5th International Forum on Sustainable Future in Asia/
5th NIES International Forum

AN INTEGRATED ENERGY ACCESS MODEL TO SUSTAINABLE DEVELOPMENT

S. Kumar*; Thaw Thaw Phyu Htoon, M. A. C. Mozo
*Professor, Energy program, Asian Institute of Technology

January 21-22, 2020, Yangon, Myanmar

Main theme:

Fostering a Healthy and Sustainable Environment to Achieve the SDGs

- **introduce recent research findings on SDGs; find new ways of building sustainable societies in Asia; catalyze policy–research networking to formulate relevant science-based policies**

Session 3:

Integrative Approach for Strategic Design toward SDGs in Asia.

- **find feasible paths toward sustainable societies in Asia by converting aspirations into actions at the local, national, and regional levels**

Presentation title:

An integrated energy access model to sustainable development

Objective of this presentation

- **Why development has to be sustainable, and so, what is sustainable development in the practical sense?**
- **Show how provision of energy services could be an entry point for sustainable development (through case studies).**

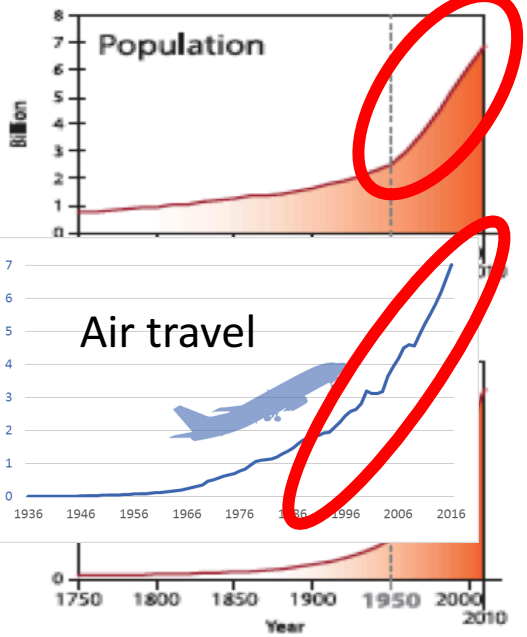
5th International Forum on Sustainable Future in Asia / 5th NIES International Forum

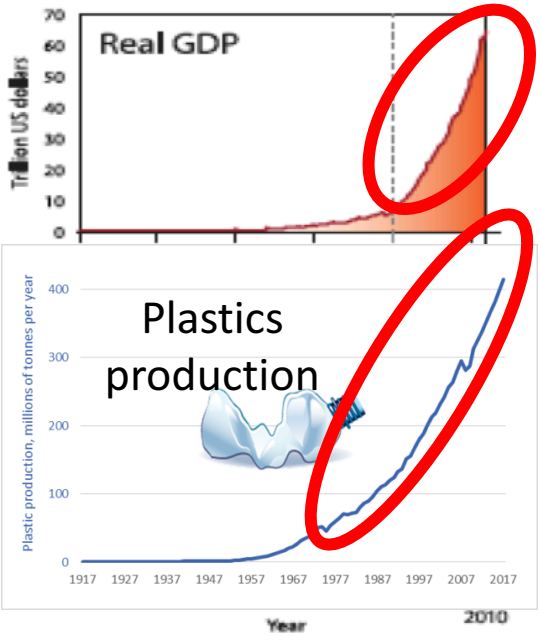
Q: Why development has to be sustainable?
A: For this, we will see how the world has progressed, and during this path, what went wrong with the current status in the world and what is the solution.

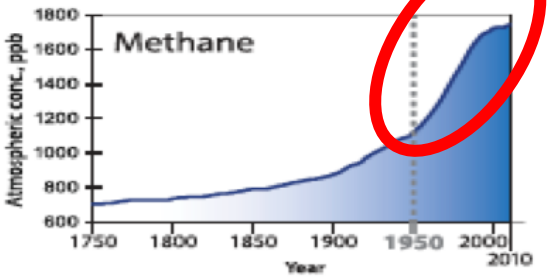
Q: What is the role of energy/energy services in sustainable development?
A: For this, we will discuss the major dimensions of sustainable development,

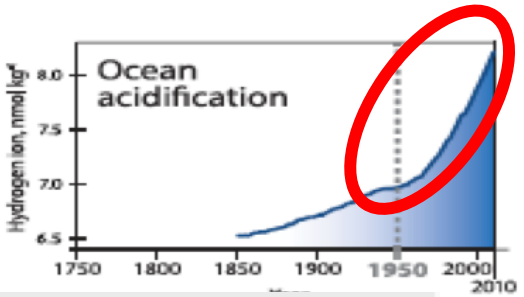
- **demonstrate how energy plays a central role in this development route with examples, and**
- **AIT's experience in providing energy access in this journey**

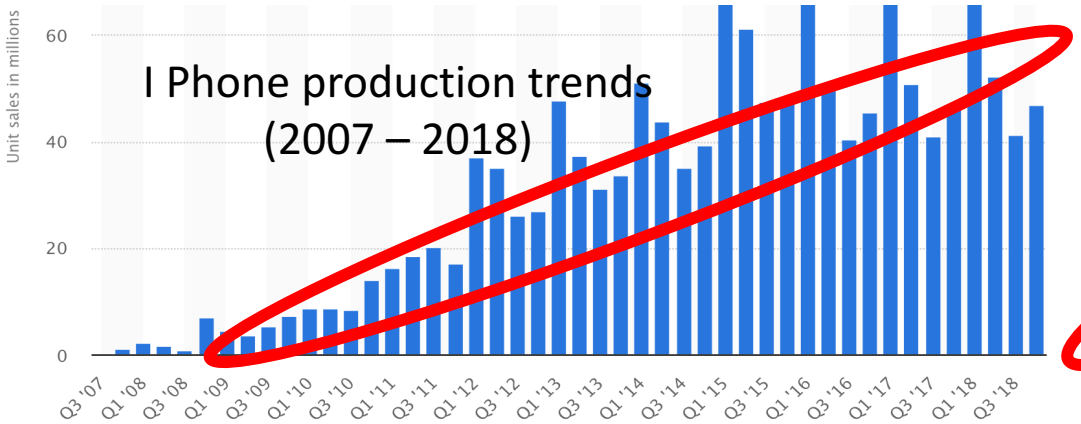
SOCIO – ECONOMIC – ENVIRONMENT INDICATORS OF "THE GREAT ACCELERATION"

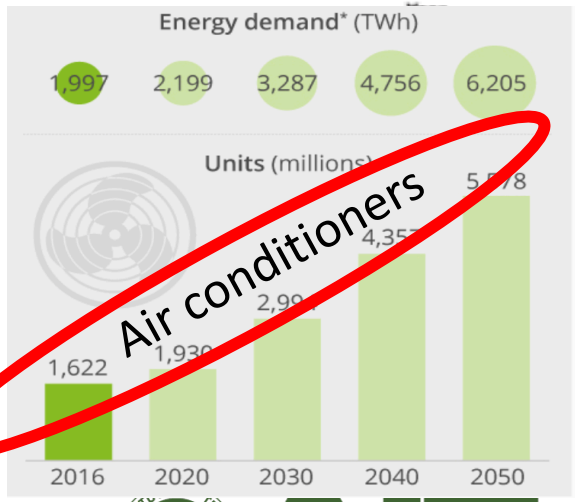












https://www.statista.com/statistics/263401/global-apple-iphone-sales-since-3rd-quarter-2007/

THE REVOLUTIONS DURING THE LAST 200 YEARS

- **Agricultural revolution**
  - Mechanization, fertilisers, pesticides, storage, refrigeration
- **Social revolution**
  - Public sector growth and decline, education, middle class, cities
- **Political revolution**
  - USA, Colonization and de colonization, World Wars, Democracy, Gender, Social Media
- **Transport revolution**
  - Railroad, Ship, Cars and Airplanes (and Rockets), public transport

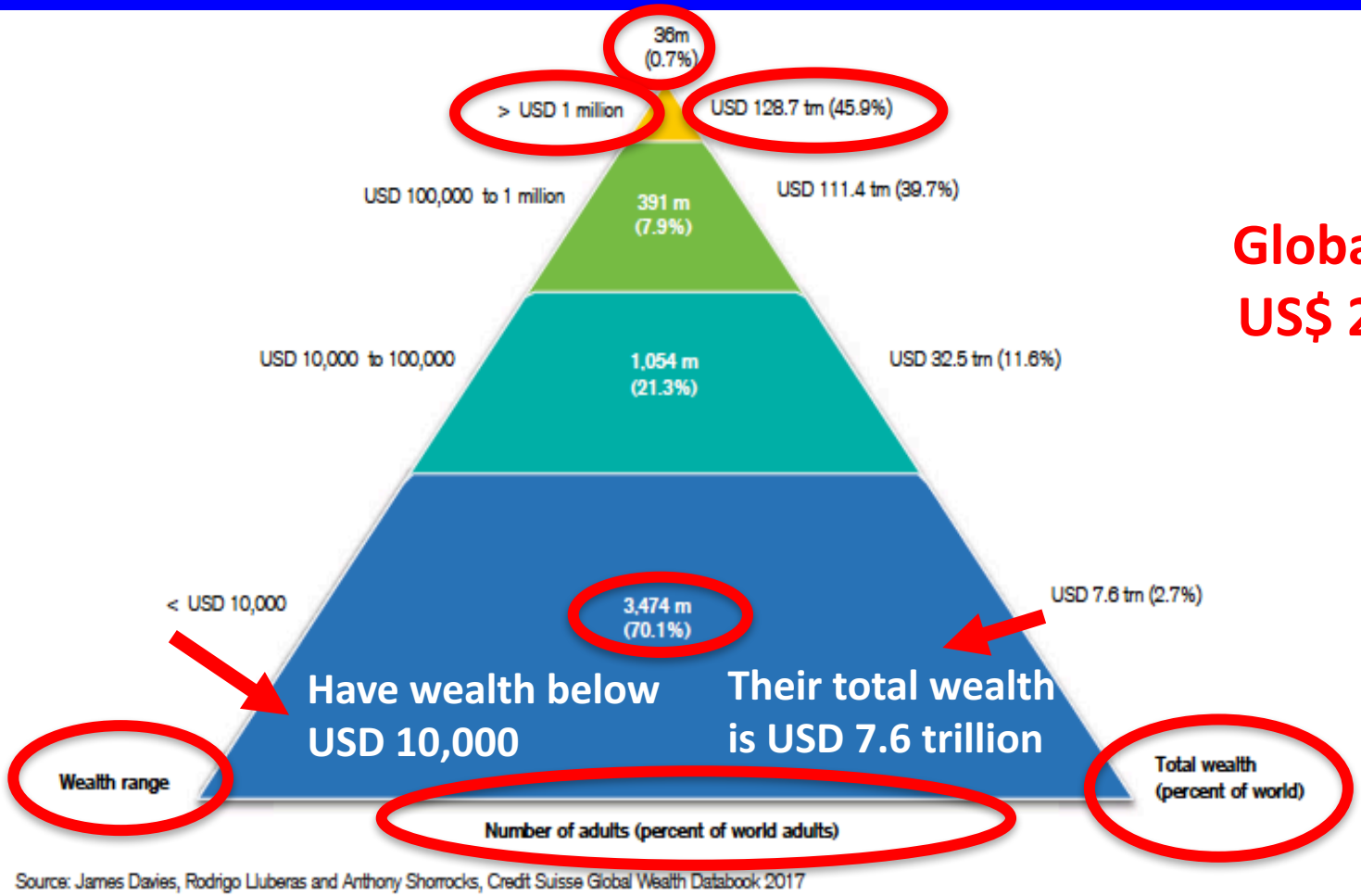
Technology enabled platform/economy

- **Uber owns no vehicles**
- **Facebook creates no content**
- **Alibaba/Amazon have no inventory**
- **Airbnb owns no real estate**

- **Energy revolution**
  - Coal, oil and in 2010s - renewables
- **Environmental revolution**
  - Pollution of – soil, water and air; climate change, Indoor air quality, plastics
- **Medical revolution**
  - Germs, surgery, medicines, hospitals, life expectancy
- **Communication revolution**
  - Telephone, Wireless, Satellite, Internet, 24X7 news; IOT, AI and DA
- **Prediction revolution**
  - Weather, energy use, pollution, stocks

AIT
Asian Institute of Technology

WEALTH AND INEQUALITY



Source: James Davies, Rodrigo Lluberas and Anthony Shorrocks, Credit Suisse Global Wealth Databook 2017

Global wealth =
US$ 280 trillion

According to Oxfam, the number of people whose wealth is equal to that of the poorest half of the world's population since 2010.

- **2018 26; 2017 43**
- **2016 61; 2010 388**

Asian Institute of Technology

BREACHING PLANETARY BOUNDARIES

Earth-system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	(i) Atmospheric carbon dioxide concentration (parts per million by volume)	350	387	280
	(ii) Change in radiative forcing (watts per metre squared)	1	1.5	0
Rate of biodiversity	Extinction rate (number of species per million species per year)	10	>100	0.1-1
Nitrogen cycle	Amount of N2 removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle	Quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5–9.5	-1
Statospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km^3 per year)	4000	2600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	low
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis	to be determined		
Chemical pollution	For example, amount emitted to or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste in the global environment, or the effects on ecosystem and functioning of the Earth system	to be determined		

Boundaries for processes in red have been crossed. Data source: Rockström *et al.* (2009) *Nature*

WHAT THIS MEANS.. RESOURCE USE, ECONOMIC CHANGES, AND ENVIRONMENTAL DEGRADATION

- Humans have been using resources (all types) in very large quantities – both non renewable and renewable; non renewables resource is diminishing.
- The numbers (population) has also seen a huge increase in recent centuries; and their requirements for resource is ever increasing.
- Also, their past usage has led to remarkable changes to the environment, where they live in (earth is a closed system).
- Looking at the future, where economic changes are without precedent, and so without significant improvements in productivity, it would not be possible to meet the 9 billion people's requirements in 2050 (and eradicating poverty).

- Note: We have only one planet

Sustainable Development

SUSTAINABLE DEVELOPMENT

Sustainable development is an approach to development that takes into account the "finite resources of the earth" into consideration. This means creating a system that is sustainable, ie. that can keep on going indefinitely into the future.

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" - The Brundtland Report, Our Common Future, 1987

Social; Economic; Environment

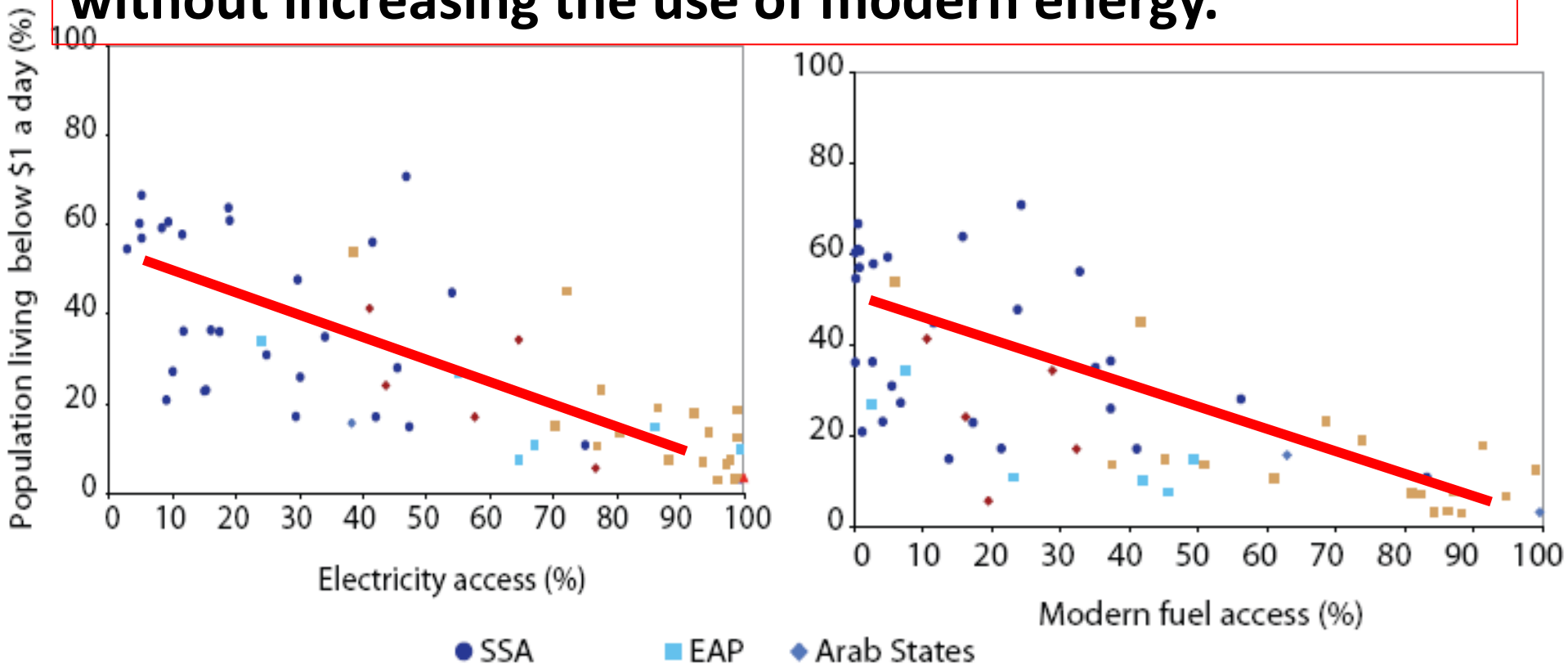
7.1 ensure universal access to affordable, reliable and modern energy services
7.2 increase substantially the share of renewable energy in the global energy mix

7.3 double the global rate of improvement in energy efficiency

Asian Institute of Technology

ENERGY AND SD/ENERGY USE AND POVERTY (INCOME): SOCIAL

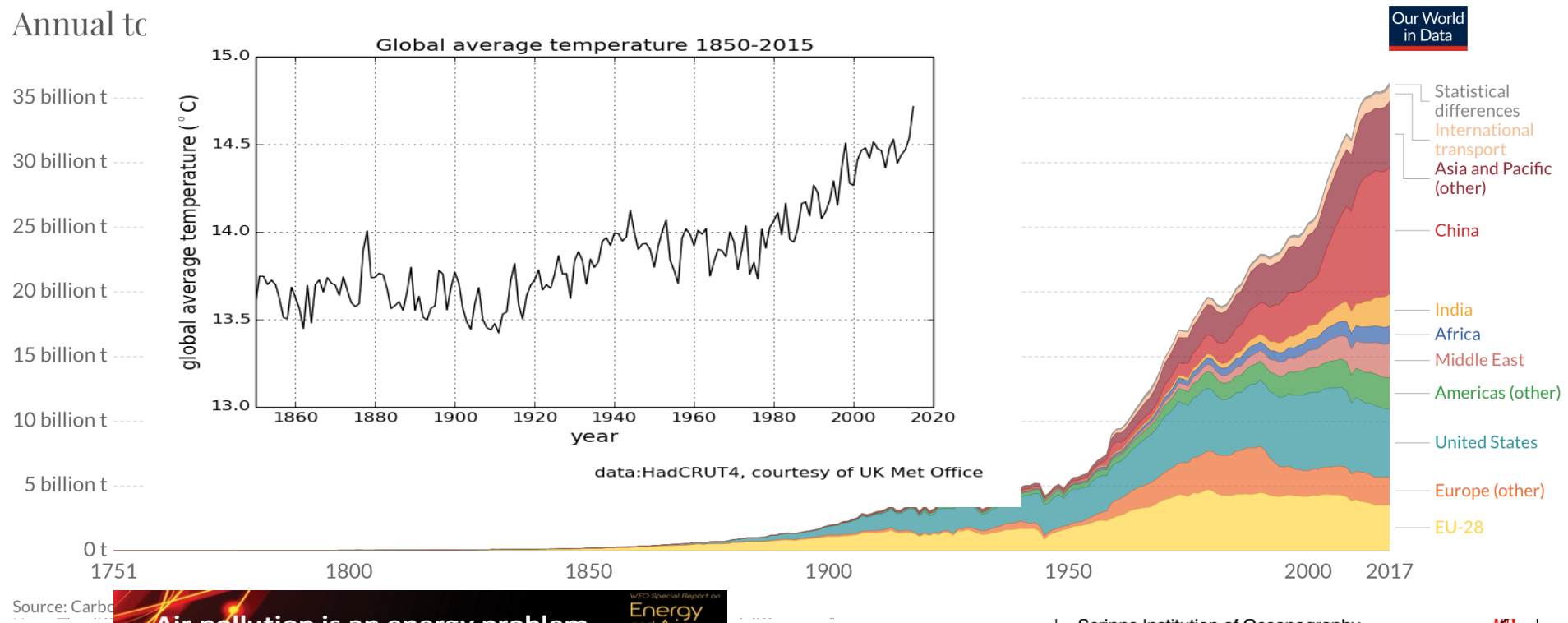
No country has made a significant reduction in poverty without increasing the use of modern energy.



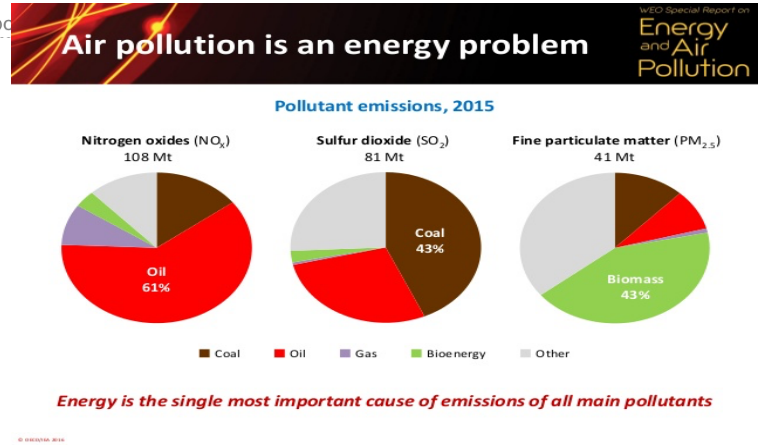
When income increases, energy consumption will increase.

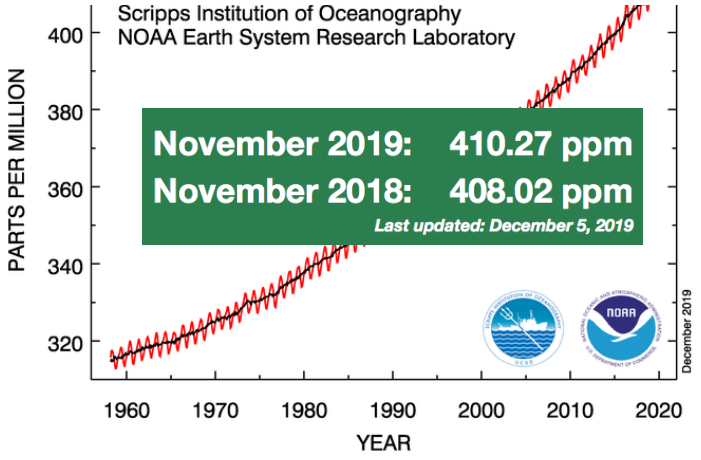
Asian Institute of Technology

ENERGY AND SD/ENERGY USE AND AIR POLLUTION/GHG EMISSIONS: ENVIRONMENT



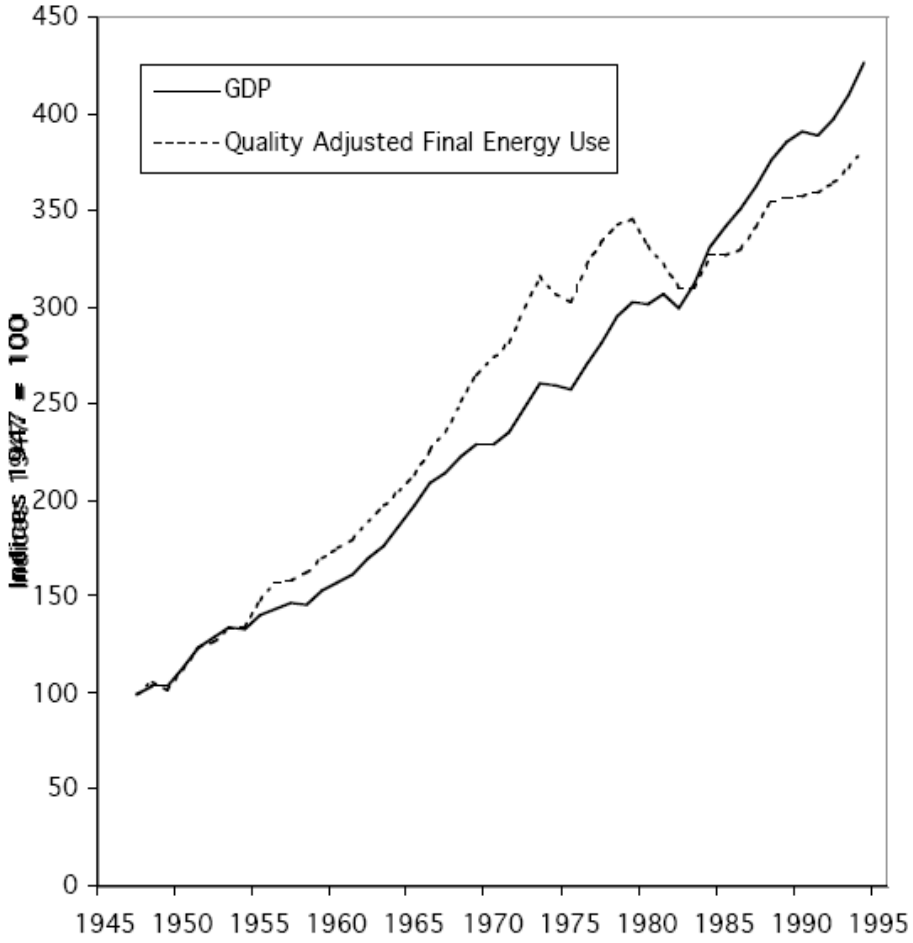
Source: Carbo



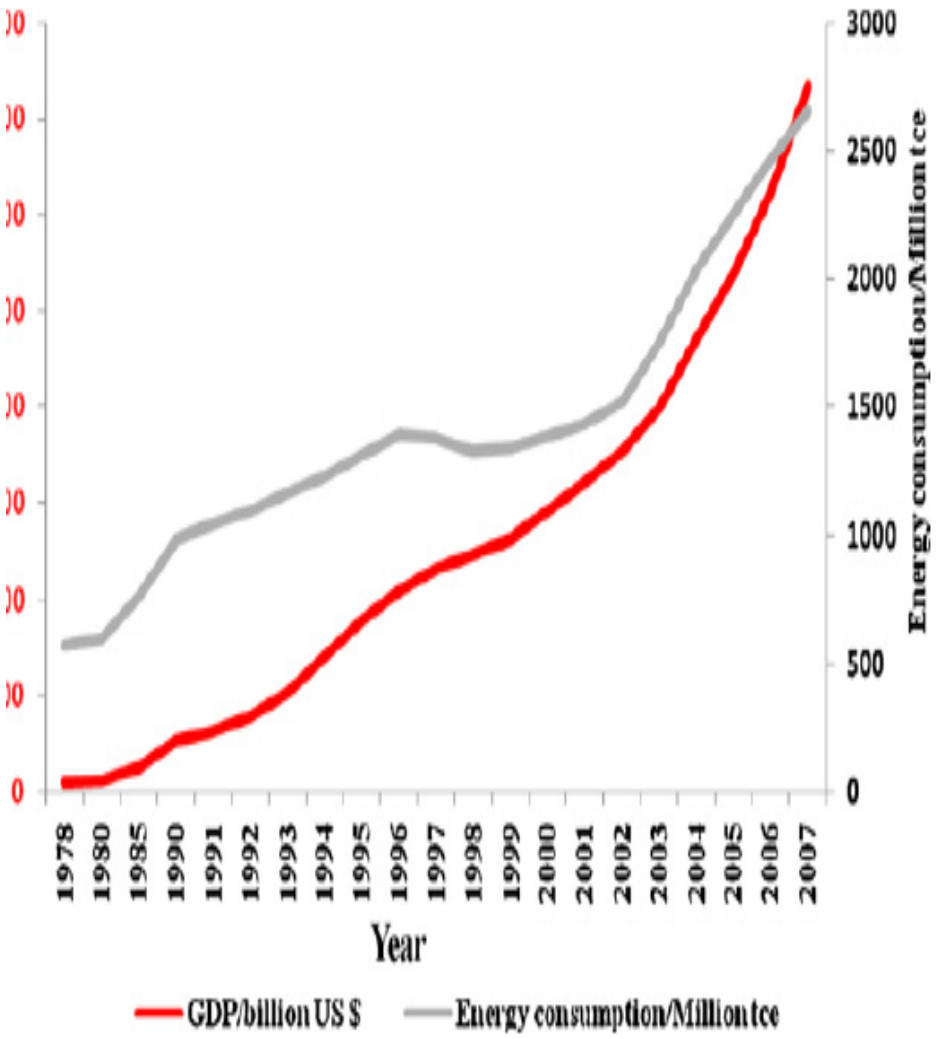


https://www.esrl.noaa.gov/gmd/ccgg/trend

ENERGY AND SD/ENERGY USE AND GDP: ECONOMIC



Notes: GDP is in constant dollars i.e. adjusted for inflation. Energy use is a Divisia index of the principal final energy use categories – oil, natural gas, coal, electricity, biofuels etc. The different fuels are weighted according to their average prices.



Source: Stern and Cleveland, 2004

WHAT THIS MEANS …AND WHAT WE WILL SEE…

- Development has to be sustainable, and energy service has an important influence in the move towards sustainable development.
- But, currently, only 89% population of the world have access to electricity and 60% to clean cooking. In South East Asia, 65 million people do not have access to electricity.

- How to provide access to electricity to those communities in a sustainable manner?
- The problem has to be looked at in **technical, economic, social and environmental considerations - sustainable development**.

- **Technology:** PV / PV and Improved cooking stoves
- **System Size:** Varying (depends on user) / Same size
- **Business model:** Commercial Enterprise in place/ Initiated
- **Level:** Region / Village / Institution
- **Country:** Bangladesh, Myanmar, Philippines, Thailand (AIT)

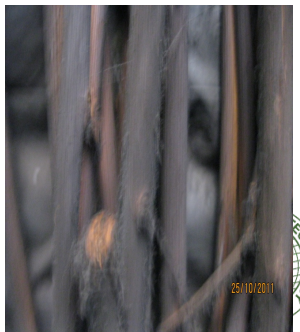
ENERGY ACCESS FOR SMALL SHOPS IN BANGLADESH

- Partnered with Grameen Shakthi and CMES, Bangladesh.
- 21 users (grocery shop, restaurant, barbershop, pharmacy, village doctor's chamber and tea stall) in Manikganj, Bangladesh were provided with PV based micro utility (1999).
- The system is designed to provide uninterrupted power supply for 5 hours every evening
- Each shop had a switch to control its light. The supply is controlled by a main switch in the control room
- A daily tariff of US¢ 8 per day for each lamp and a security deposit of USD 3.38 (refundable) was agreed.
- High user satisfaction in having a local and full time technician. Amount of light is sufficient and the service is good. All shops reported that the market was more lively and that they had increased their business.

Institute of Technology

IMPACT: AFTER 15+ YEARS, THE CONCEPT

- **System size:** About 40 - 85 Wp supporting 2-3 users.
- **Application:** lighting, mobile phone charging, TV, radio and fan.
- **No. of systems:** More than 10,000.
- **Impact (economic):** Technician to operate/maintain the system. More than 30 companies installing PV systems. Making basket and knitting clothes.
- **Impact (social):** Hardly two students can read using one traditional light, whereas more than 5 students can read under one 7 W solar light. Can cook under good light and can watch television.
- **Impact (environmental):** Replacing unhygienic kerosene lamp (smoke). PV light luminance is more than that of traditional light

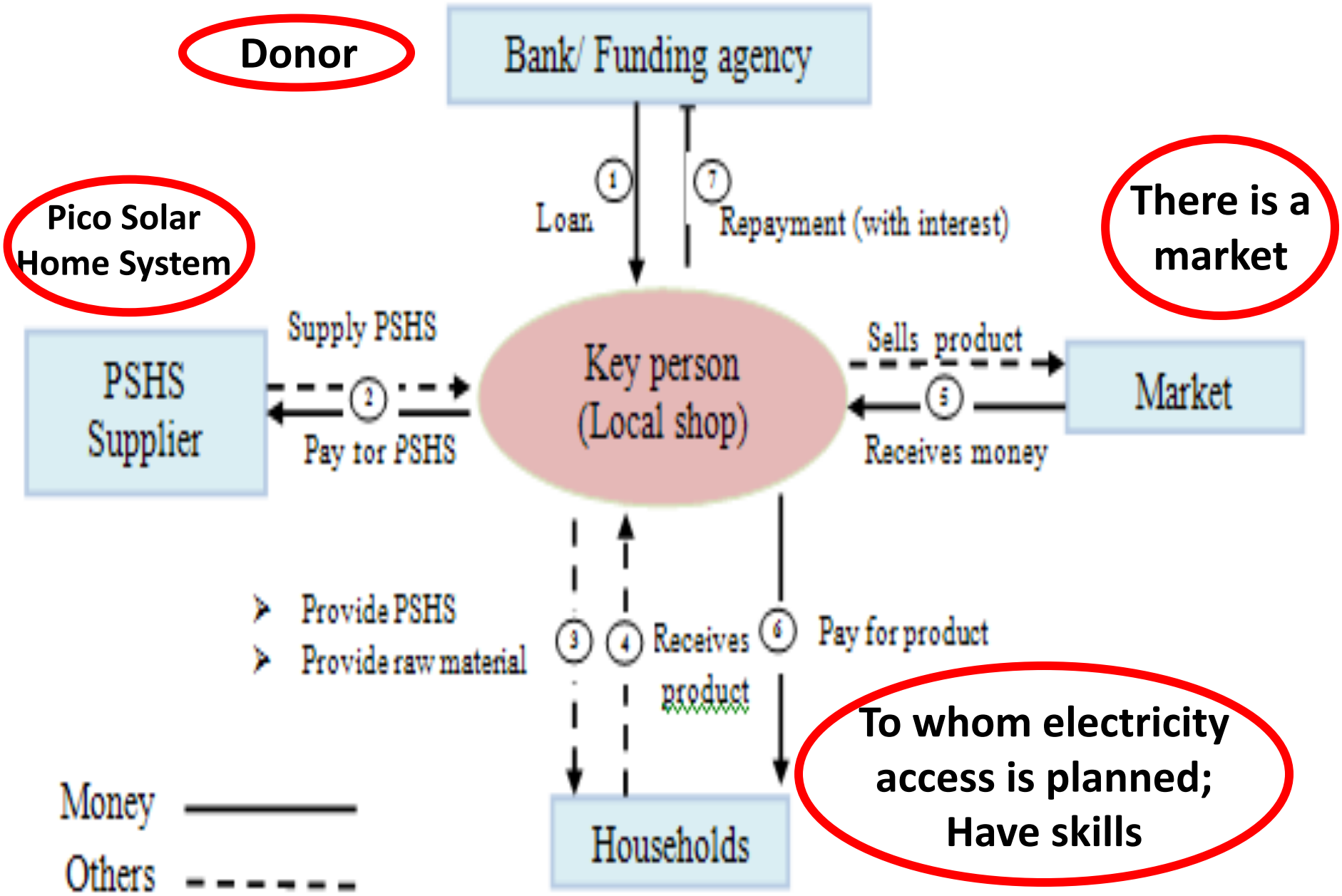


AIT
Asian Institute of Technology

A MODEL FOR ENERGY ACCESS – THE ENERGY+ APPROACH

- **Objective: To provide electricity access to the poor (BoP)**
- **Constraints**
  - **Technical:**
    - The technology should be simple and easy to use
    - It should be scalable
  - **Social**
    - It should empower users
    - Provide value addition, educational/entertainment opportunities
  - **Environment:**
    - Less harm to the environment
    - No local pollution
  - **Financial**
    - Users should be able to pay for it

THE ENERGY+ APPROACH



PROVIDING SUSTAINABLE ENERGY ACCESS NEAR MANDALAY

Thar Lay Swa: Amarapura Town ship, 11 km south of Mandalay.

Population: nearly 2,000

***Total number of households*:** About 400

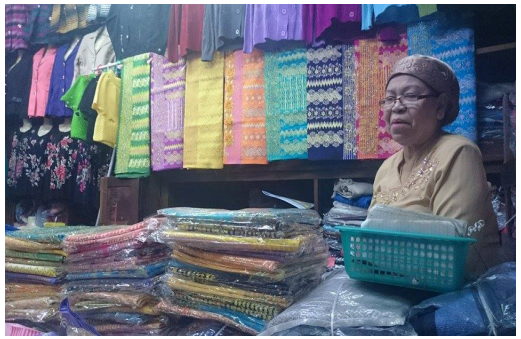
Occupation: Farming, fishing, etc

Electrification: 50%

- Electricity needs: Lighting - 3-5 hours per day
- Technology (PSHS): 2.5 Wp; one lamp

Painting on plain cloth

Hand art on painted longyi



In the market

- **Survey to know the demand, interest and key person**

IMPACT OF PROVIDING BASIC ELECTRICITY ACCESS

- ***20 households selected***
  - Do not have grid electricity access
  - The income range between $1 to $4 per day, and
  - Must have the skill of making local product (traditional longyi)
- **After installation of PSHS**
  - **Economic impact:** Working opportunity increased, more income. PSHS paid back in 18 months. Income from selling. Save , on average 3,000 Kyats per month
  - **Environmental impact:** Better quality light (PSHS produces about 130 lumens vs 13 lumens from candle), Reduction of health hazard (wax droppings), and no CO2 emissions
  - **Social impact:** More security, less tiredness

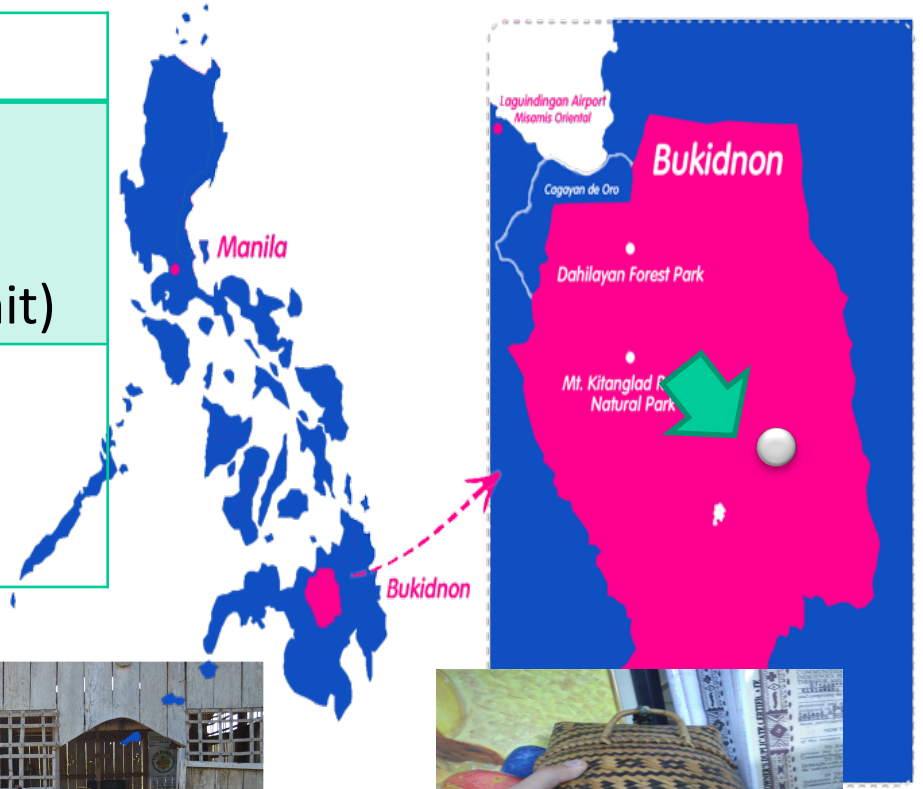
IMPACT OF PROVIDING BASIC ELECTRICITY ACCESS

- All stakeholders "win"
  - Bank/Donor – money repaid (loan)
  - PV mfr – money received for PV sales
  - Key person – make profit
  - Market – make profit by selling product to customer
  - Household – Lighting access (better quality of life), no pollution and increased income

SITIO PATULANGAN, BUKIDNON, THE PHILIPPINES

- Total hhs: 14. population: 73. 15 km from nearest town.
- Food (php 1,013) has the highest expenditure, followed by education (php 571) and lighting (php190). no cost for cooking

Product	Details
PSHS 7500	14 units of PSHS 7500 Brand name: Fosera Total cost: $1,680 ($120/unit)
Bakal kalan cook stove	14 units of Bakal Kalan Local supplier: Bohol trade Total cost: $140 ($10/unit)



IMPACT OF PROVIDING BASIC ELECTRICITY ACCESS

- **Technical:** Before: Lighting – mostly used inefficient sources of fuel,
  Cooking: 1 yr lifespan of open type CS, performance: low thermal efficiency and took time in cooking
  After: Lighting: 400 lumens compared to 50 lumens of wick lamp
  . Cooking: 5 years life span, less time for cooking, good performance
- **Economic:** Before: 89% of HHs were dissatisfied with the cost and quality of light of wick lamp.
  After : 89% HHs were satisfied with the cost of lighting services, and all HHs were satisfied for the quality of lighting.
  Average savings: Php110/month/HH in the lighting services
- **Social:** Empowerment of women – 67% of women participated in income generation. The system can extend hours of their livelihood especially in making handicrafts, milling of corn, preparing dinner, and studying for their children.
- **Environmental:** Reduction of emission (kgCO2/yr) - 1,120 (Lighting) & 2,218 (cooking).
  Reduced the health issues in difficulty in breathing and sting eyes.

IMPACT AFTER 15 MONTHS (DECEMBER 2019)

Lighting:

- The LED lighting can light up their houses up to 10-12 hrs.
- It is convenient and hassle free for the households.
- They have no expenses in lighting now because of the PSHS.
- During rainy season, the PSHS can light-up up to 2-3 hrs.
- The system can extend hours of their livelihood especially in making handicrafts, milling of corn, preparing dinner, and studying for their children.

Handicraft:

- The handicraft making is seasonal because of the seasonal order – Fiesta or special event in their neighboring Municipality.

Current/Future Plans:

- To use the funds for agriculture and water supply

This study further highlights the importance of considering social, environment and economic aspects during access to electricity

COMMUNITY FARMING USING PV AT AIT

- More than 60 participants in about 12 - 14 groups.
- Eggplants, tomatoes, chili, okra, water spinach, French bean, corn, snake gourd, ridge gourd and bitter gourd

COMMUNITY FARMING USING SOLAR DRIERS AT AIT

AIT
Asian Institute of Technology

SDG 7 WAS THE FOCUS, BUT THESE EXAMPLES ARE ALSO RELATED TO OTHER SDGS

Social; Economic; Environment

- **SDG 1: No poverty**
- **SDG 4: Quality Education**
- **SDG 8: Decent work and economic growth**
- **SDG 10: Reduced Inequalities**
- **SDG 11: Sustainable cities and communities**
- **SDG 13: Climate action**

find feasible paths toward sustainable societies in Asia by converting aspirations into actions at the local, national, and regional levels

SUMMARY

- We have been using resources significantly in the last 200 years. Coupled with other issues, this has caused/ causing serious harm to the environment and society.

- We need to promote sustainable development – economic, social, environmental – holistically.

- Modern energy services provide a positive impact in all aspects of sustainable development - institution, village and regional level.

- However, the applicable model has to be developed to suit specific situations. No one model will suit all situations

References

Muhammad Ibrahim, M. Anisuzzaman, S. Kumar, and S. C. Bhattacharya, Demonstration of PV microutility system for rural electrification, ***Solar Energy*, 72, 6, 521-530, 2002.**

Najmul Hoque and S. Kumar, Performance of photovoltaic micro utility systems, ***Energy for sustainable development*, 17, 5, 424-430, 2013.**

Thaw Thaw Phyo Htoon: Energy access in Myanmar: From Vicious to Virtuous cycle of development**, Master's thesis, 2016, AIT.**

Mardione Albert Compoc Mozo: Design, Implementation and Impact Assessment of Modern Energy Access to the Indigenous Community: The Energy Plus Approach in Sitio Patulangan, Bukidnon Philippines**, Master's thesis, 2018, AIT.**

AIT Asian Institute of Technology

Thank You

https://eecc.ait.ac.th
faculty.ait.ac.th/kumar
kumar@ait.ac.th

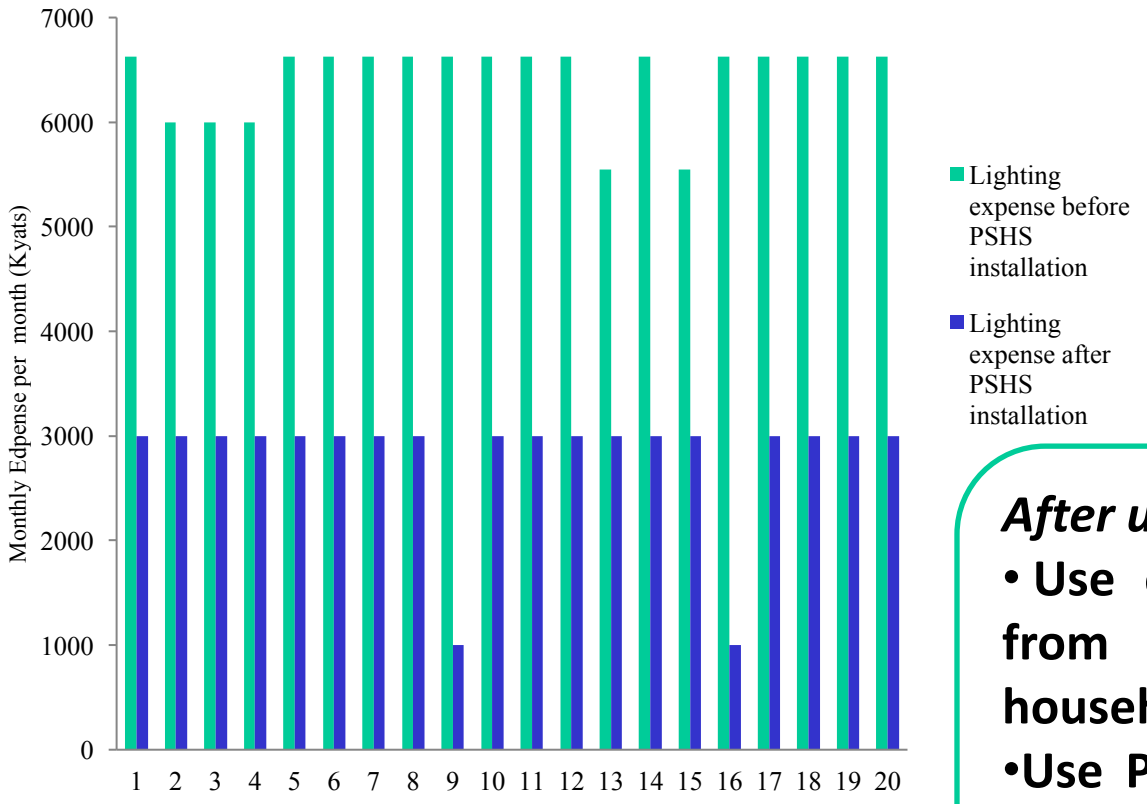
MONTHLY EXPENSE BEFORE AND AFTER USING PSHS

No. on PSHS	Name	Previous types of lighting sources	Monthly expenses for lighting before PSHS installation (Kyats)	Monthly expenses for lighting after PSHS installation (Kyats)	Main Job	Remarks
1	U Thein Lwin Oo	LED charging	6250-7000	3000	Farmer	
2	U Wai Lin	Car battery	6000	3000	Farmer	
3	U Thar Din	Car battery	6000	3000	Driver (assist:)	
4	U Khin Maung Htay	Car battery	6000	3000	Farmer/fisherman	
5	U Phyu Ko	Candle	6000-7500	3000	Hand painting	
6	U Min Kyaing	LED charging	6250-7000	3000	Carpenter	
7	U Shan	LED charging	6250-7000	3000	Fisherman	
8	U Ko Ko Maung	LED charging	6250-7000	3000	Farmer	
9	Daw Nyein Nyein	Candle	6000-7500	1000	Hand painting	No more use generator's electricity
10	U Ba Shwin	LED charging	6250-7000	3000	Selling chicken	

MONTHLY EXPENSE BEFORE AND AFTER USING PSHS

No. on PSHS	Name	Types of lighting source	Monthly expenses for lighting before PSHS installation (Kyats)	Monthly expenses for lighting after PSHS installation (Kyats)	Main Job	Remarks
11	U Cho Hlaing Win	LED charging	6250-7000	3000	Hand painting	
12	U Tin Myint	LED charging	6250-7000	3000	Clark at Mosque	
13	U Htun Htun	Dry cell battery	5100-6000	3000	Farmer	
14	U Htun Htun	Candle	6000-7500	3000	Farmer	
15	U Htun Oo	Dry cell battery	5100-6000	3000	Farmer	
16	Daw Yi	Candle	6000-7500	1000	Hand painting	No more use generator's electricity
17	U Than Oo	LED charging	6250-7000	3000	Farmer	
18	U San Hlaing	LED charging	6250-7000	3000	Farmer	
19	U Tin Htun Aung	LED charging	6250-7000	3000	Farmer	
20	U Tin Swe	LED charging	6250-7000	3000	Farmer	

MONTHLY EXPENSE BEFORE AND AFTER USING PSHS



Cost saving by using PSHS

Before using PSHS,

- **Use electricity from the generator from 6 to 9 pm + traditional lighting sources**

After using PSHS,

- **Use electricity from generator from 6 to 9pm + PSHS (18 households)**
- **Use PSHS only from 6 to 9 pm and afterwards (2 female headed households)**

Cost saving per month after using PSHS:

- **Save 4,000 to 6,000 Kyats/month. (2 female headed households)**
- **Save approximately 3,000 Kyats/month (remaining 18 households)**

USER SATISFACTION ON PSHS SYSTEM

User Satisfaction on PSHS		Satisfaction level					Mean	SD
		1	2	3	4	5		
More working opportunity is increased	N	18	2	0	0	0	1.1	0.308
	%	90	10	0	0	0		
Ability to work longer at night	N	15	5	0	0	0	1.25	0.444
	%	75	25	0	0	0		
More income is generated	N	18	2	0	0	0	1.1	0.308
	%	90	10	0	0	0		
More convenient for preparing food at dawn time	N	10	4	6	0	0	1.8	0.894
	%	50	20	30	0	0		
Lighting access in cooking area	N	13	3	4	0	0	1.55	0.826
	%	65	15	20	0	0		
Decrease indoor air pollution	N	12	6	2	0	0	1.5	0.688
	%	60	30	10	0	0		
Improve women's health	N	7	13	0	0	0	2.3	0.979
	%	35	65	0	0	0		
Increase in children study time	N	9	11	0	0	0	2.1	1.021
	%	45	55	0	0	0		
More reading time (especially for women)	N	5	1	14	0	0	2.45	0.887
	%	25	5	70	0	0		
Better quality of light	N	14	5	1	0	0	1.35	0.587
	%	70	25	5	0	0		
More security	N	18	2	0	0	0	1.1	0.308
	%	90	10	0	0	0		
Reduction of fire hazard	N	13	7	0	0	0	1.35	0.489
	%	65	35	0	0	0		

1= Strongly agree, 2=Agree, 3= Neutral, 4=Disagree, 5= Strongly disagree