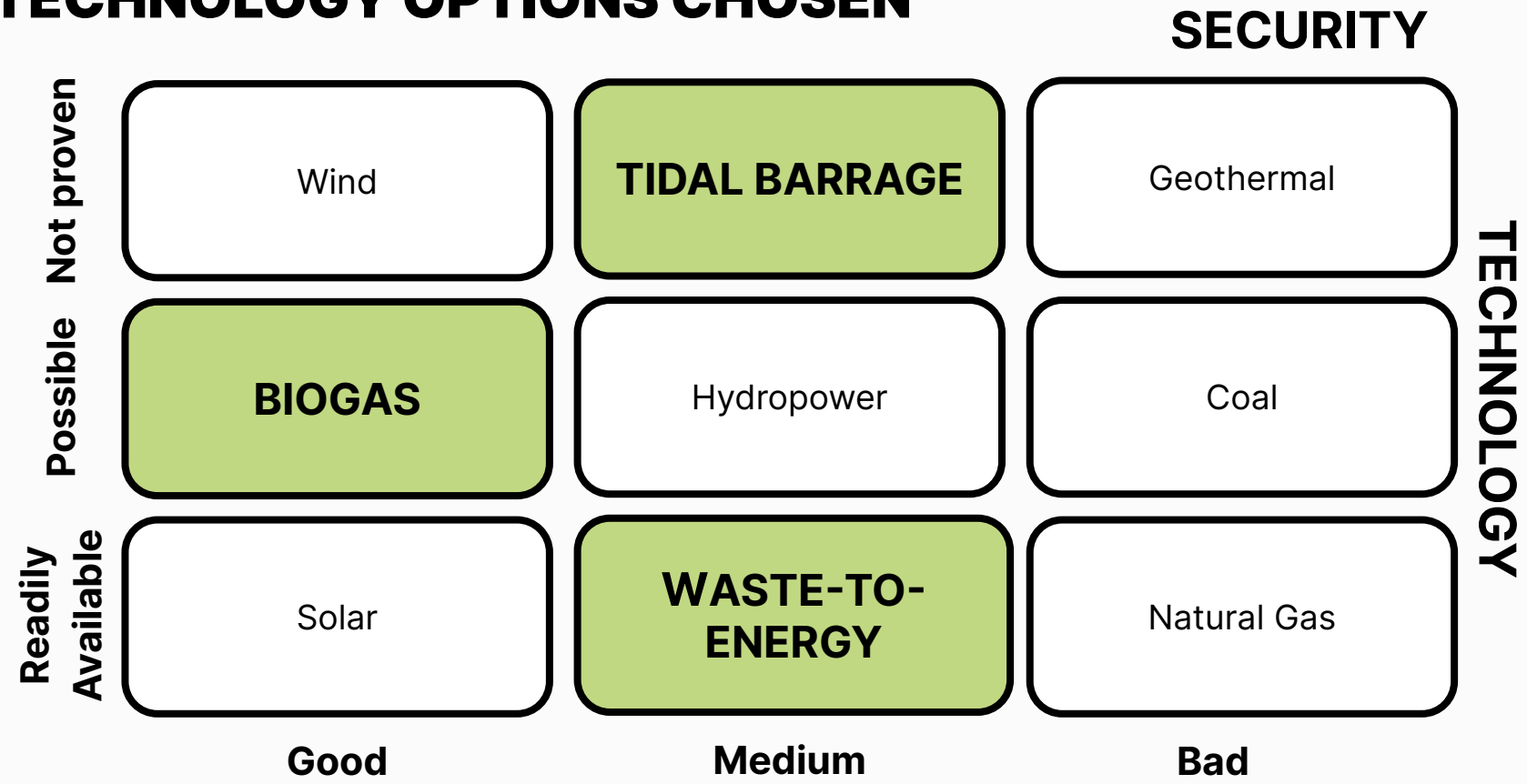
Secure Reliable Energy — **Reduce energy imports by 20%**

Improve public health — **Reach 40% clean cooking fuel access**

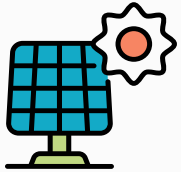
Our Targets

Keep energy affordable — **Keep cost of energy less than 6% of income**

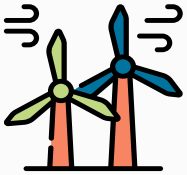
TECHNOLOGY OPTIONS CHOSEN



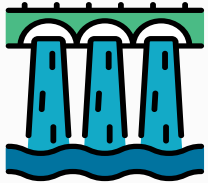
Other Energy Sources Considered



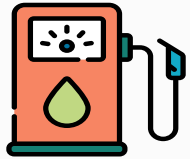
Solar



Wind



Hydropower



Natural Gas

Environmental Impact	Low	Low	Low	High
Security	Good	Medium	Medium	Poor
Affordability	Average	Average	Poor	Poor
Additional Considerations	Multiple Ongoing/ Successed Projects	Mechanics can be negatively impacted by humidity	A project failed due to water shortage	Unsure exploitation potential

Proposed Solution 1: Retrofitting Coal Plant to Waste-To-Energy (WTE) Plant With Carbon Capture And Storage

WTE: Challenges in Current Situation

Major Pressing Problems

Coal

Coal price volatility causes **frequent power plant shutdowns**, rendering new coal plants as stranded assets.

Open Dumps

Bangladesh's open dumps **release** significant amounts of **methane,** which adversely affect the health of surrounding communities.

Biowaste

15-20% of agricultural waste in Bangladesh is **burned in open fields**, leading to severe land and water pollution.

WTE: Current and ongoing efforts to resolve

	Fossil Fuels	Waste
Ongoing efforts	10 coal-fired power plants cancelled and on-going plans to explore indigenous natural gas resources.	Dhaka City Corp, with Japan Int'l Cooperation Agency's aid, develops solid waste management plan.
Complication	Less than 1% of natural gas exploration are economically-viable.	The plan has been in development since 2005 and is still unfinished.
Question	How can we reduce fuel supply risk and waste from open dumping and burning?	
Our Solution	Retrofit a coal plant into a waste-to-energy facility to use local waste as fuel. Install a Carbon Capture and Storage system to comply with current global regulations.	
Has it been done?	A 42.5MW WTE Plant is planned at Dhaka for operation in 2026. Currently in permitting stages.	

Waste-To-Energy (WTE)

Overview

Process of generating electricity from the primary treatment of municipal and agricultural waste.

Location

The Matarbari Power Plant in Chittagong, Bangladesh.

Waste Source

1,500 tons of waste and 20,000 tons of agricultural waste to be collected from open dumps and farming areas around Chittagong, totaling 1 GW.

Carbon Capture and Storage System

Capture 10 tonnes of CO2 a day from waste-to-energy plant via amine-based scrubbing. Potential storage sites: Sylhet gas fields.

Rationale

As a new plant, retrofitting the Matarbari Power Plant is easier. Its proximity to water transport simplifies feedstock transportation and captured carbon transportation.

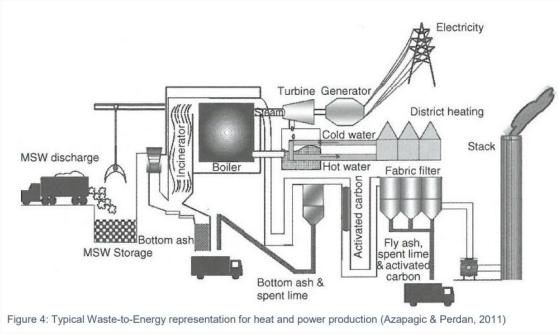


Figure 4: Typical Waste-to-Energy representation for heat and power production (Azapagic & Perdan, 2011)

Open Dump

Matarbari Power Plant

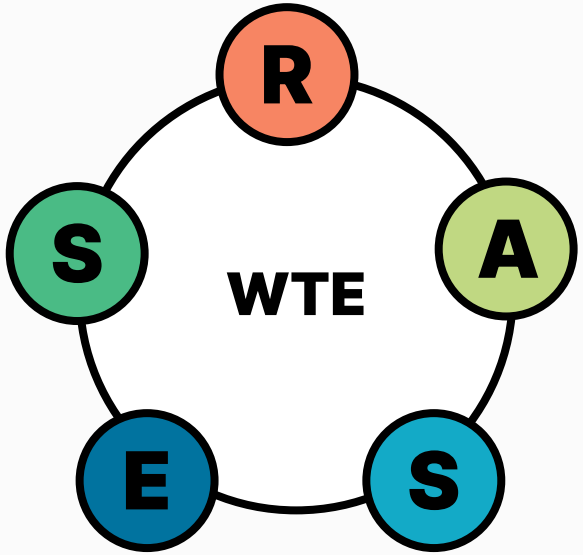
Energy Poverty Factors Addressed

Security

Using local resources (waste) can increase self-sufficiency.

Environmental

Reduce methane emissions from landfills and carbon dioxide from open burning.



Reliability

Reducing the risk of a volatile coal market can help prevent power shutdowns.

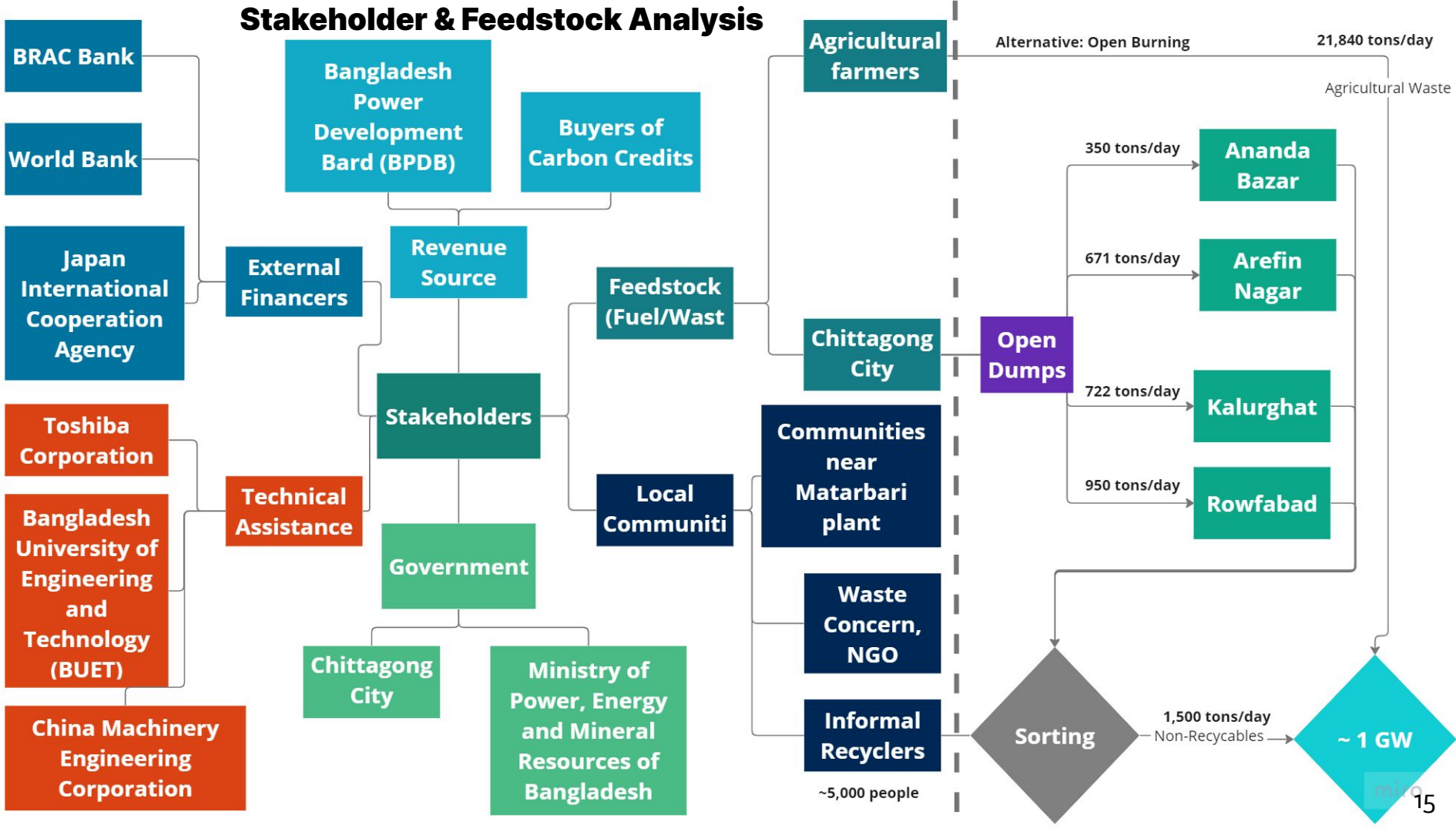
Affordability

Fuel is not susceptible to volatile global markets.

Safety

Tackles open burning and unsanitary dumps.

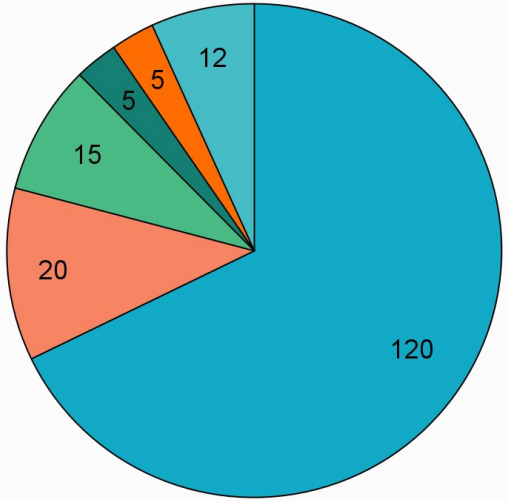
Stakeholder & Feedstock Analysis



Cost, Revenue and Financing

Cost: $172 million per year

*in millions of dollars ($)

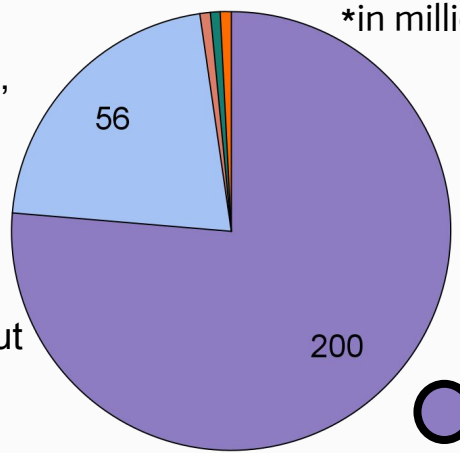


- Investment Cost ($100 mil per unit, $1 billion for CCS)
- Fixed Cost (Salaries, Insurance)
- Maintenance Cost
- Community Reachout
- Sourcing feedstock Costs ($10 per ton)
- Informal Recyclers Incentive & Welfare ($2,000 per person)

Financers:
World Bank & JICA (70%), Green Bonds (20%), Chittagong City Corporation (10%)

Revenue: $259 million per year

*in millions of dollars ($)



- Sale from Electricity
- Heat Sales
- Carbon Credits ($10 per kg of CO2)
- Stored Carbon Sale
- Ash and Slug Sale

WTE: 10-year Implementation Plan

Technical & Government

Consult

- Consult local government bodies for necessary permits.
- Finalize design and start construction.

Assess

- Commission the first unit and monitor compliance with local regulations.
- Address issues if they arise.

Monitor

- Evaluate the technical performance and regulatory compliance of the overall project.
- Identify areas for improvement.

Identify

- Establish Information offices across the Chittagong Division.
- Conduct surveys and identify concerns raised by local community leaders.

Engage

- Secure contracts with local communities to secure waste feedstock.
- Provide vocational training for informal recyclers.

Educate

- Educate the local population on benefits of the project
- Provide regular updates on progress of the project.

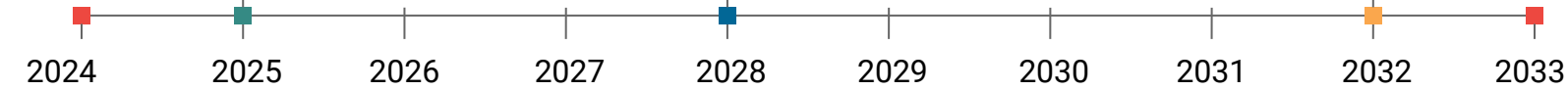
Local Engagement

WTE: 10-year Impact

Local Community
$13 million annually supports low-income communities, especially informal recyclers.

Local Industries
Captured CO2 is an important feedstock for agriculture.

Repurposing Stranded Asset
Converting the new $4.5B coal plant will add value and avoid it becoming a stranded asset due to renewable energy priorities.



Energy Poverty Impacts	Previous situation	Post-implementation
Capacity Addition	Only 600MW (Supply Risk)	1GW
CO2 emissions reductions	8.94 CO2 million tons per year	3.32 CO2 million tons per year
Methane diverted from dumps	15,000 kg per year	
Health	22,000 tons of PM2.5 diverted from open burning per year	
Economic	Expand job creation and expertise (~5000 informal recyclers)	

Proposed Solution 2:
Offgrid Household Biogas

Challenges in Current Situation

Lack of Clean Cooking Fuel

Access

28% of homes have access to clean cooking fuel

Health Risks

Harmful inhalation of particulate matter - correlating to at least **107,000 deaths** yearly

Environment

2000 kg of CO2 is released per household per year from the burning of wood alone

Current and ongoing efforts for clean cooking fuel

	Cooking fuel	Organic waste
Current situation	Burning biomass is the main source of cooking fuel.	Large quantity of household waste sent landfills.
Complication	High indoor air pollution, women and girls spend large amounts of time collecting fuel and inhaling toxins.	Methane introduction into the atmosphere reduces the already struggling air quality.
Problem	How can we have a direct impact on the air indoor air quality along with tackle of the abundance of organic waste?	
Solution	Construct household biogas digesters while providing consistent education and troubleshooting.	
Has it been done?	71,396 biogas plants have been installed in Bangladesh.	

Biogas Energy

Overview

Process of generating energy by anaerobically digesting organic matter. Product of biogas used as cooking fuel. Nutrient rich slurry is a secondary product.

Waste Source

Household and agricultural organic food scraps and animal manure. Production rate of 1.8 kg/household/day in cities and 0.5 kg/household/day in rural areas.

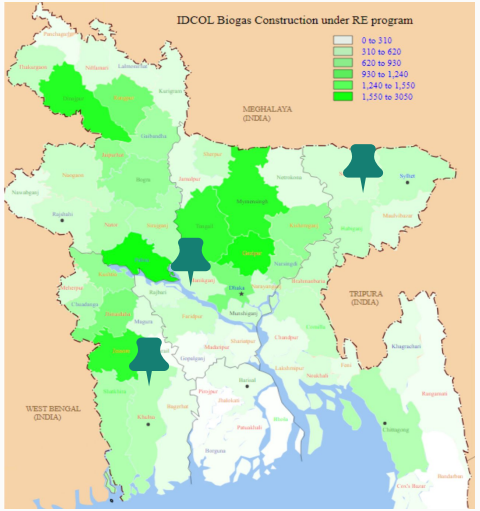
Location

Biogas digesters will be be constructed in 15,000 homes in 3 different rural communities to start. Following success, exponential growth of domestic biogas in the surrounding areas.

Rationale

Focusing on rural areas, there will be adequate space for the plants (around 2 square meters).

First communities to receive biogas

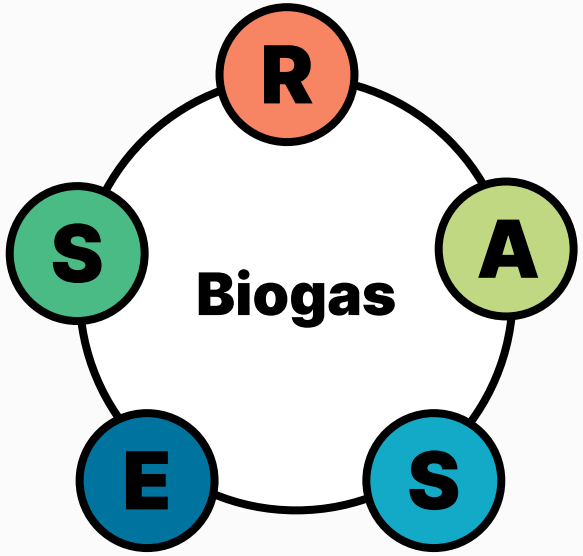


IDCOL, https://idcol.org/

Energy Poverty Factors Addressed

Security
Using the waste generated in the home reduces the dependency on fuel imports from other nations

Environmental
Reduce methane emissions from organic waste landfills and carbon dioxide from open burning.

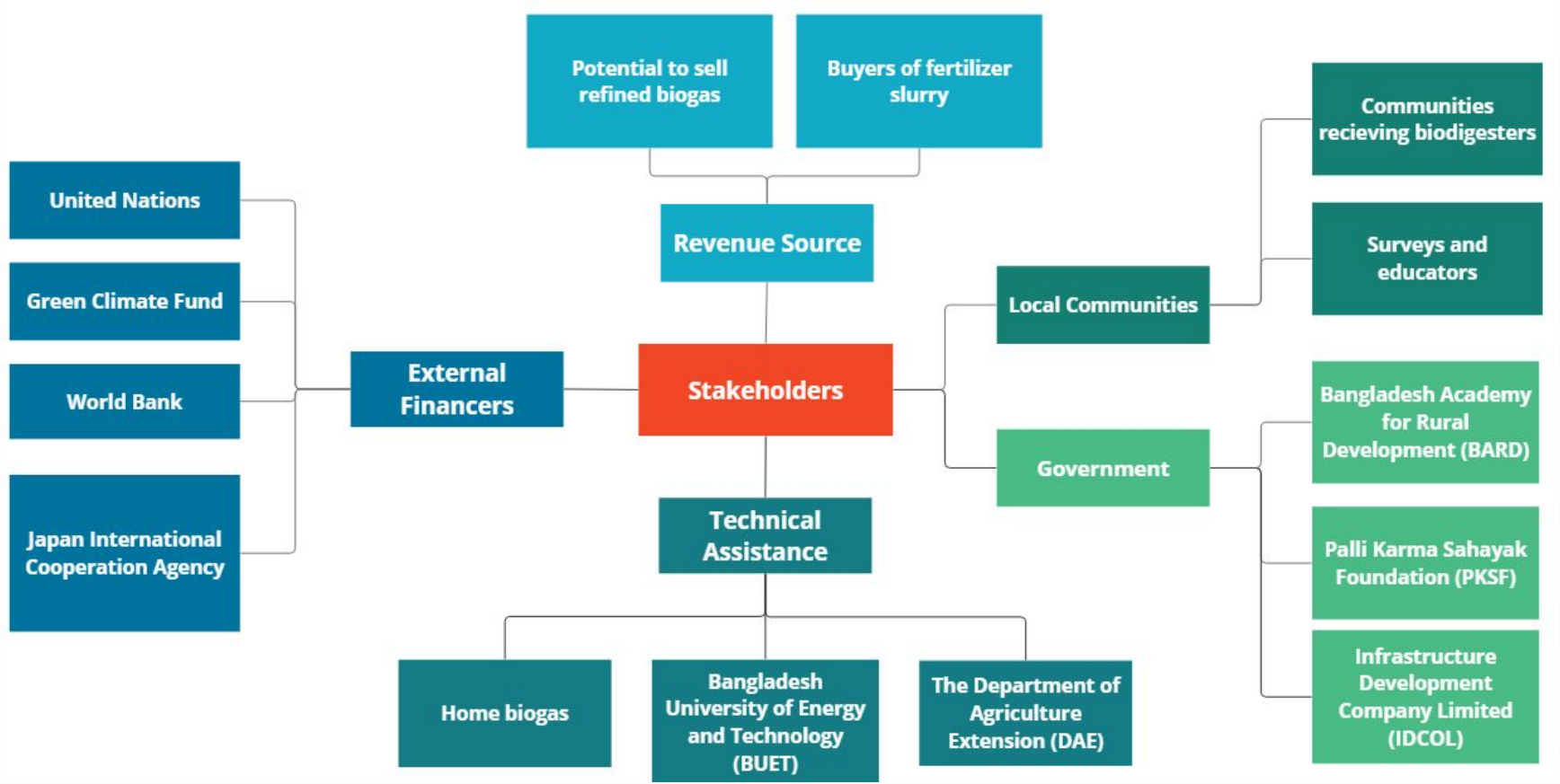


Reliability
On demand energy for cooking

Affordability
Fuel cost negligible, and upfront costs small

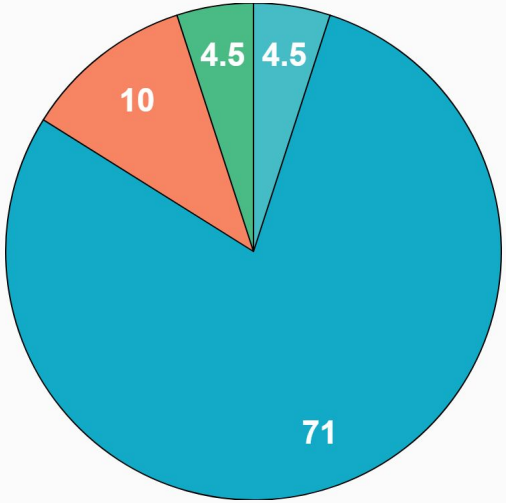
Safety
Reduction of indoor particulate matter

Stakeholder Analysis



Cost, Revenue, and Financing

Total Cost: $90 million per year



*in millions of dollars ($)

Financers:
World Bank (40%), UN (25%), IDCOL (30%), Homeowner (5%)

- Investment Cost ($350 per home) (79%)
- Fixed Cost (Construction salaries, Insurance, etc) (11%)
- Education (5%)
- Community outreach (surveys, home visits) (5%)

$450

Total cost for each household over 10 years

$1,200

Annual income generation per home, from the sale of fertilizer and lack of chemical fertilizer

4,500 jobs

Created annually in community outreach

https://www.thethirdpole.net/en/energy/running-on-bio-gas-in-bangladesh/

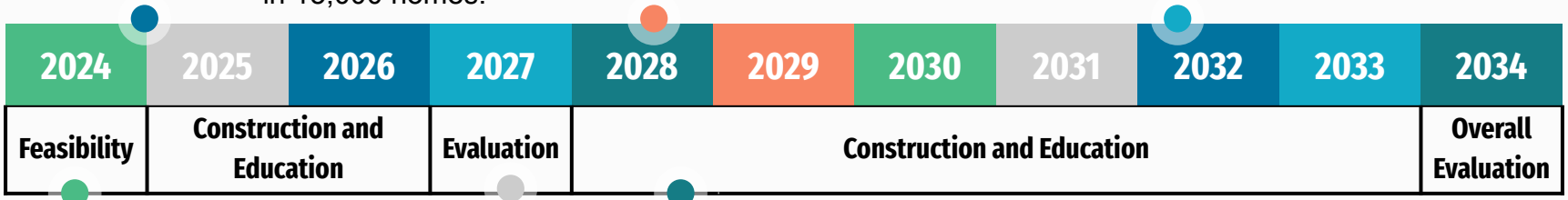
Biogas: 10-year Implementation Plan

Technical & Government

Consult
- Collaborate with Home biogas and IDCOL on best practices.
- Finalize design and begin construction in 15,000 homes.

Assess
- Expand construction to all rural regions.
- Utilize survey results for design or strategy modification.

Monitor
- Visit households and access quantity of biogas produced.
- Identify areas for improvement.



Identify
- Begin training regional community outreach teams.
- Promote the benefits of biogas.

Engage
- Conduct surveys in the community for feedback on the program.
- Create full educational framework.

Educate
- Host monthly Biogas education sessions via community outreach teams.

Local Engagement

Biogas: 10-year Impact

Local Business

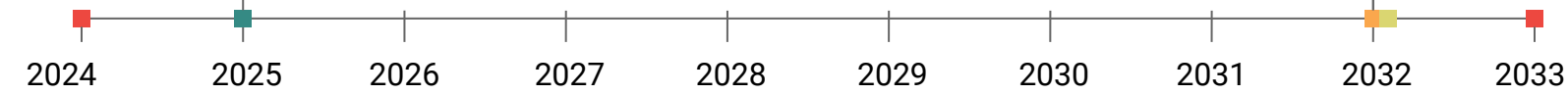
$9 million annually supports 4,500 jobs in and education and outreach.

Local Communities

2 million homes in having reliable clean cooking fuel.

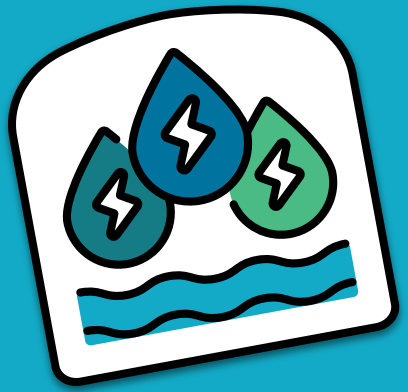
Inequality reductions

Women and girls save roughly 240 hours a year by no longer searching for cooking fuel.



Energy Poverty Impacts	Previous situation	Post-implementation
Clean energy access	28% access	45% access
CO2 emissions reductions	6 million tons of CO2 per year diverted	
Methane diverted from dumps	250 tons per year	5000 tons per year
Health	88% reduction in kitchen PM 2.5 concentration	

Proposed Solution 3: Tidal Barrages



Environmental Challenges

Impact on the Bangladesh Coast

Coastal Flooding

In 2022, **70 million people lived in flood-prone areas.**

Storm Surges

In 2022, **8 mill people** were vulnerable to surge depths > 3 m: this will increase to **13.5 mil by 2050.**

Loss of Land

By 2050, rising sea levels will submerge 17% of the land; **displacing ~20 million people.**

Current and ongoing efforts to resolve issues

	Coastal Environmental Impact
Past efforts	The gov. has successfully implemented the Coastal Embankment Improvement Project (CEIP) to build 139 polders to mitigate flooding.
Ongoing Efforts	Phase II of the CEIP aims to upgrade 15 of these embankments to also protect against storm surges.
Proposal	We propose a phase III of the CEIP to build/ upgrade structures that can protect coasts and generate energy.
Our Solution	Create **tidal barrages** in appropriate locations. Upgrade existing coastal mitigation infrastructure–such as the CEIP projects in phase I and II– to save on capital costs.
Has it been done?	No tidal energy projects have been done in Bangladesh. Proof of concept in France (La Rance) and South Korea (Sihwa).

Tidal Barrages

Overview

Tidal barrages harness the energy from the ebb and flow of tides to generate electricity; **<u>can prevent flooding and serve as a road!</u>**

Disclaimer

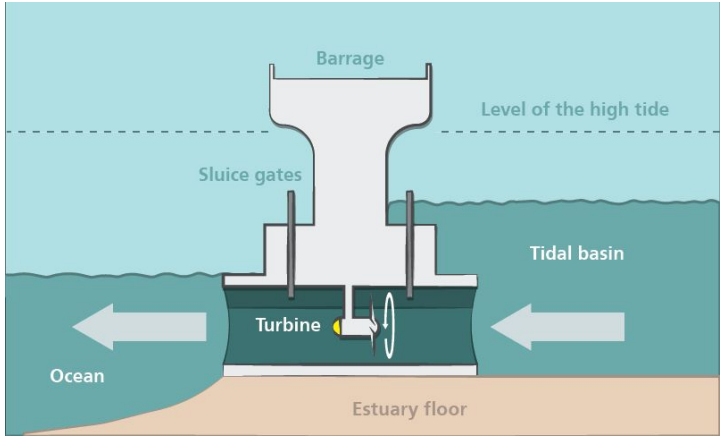
Barrages are not popular because they can disrupt local ecosystems, alter sediment transport patterns, and impede fish migration; however, emerging tech can help with this.

Pilot Location

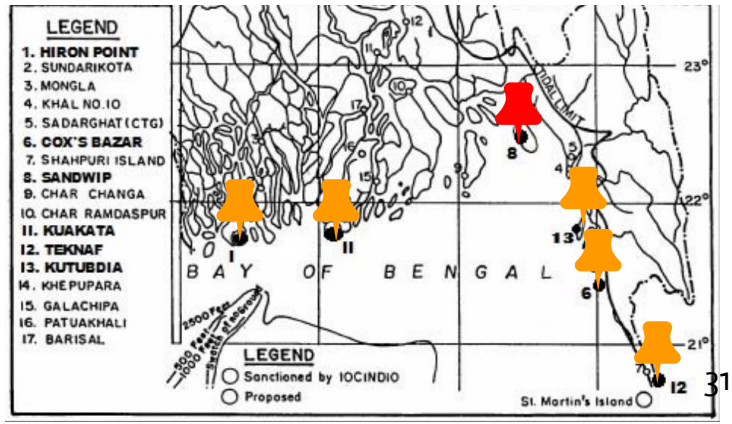
To gain public acceptance and demonstrate feasibility, Sandwip Island will be the pilot location; has existing infrastructure as well as high tidal range.

Phase IV

If Sandwip is successful, tidal plants will be installed at Kutubida, Cox's Bazar, Teknaf, Hiron Point, and Kuakata.



Sandwip Pilot Plant Phase IV Plants



Sikder et al., 2014; Hossain et al., 2014; Mia et al., 2021

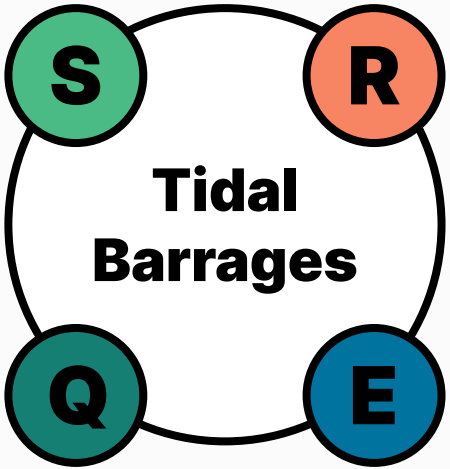
Energy Poverty Factors Addressed

Security

Renewable tidal energy reduces dependence on imported fossil fuels.

Quality

Tidal generates continuous renewable energy 24/7.



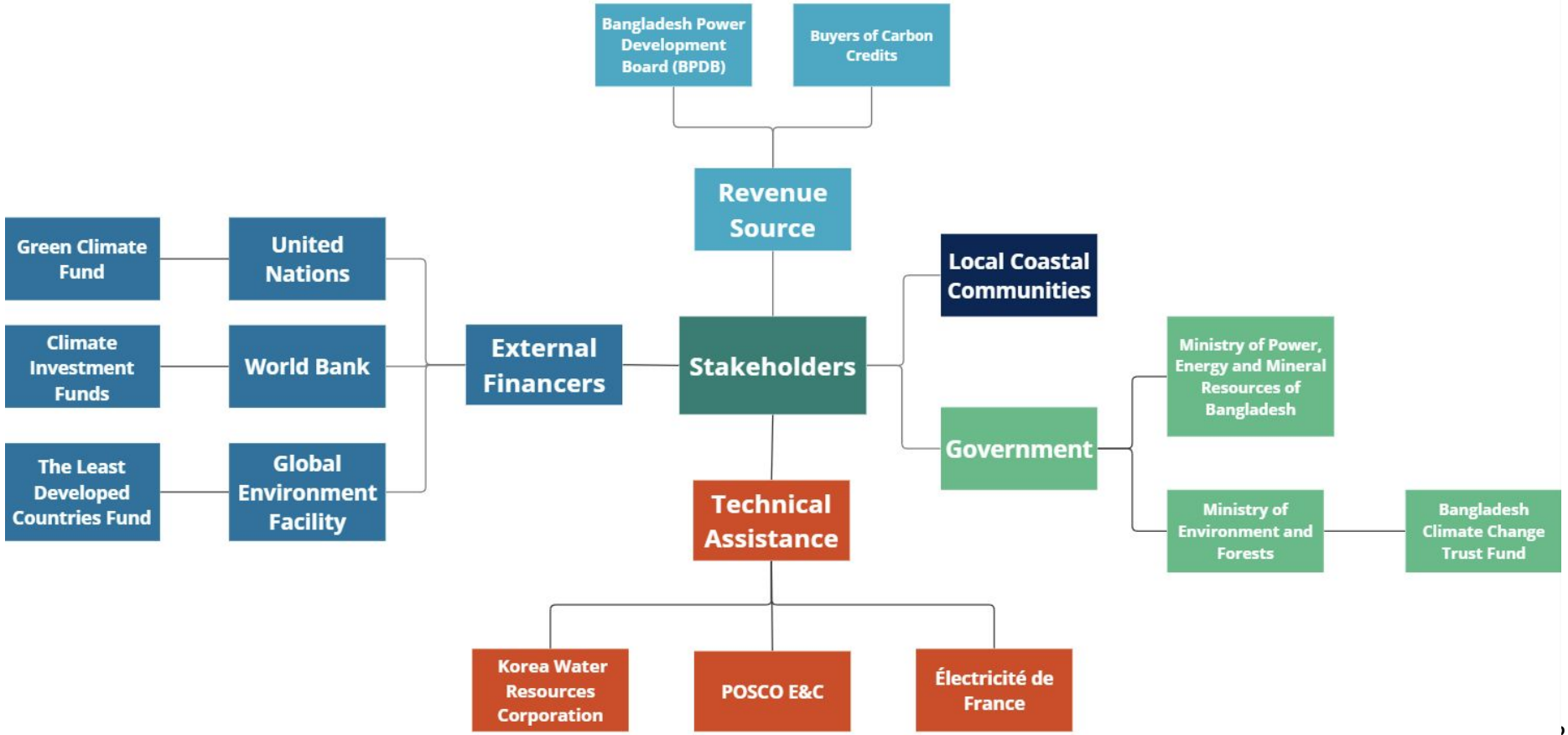
Reliability

Tides are highly predictable and consistent, enabling precise forecast of power generation.

Environmental

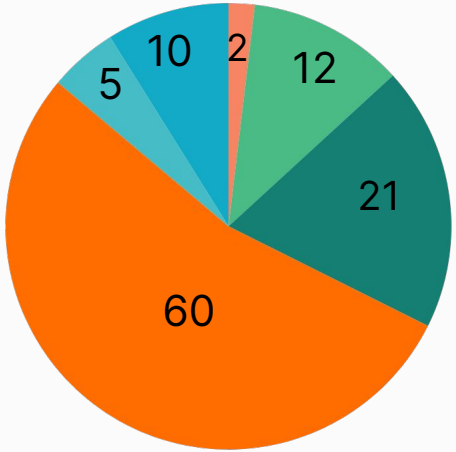
Tidal barrages mitigate flooding, storm surges, and coastline degradation.

Stakeholder Analysis for Tidal Barrage Projects



Cost, Revenue and Financing

Cost: $11 million per year

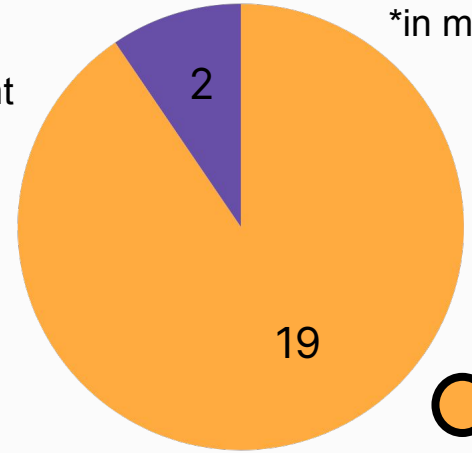


*in millions of dollars ($)

- Sandwip Pilot Plant
- Kutubida Tidal Plant
- Cox Bazar's Tidal Plant
- Teknaf Tidal Plant
- Hiron Point Tidal Plant
- Kuakata Tidal Plant

Revenue Sources: $21 million per year

*in millions of dollars ($)



- Sale of Tidal Electricity
- Carbon Credits ($10 per kg of CO2)

Financers:
World Bank, UN, GEF (90%), Bangladesh Climate Change Trust Fund (10%)

Tidal Barrages: 10-year Implementation Plan

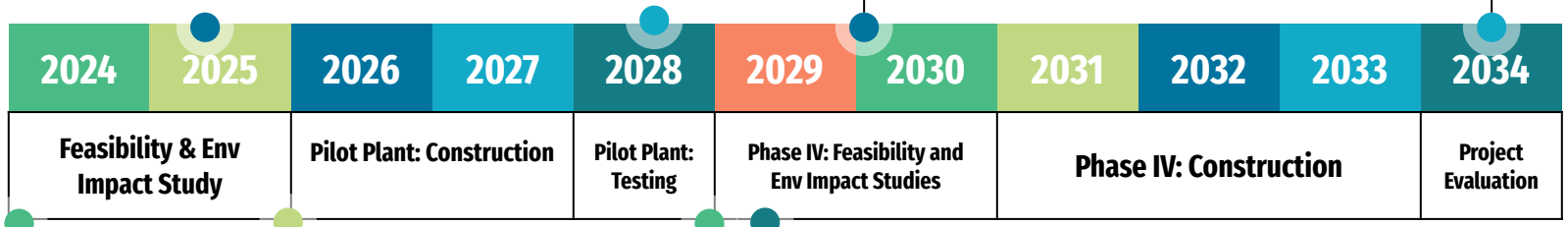
Technical & Government

Permitting

- Attain the required permitting for site selection based on impact study data.

Monitor

- Evaluate the technical performance and regulatory compliance of the plants.



Local Engagement

Identify

- Ensure feasibility of project in Sandwip and that the environmental impacts meet guidelines.

Educate

- Educate the local population on benefits of the project.
- Garner public acceptance.

Engage

- Conduct surveys on public acceptance of pilot plant prior to starting phase IV.

Tidal Barrages: 10-year Impact

Self Sustaining Power

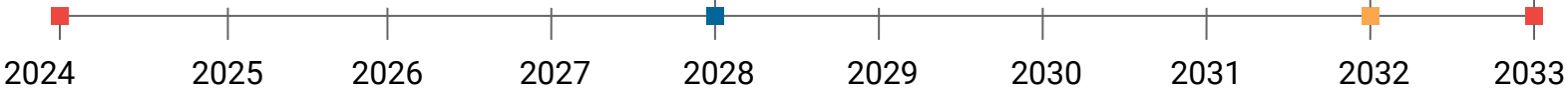
The Sandwip Pilot would provide renewable energy for 30% of the island's population.

Coastline Protection

All 6 tidal power plants together will mitigate coastal damage ~10% of the entire coastal zone.

Tidal Barrage Causeways

The 5 phase IV plants can also serve as causeways to bridge lands typically separated by water (similar to Sihwa in South Korea.)



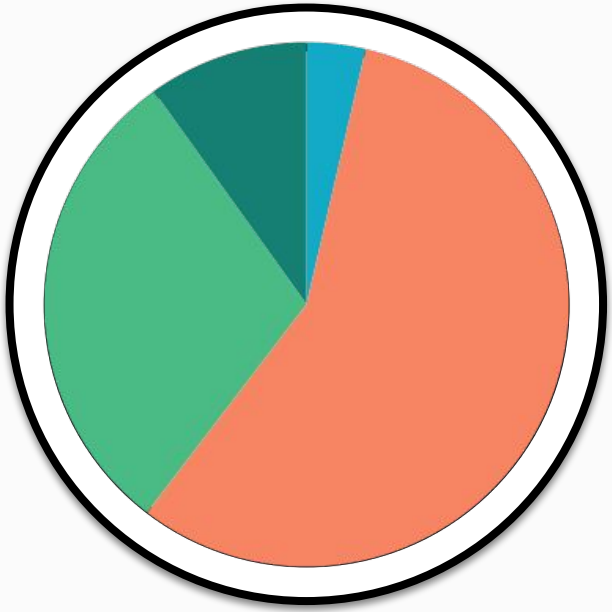
Energy Poverty Impacts	Previous situation	Post-implementation
Capacity Addition	0 Tidal Energy	60 MW of continuous 24/7 power
CO2 emissions reductions	0 reduction from tidal	580,000 tons of CO2 per year

Projects Overview

Overall Fund Breakdown: $3 billion

Contingency
10%
$300 million

Biogas
30%
$900 million



Tidal Barrages
3%
$110 million

Waste-To-Energy with CCS
57%
$1.72 billion

Bangladesh beyond the 10 years

The carbon stored could be utilized for global market use. Other coal-fired power plants could potentially be upgraded and retrofitted as well.

Potential efforts can be made to refine biogas as biomethane to be used in natural gas infrastructure.

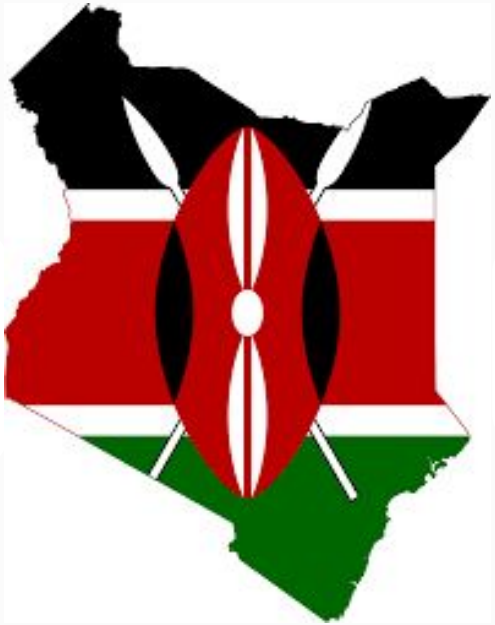
Greater expansion of tidal barrages can be applied to locations prone to flooding.

Application of Our Solutions in Bangladesh to Kenya

Kenya

Rural Population

71% of population



Climate

Subtropical
Have both dry and wet season

Poverty

18% of the population living below the poverty line ($2.15/day)

Largest Sector

Agricultural Sector, with 30% of total workforce

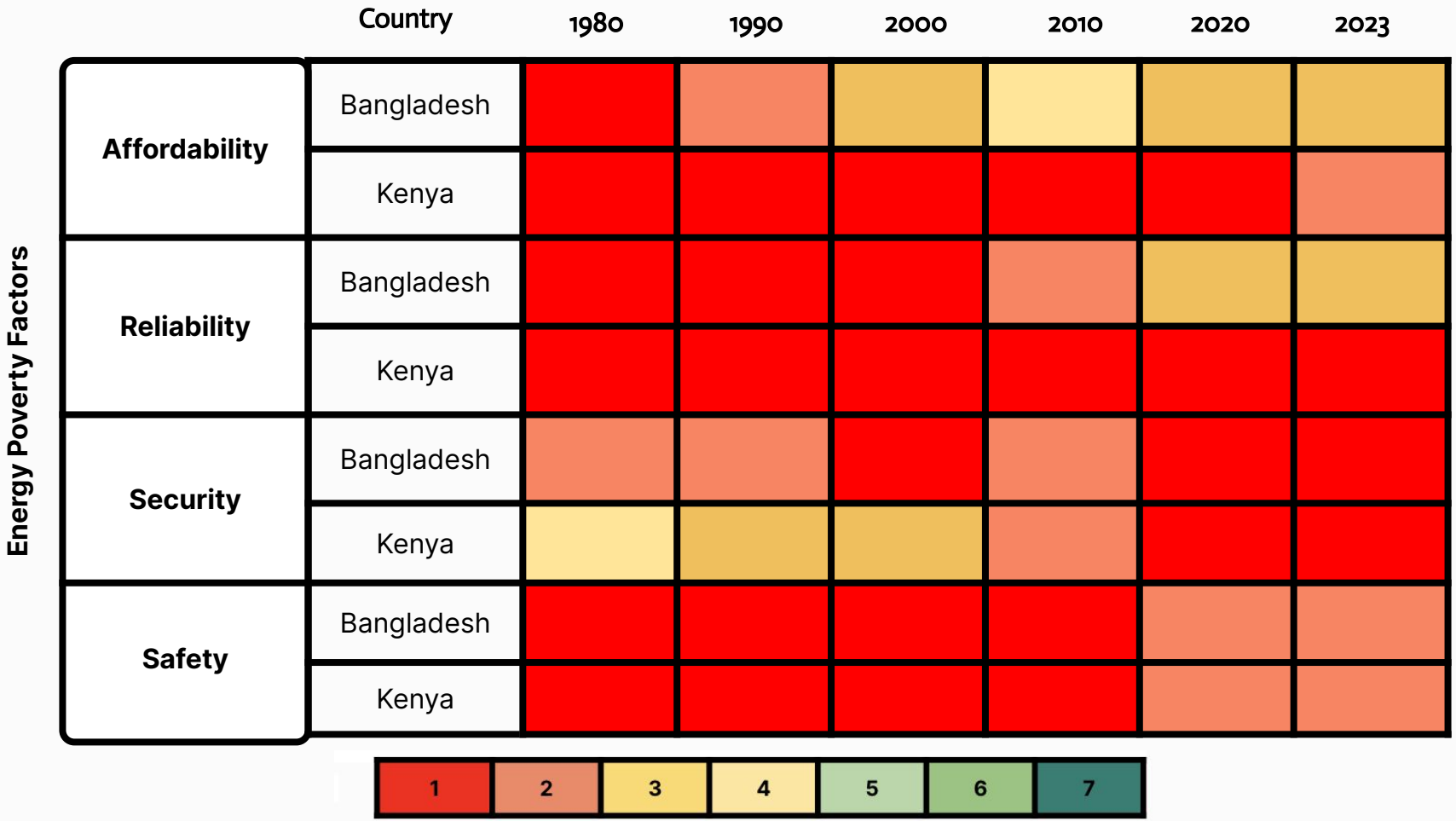
Population & GDP

53 million people
$2190 per capita

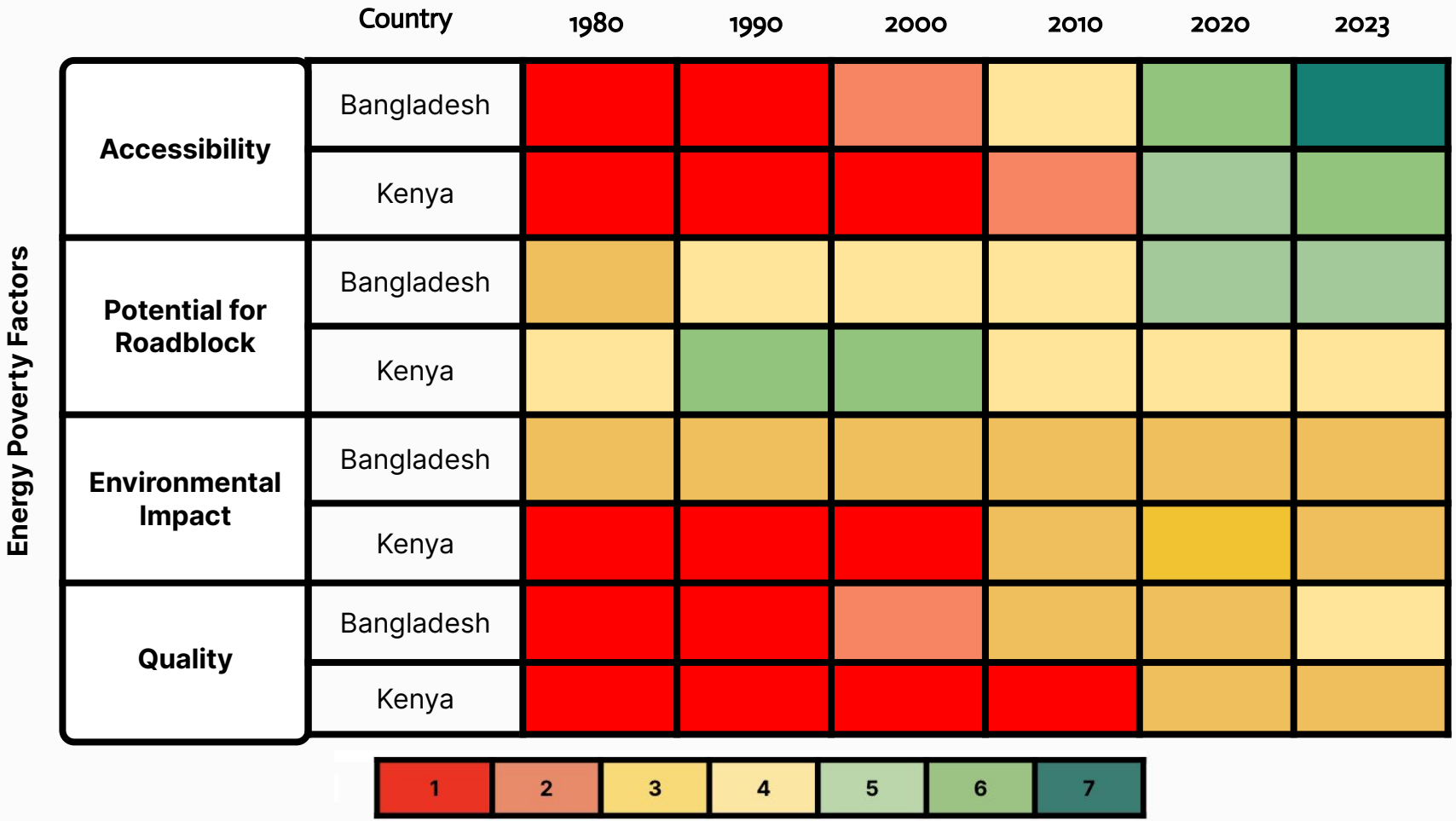
Air Quality

The Air Quality Index is 55, which is 88th in the world.

Energy Poverty Analysis: Bangladesh & Kenya



Energy Poverty Analysis: Bangladesh & Kenya



Energy Poverty: Bangladesh vs Kenya

Similarities

1. Energy takes up a large percentage of income for both nations
2. Both nations are dependent on energy fuel imports
3. Both nations have less than 30% access to clean cooking fuel
4. Kenya and Bangladesh has similar high levels of corruption which might deter projects development.

Differences

5. Kenya has only 76% access to electricity opposed to Bangladesh at 100%, however reliability is poor.
6. For energy mix, Bangladesh has < 2% renewables; Kenya has > 80%.
7. Kenya has embraced a federal system with significant powers to counties while Bangladesh has a centralized approach to government.
8. For people with access to electricity, Kenya has a higher level of sustained energy compared to Bangladesh.

Solution Transfer Feasibility

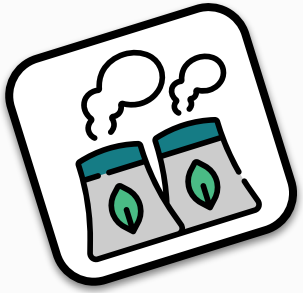
WTE

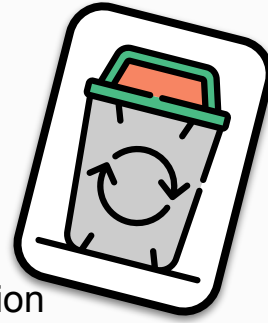
Biogas

Tidal Barrage

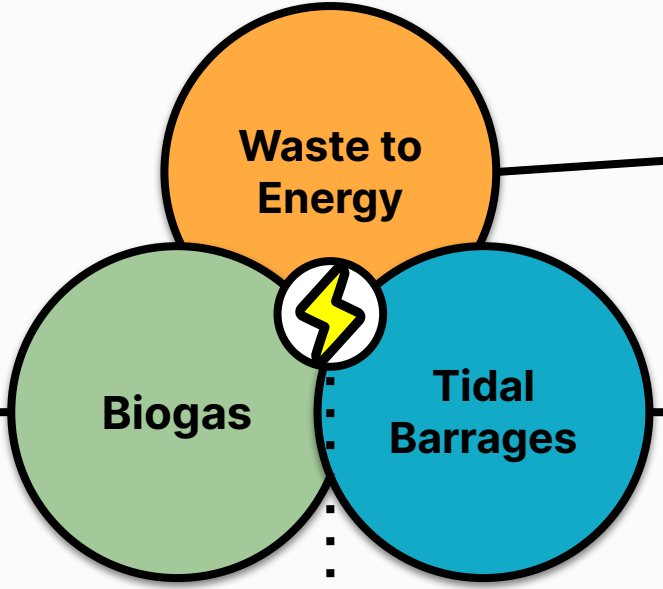
Feasibility	NOT RECOMMENDED	GOOD	GOOD
Location Availability	Kenya has no currently operating coal-fired power plants.	Kenya already has biogas digesters with the Home Biogas Company in rural areas	Kenya also has locations for TBs: Lamu, Mombasa, Vanga Bay, Malindi Bay
Source Availability	Their waste generation per capita is below global average.	Both countries have agriculture as the main sector - adequate organic waste	The tidal ranges and basin area at these places are sufficient for TBs.

Summary of Our Solutions



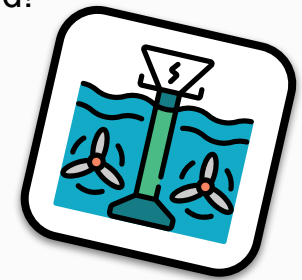


Investing $13 million dollars to low income communities; reduce 10,000 tons of waste from dumps



2 million homes will fuel their cooking with organic waste, and there will be significant reduction of indoor air pollution!

24/7 continuous renewable energy; 10% coastline mitigated from flooding, storm surges, and loss of land!



Significant Reduction in Energy Poverty!

We would like to give a round of **a-paws** and a big **ROAR** to Switch Energy Alliance, judges, our audience and especially to our mentor, Kathy for her guidance throughout the competition. - RoarEEE

References

- *Bangladesh - Countries & Regions*. IEA. https://www.iea.org/countries/bangladesh
- *Kenya - Countries & Regions*. IEA. https://www.iea.org/countries/kenya
- A. K. Sikder, N. A. Khan, M. T. Rahman, M. Islam and A. Hoque, "Tidal energy: A solution to energy crisis in coastal area of Bangladesh," *2014 International Conference on Electrical Engineering and Information & Communication Technology*, Dhaka, Bangladesh, 2014, pp. 1-6, doi: 10.1109/ICEEICT.2014.6919131.
- Hossain, M. A., Hossain, M., & Rahman, M. M. (2014). Perspective and challenge of tidal power in bangladesh. *World Academy of Science, Engineering and Technology, 8*, 1040-1043. doi:10.11591/telkomnika.v12i11.6050
- Hannah Ritchie and Pablo Rosa (2020) - “Energy Mix” Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/energy-mix' [Online Resource]
- Mia, M., Islam, M. A., & Islam, M. (2021). Powering offshore structure using renewable energy: A review study. *SSRN Electronic Journal, 05*, 61-80. doi:10.2139/ssrn.3807353
- Lee, K. (2023, September 28). Financing the Energy Transition in Latin America and the Caribbean: An Incomplete Puzzle. Center on Global Energy Policy at Columbia University SIPA | CGEP. https://www.energypolicy.columbia.edu/publications/financing-the-energy-transition-in-latin-america-and-the-caribbean-an-incomplete-puzzle/
- World Energy Investment 2023 – Analysis. (n.d.). IEA. Retrieved October 29, 2023, from https://www.iea.org/reports/world-energy-investment-2023
- Scaling Up Private Finance for Clean Energy in Emerging and Developing Economies – Analysis. (n.d.). IEA. Retrieved October 29, 2023, from https://www.iea.org/reports/scaling-up-private-finance-for-clean-energy-in-emerging-and-developing-economies

References

- Islam, A., Ahmed, M., Mondal, M. A. H., Awual, M., Monir, M., & Islam, M. (2021). A snapshot of coal-fired power generation in Bangladesh: A demand–supply outlook. Natural Resources Forum, 45, 157–182. https://doi.org/10.1111/1477-8947.12221
- Bangladesh developing first waste-to-energy power plant—Climate Action. (n.d.). Retrieved October 29, 2023, from https://www.climateaction.org/news/bangladesh_developing_first_waste_to_energy_power_plant
- Republica. (n.d.). Bangladesh enters wind power era with Cox's Bazar project into operation. My Republica. Retrieved October 29, 2023, from http://myrepublica.nagariknetwork.com/news/146812/
- Rahman, A. (2023, July 28). Bangladesh to clear energy bills ahead of elections, revamps upstream contracts. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/lng/072823-bangladesh-to-clear-energy-bills-ahead-of-elections-revamps-upstream-contracts
- Yep, A. R. and E. (2022, September 28). Bangladesh to lean on more coal than natural gas in power generation to curb costs. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/092822-bangladesh-to-lean-on-more-coal-than-natural-gas-in-power-generation-to-curb-costs
- Yep, A. R. and E. (2022, September 28). Bangladesh to lean on more coal than natural gas in power generation to curb costs. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/092822-bangladesh-to-lean-on-more-coal-than-natural-gas-in-power-generation-to-curb-costs

References

- Bangladesh's 2nd waste-to-energy project. (n.d.). The Daily Star. Retrieved October 29, 2023, from https://www.thedailystar.net/tags/bangladeshs-2nd-waste-energy-project
- Fan, J.-L., Fu, J., Zhang, X., Li, K., Zhou, W., Hubacek, K., Urpelainen, J., Shen, S., Chang, S., Guo, S., & Lu, X. (2023). Co-firing plants with retrofitted carbon capture and storage for power-sector emissions mitigation. Nature Climate Change, 13(8), Article 8. https://doi.org/10.1038/s41558-023-01736-y
- Chowdhury, R. (n.d.). Current municipal solid waste disposal and recycling practices in Chittagong, Bangladesh. Waste Management. Retrieved October 29, 2023, from https://www.academia.edu/31301168/Current_municipal_solid_waste_disposal_and_recycling_practices_in_Chittagong_Bangladesh
- Islam, Md. S., Al-Amin, A. Q., & Sarkar, Md. S. K. (2021). Energy crisis in Bangladesh: Challenges, progress, and prospects for alternative energy resources. Utilities Policy, 71, 101221. https://doi.org/10.1016/j.jup.2021.101221
- Unb, D. (2021, June 28). Govt officially cancels 10 coal power plant projects. The Daily Star. https://www.thedailystar.net/news/bangladesh/governance/news/govt-officially-10-coal-power-plant-projects-2119405
- Unb, D. (2021, June 28). Govt officially cancels 10 coal power plant projects. The Daily Star. https://www.thedailystar.net/news/bangladesh/governance/news/govt-officially-10-coal-power-plant-projects-2119405
- Rahman, A. (2023, September 28). INTERVIEW: Bangladesh plans to clear LNG debt, boost imports, gas production.https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/lng/092823-interview-bangladesh-plans-to-clear-lng-debt-boost-imports-gas-production

References

- Shatil, A. Md., Rahman, S. A., Khatun, F., Bhowmick, S., Phoumin, H., Salim, R., Rahman, M., Ravago, M.-L., Yue, M., Buckley, T., Alexy, A., Nossal, K., Parashar, D., Huang, Y., editors, E., & Arao, D. A. (2023, August 19). *Renewing Bangladesh's energy transition*. East Asia Forum. https://www.eastasiaforum.org/2023/08/19/renewing-bangladeshs-energy-transition/#:~:text=Three%20key%20challenges%20plaguing%20Bangladesh's,for%20power%20in%20the%20country.
- Islam, K. M. N. (2016). Municipal Solid Waste to Energy Generation in Bangladesh: Possible Scenarios to Generate Renewable Electricity in Dhaka and Chittagong City. Journal of Renewable Energy, 2016, e1712370. https://doi.org/10.1155/2016/1712370
- Mohiuddin. (2023, May 28). Power generation in Payra plant to stop. Prothomalo. https://en.prothomalo.com/bangladesh/wuvuutkied
- Pasha, A. B. M., Basak, G., Parveen, M., Chowdhury, M., Mozumder, S., & Mahmudur Rahman, M. (2022). SOLID WASTE MANAGEMENT SYSTEM: A CASE STUDY BASED ON SAVAR, DHAKA, BANGLADESH. Daffodil International University Journal of Science and Technology, 17, 2408–8498.
- Amin, S., Jamasb, T., Llorca, M., Marsiliani, L., & Renstrom, T. (2022). The case of waste to energy in Bangladesh (pp. 127–144).
- Kearns, D. T. (n.d.). Waste-to-Energy with CCS: A pathway to carbon-negative power generation.
- Sengupta, S., & Manik, J. A. (2023, June 18). Why a Huge Coal Power Plant in Bangladesh Keeps Running Out of Coal. The New York Times. https://www.nytimes.com/2023/06/18/climate/coal-electricity-bangladesh.html

References

- Shivamurthy Harris Amjad, A., & Amjad, H. (2022, November 18). *Power crisis in Bangladesh: An overview of its economic and strategic implications*. ORF. https://www.orfonline.org/expert-speak/power-crisis-in-bangladesh/
- *Bangladesh - power and Energy*. International Trade Administration | Trade.gov. (n.d.). https://www.trade.gov/country-commercial-guides/bangladesh-power-and-energy
- Addressing complexities of measuring women's time use in Bangladesh. Agriculture for Nutrition and Health. (n.d.). https://a4nh.cgiar.org/2015/02/02/addressing-complexities-of-measuring-womens-time-use-in-bangladesh/
- Alternative energy & power 2023. Alternative Energy & Power 2023 - Kenya | Global Practice Guides | Chambers and Partners. (n.d.). https://practiceguides.chambers.com/practice-guides/alternative-energy-power-2023/kenya/trends-and-developments
- Bangladesh Hikes Retail Power prices by 5.0PC for February. The Financial Express. (n.d.). https://thefinancialexpress.com.bd/trade/bangladesh-hikes-retail-power-prices-by-50pc-for-february-1675143370
- Biodigesters for developing countries. (n.d.). https://biogas.ifas.ufl.edu/ad_development/
- Biogas is Business – Even at household scale. Wageningen University & Research eDepot. (n.d.). https://edepot.wur.nl/426303

References

- BIOGAS PRODUCTION POTENTIAL FROM MUNICIPALORGANIC WASTES IN DHAKA CITY, BANGLADESH. (n.d.-a). https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=afa0bad9602fbf152011c2c88cd67ad209446b22
- Common Objective. (2023, January 4). Bangladesh case study: A supplier-brand living wage framework. https://www.commonobjective.co/article/bangladesh-case-study-a-supplier-brand-living-wage-framework#:~:text=An%20updated%202021%20living%20wage,Wage%20Living%20Income%20Research%20Institute.
- Diouf, B., & Miezan, E. (2019). The biogas initiative in developing countries, from technical potential to failure: The case study of senegal. Renewable and Sustainable Energy Reviews, 101, 248–254. https://doi.org/10.1016/j.rser.2018.11.011
- Feasibility study Bangladesh - build a biogas plant. (n.d.-b). https://www.build-a-biogas-plant.com/PDF/Feasibility_study_Bangladesh_2005.pdf
- Financing clean energy transitions in emerging and developing economies. (n.d.-c). https://iea.blob.core.windows.net/assets/6756ccd2-0772-4ffd-85e4-b73428ff9c72/FinancingCleanEnergyTransitionsinEMDEs_WorldEnergyInvestment2021SpecialReport.pdf
- Infrastructure Development Company Limited (IDCOL). (n.d.). https://idcol.org/home/dbiogas
- Kenya. Our World in Data. (n.d.). https://ourworldindata.org/country/kenya#search=energy

References

- Sarker, S. A., Wang, S., Adnan, K. M. M., & Sattar, M. N. (2020). Economic feasibility and determinants of biogas technology adoption: Evidence from Bangladesh. Renewable and Sustainable Energy Reviews, 123, 109766. https://doi.org/10.1016/j.rser.2020.109766
- Shah, M. S., Halder, P. K., Shamsuzzaman, A. S., Hossain, M. S., Pal, S. K., & Sarker, E. (2017). Perspectives of biogas conversion into bio-cng for automobile fuel in Bangladesh. Journal of Renewable Energy, 2017, 1–14. https://doi.org/10.1155/2017/4385295
- Shams, S., Sahu, J. N., Rahman, S. M. S., & Ahsan, A. (2017). Sustainable Waste Management Policy in Bangladesh for reduction of greenhouse gases. Sustainable Cities and Society, 33, 18–26. https://doi.org/10.1016/j.scs.2017.05.008
- Sustainable & Renewable Energy Development Authority. (n.d.-d). https://www.cif.org/sites/cif_enc/files/bangladesh_srep_ip_final.pdf
- United Nations. (n.d.). Developing an efficient and sustainable biogas model for the rural Bangladesh | Department of Economic and Social Affairs. United Nations. https://sdgs.un.org/partnerships/developing-efficient-and-sustainable-biogas-model-rural-bangladesh
- World Energy Outlook 2020. (n.d.-e). https://iea.blob.core.windows.net/assets/a72d8abf-de08-4385-8711-b8a062d6124a/WEO2020.pdf
- Impact report - homebiogas. (n.d.-d). https://www.homebiogas.com/wp-content/uploads/2023/05/2022-HomeBiogas-Impact-Report.pdf