"Study and Design on Small Scale Biomass Gasification for Electricity Generation (Dual Fuel)"

Prepared by: Assoc. Prof. Sengratry Kythavone
Prof. Dr. Khamphone Nanthavong
Mr. Vongsavanh Chanhthaboune.

Outline of Presentation:

- Introduction
- Why use Biomass?
- Gasification Process and Biomass Gasification
- Type of gasifiers
- Objective of Study
- Design Concept
- Experiment and Results
- Discussion and Conclusion

- **History, Current Developments, and Future Directions**

History:

-Gasification was discovered independently in both France and England in 1789;

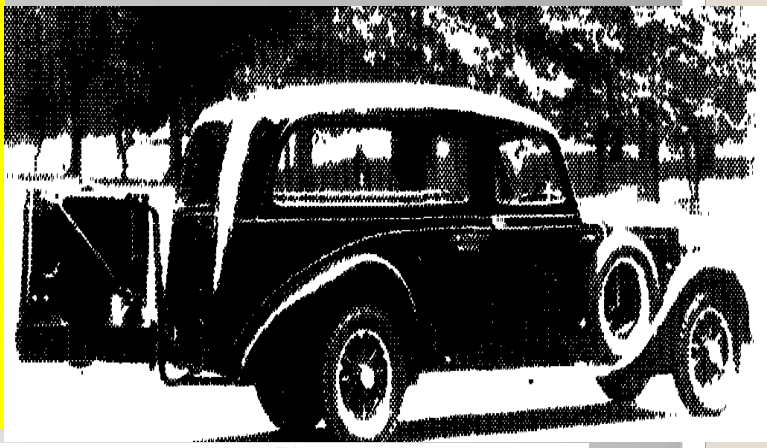
-1850 the technology has been developed; It was possible to light much of London with manufactured gas or town gas from coal;

-Starting about the time of World War I, small gasifiers were developed around charcoal and biomass feedstocks to operate vehicles, boats, trains, and small electric generators;

-By 1943, 90% of the vehicles in Sweden were powered by gasifiers;

-By the end of the 2nd World War, there were more than 700,000 wood gas generators powering trucks, cars, and buses in Europe and probably more than a million world wide;

-Soon after the war, low cost gasoline became available again, and most users went back to burning gasoline because of its convenience.



Current Development Activities:

-After OPEC oil embargo of 1973, there was renewed interest in all forms of alternative energy, including gas produced from coal and biomass;

-Recently , there has been increased interest in biomass as a renewable energy resources;

-In the last few years, a number of individuals and groups have built versions of small downdraft gasifiers and have operated them as demonstration units;

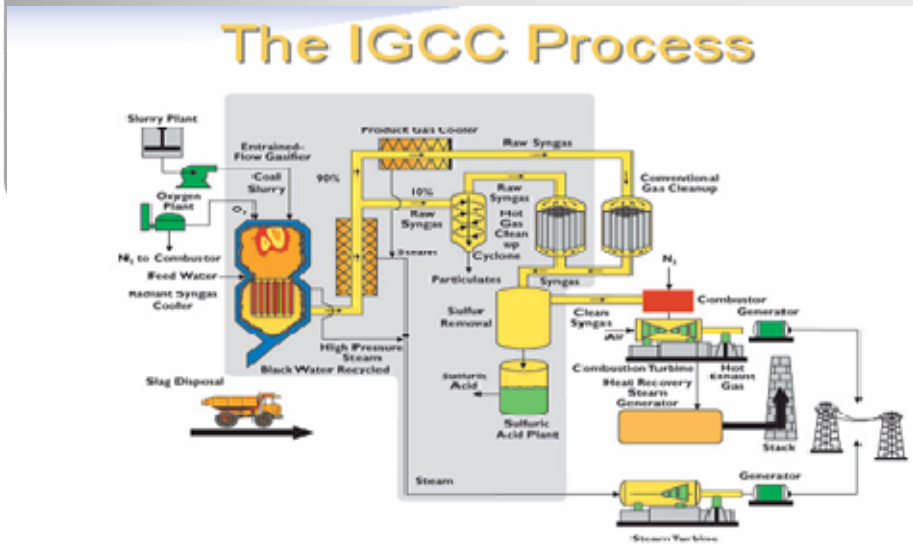
-Interest in small scale gasifiers is strong among organizations that deal with less developed countries such as the World Bank, the U.S. Agency for international development, and the equivalent organizations in European Countries;

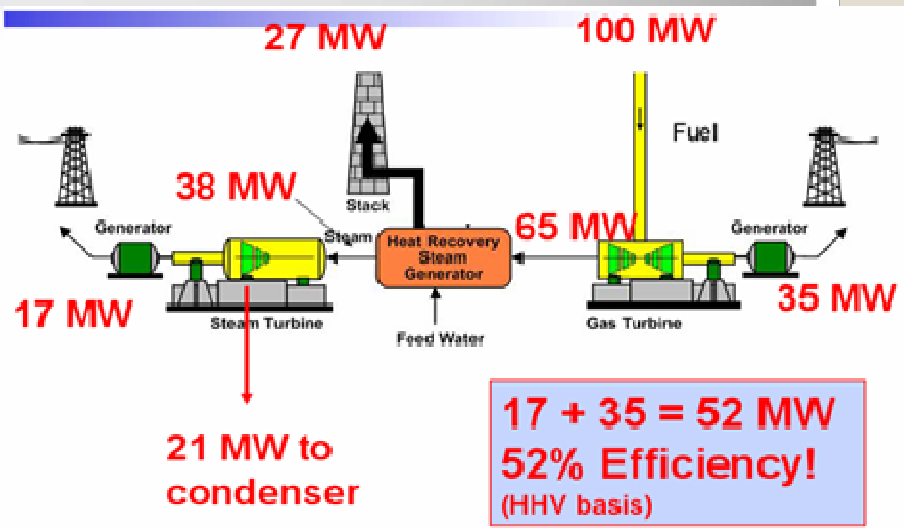
-Producer gas from charcoal has been developed commercially in the Philippines(1983) ,where more than 1,000 units have operated.

-Producer gas is generated for industrial heat by more than 30 large units operating in Brazil(1984).

- **Future Development Directions**

-Today, because of increased fuel prices and environmental concern, there is renewed interest in this century old technology. Gasification has become more modern and quite sophisticated technology.





◦ Why use biomass?

-Age-old and most widely used fuel source - Annual consumption was estimated to be of the order of 20 million tons a few years ago

- A Cheap, abundantly available fuel
- A very Clean fuel
  - Biomass has no sulphur content
  - Short CO_2 fixation cycle
- Renewable

-Its production and use also brings additional environmental and social benefits.

-Biomass is a sustainable fuel that can deliver a significant reduction in net carbon emissions when compared with fossil fuels.

-Using biomass to achieve a carbon balance

Why Biomass Gasification?

Biomass Producer Gas

Gasification Allows better process control and convenience

Highly Efficient Process

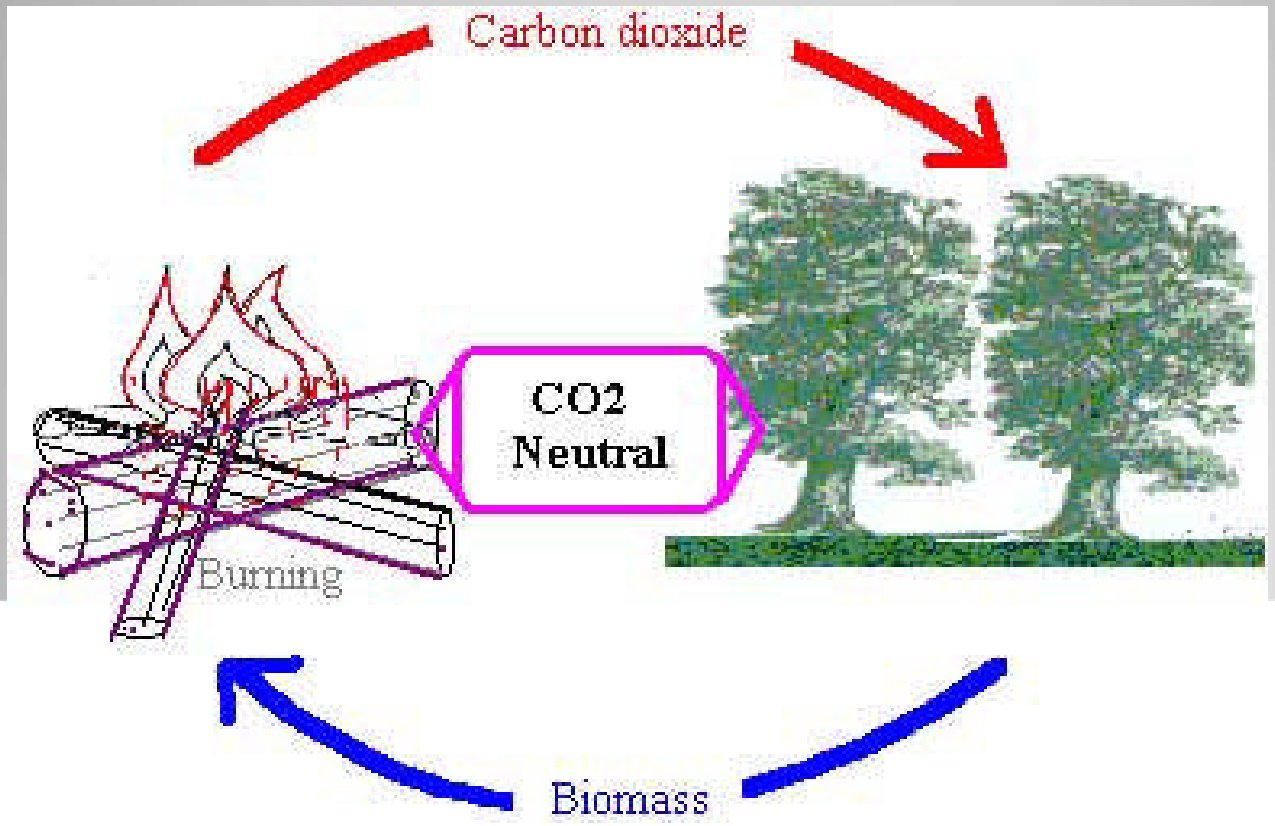
Cleaner combustion in connected equipment

Can be applied over a range of output ratings (few to hundreds of kWs)

Elimination of all pollution related to Biomass use

Can be used for thermal applications & electricity generation

Low initial investment and cost of power production


Carbon dioxide
CO2
Neutral
Burning
Biomass

◦ What is Gasification?

Basic Process Chemistry:

- **Conversion of solid fuels into combustible gas mixture called producer gas (CO + H2 + CH4)**
- **Involves partial combustion of biomass**
- **Four distinct process in the gasifier viz.**
- **Drying**
- **Pyrolysis**
- **Combustion**
- **Reduction**

- In gasification process, wood, charcoal and other biomass materials are gasified to generate so called ´producer gas´ for power or electricity generation. Gasification system basically consists of a gasifier unit, purification system and energy converters - burner or engine.

-Gasification is basically a thermochemical process which converts biomass materials into gaseous component. The results of gasification is the producer gas, containing carbon monoxide, hydrogen, methane

◦ Why use biomass?

-Biomass is a renewable, low carbon fuel that is already widely, and often economically available throughout the World.
-Its production and use also brings additional environmental and social benefits.
-Biomass is a sustainable fuel that can deliver a significant reduction in net carbon emissions when compared with fossil fuels.
-Using biomass to achieve a carbon balance

- The Problem with burning fossil fuels

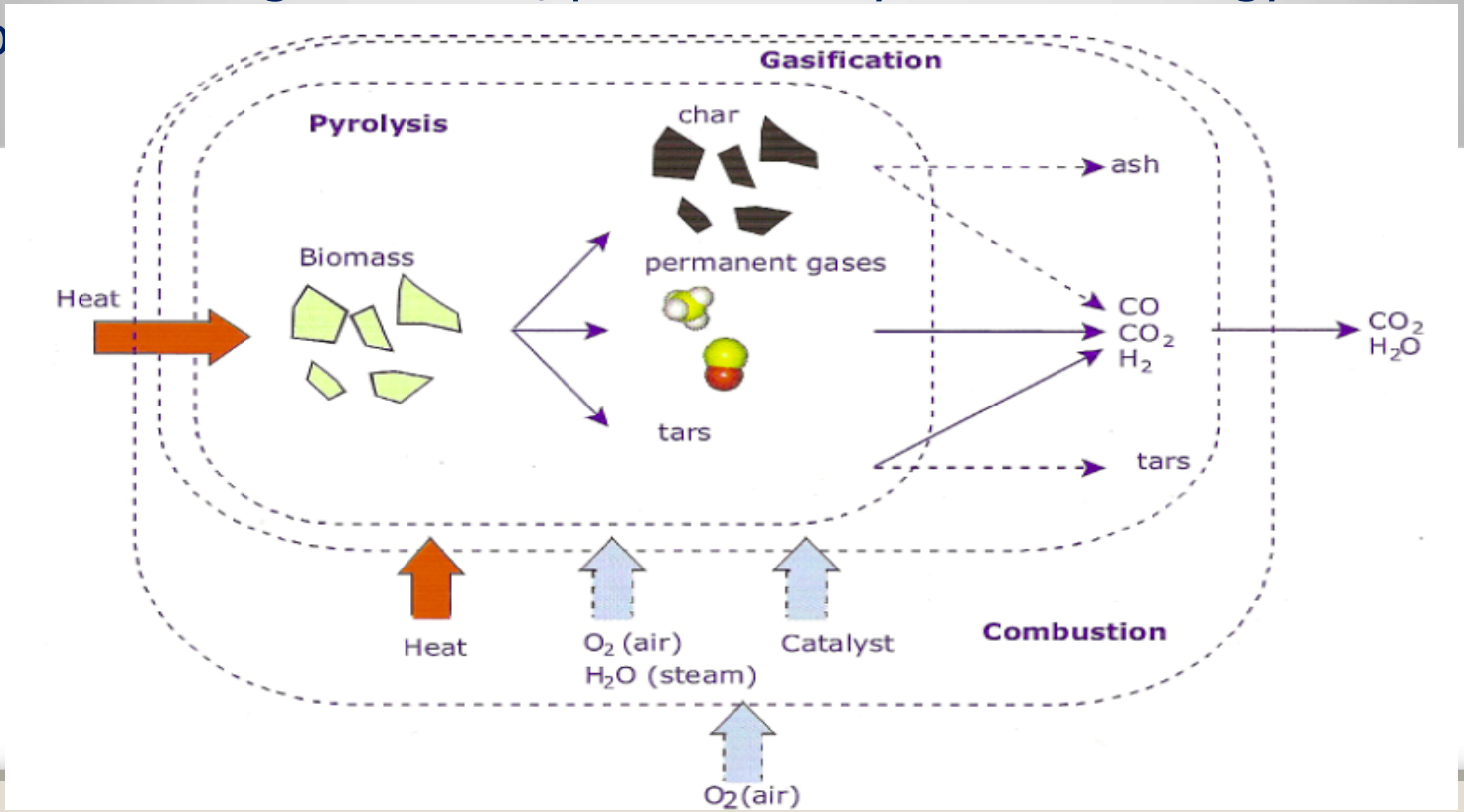
-Burning any carbon based fuel converts carbon to carbon dioxide.
-This carbon dioxide is usually released to the atmosphere, and leads to increased concentrations of carbon dioxide in the atmosphere.
-Carbon dioxide is one of a number of gases that transmit the visible light incident on the Earth from the Sun, but absorb the infrared radiation emitted by the warm surface of the Earth, preventing its loss into space. This keeps the Earth around 33°C warmer than it would otherwise be, GHG include: CO_2; CH_4 ; N_2O, and Water vapour (H_2O).

Lao PDR have huge potential of biomass energy:

No	Plant	Area, (ha)	Production, (ton/year)
1	Rice	870,320	3,144,800
2	Corn	523,500	1134,386
3		4,720	5,620
4	Sugar cane	423,300	27,030

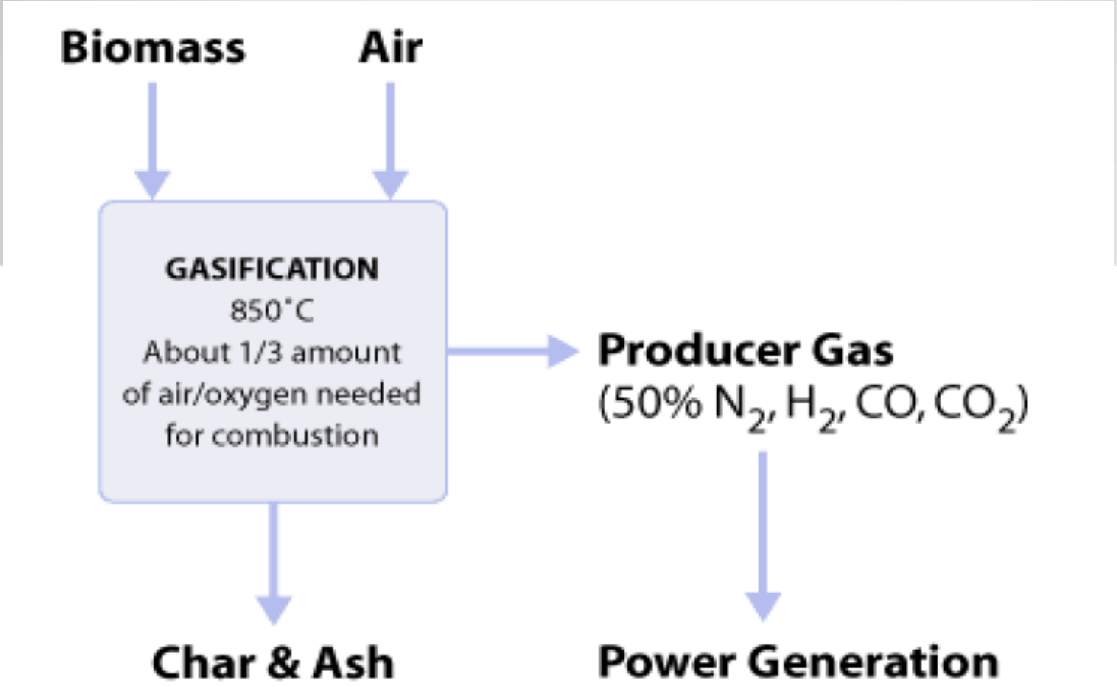
◦ Gasification Process and Biomass Gasification System

- In gasification process, wood, charcoal and other biomass materials are gasified to generate so called ´producer gas´ for power or electricity generation. Gasification system basically consists of a gasifier unit, purification system and energy co



- **How?**

- Biomass is heated with no oxygen or only about one-third the oxygen needed for efficient combustion (dry distillation) producing a mixture of carbon monoxide (CO), and hydrogen (H_2)



- The gasification process is divided into four zones:

-Drying

-Distillation (pyrolysis)

⇒Volatiles come out from the fuel

-Reduction

⇒ Carbon is converted and carbon monoxide and hydrogen are produced as the main components of the producer gas

-Oxidation, Hearth

⇒The remaining char is combusted providing the heat, the carbon dioxide and water vapour for the reactions involved in the reduction zone.

$$C + O_2 = CO_2 \quad + 393.8\ kJ/mol$$

$$C + \tfrac{1}{2}O_2 = CO \quad + 123.1\ kJ/mol$$

$$C + H_2O + 118.5\ kJ/mol = CO + H_2$$

$$C + CO_2 + 159.9\ kJ/mol = 2CO$$

$$CO_2 + H_2 + 40.9\ kJ/mol = CO + H_2O$$

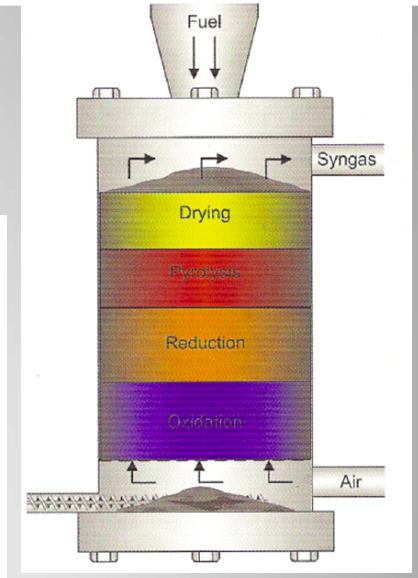
$$C + 2H_2 = CH_4 + 87.5\ kJ/mol$$

$$CO + \tfrac{1}{2}\ O_2 = CO_2 + 283.9\ kJ/mol$$

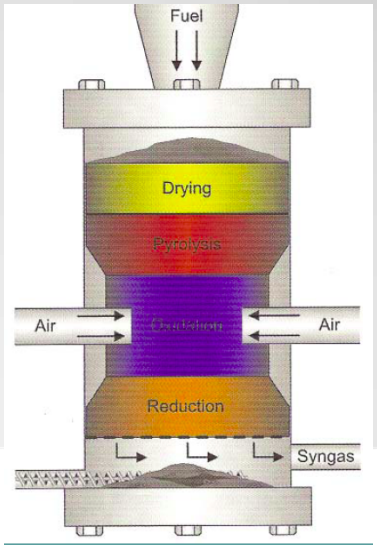
$$H_2 + \tfrac{1}{2}\ O_2 = H_2O + 285.9\ kJ/mol$$

Fixed bed gasifiers:

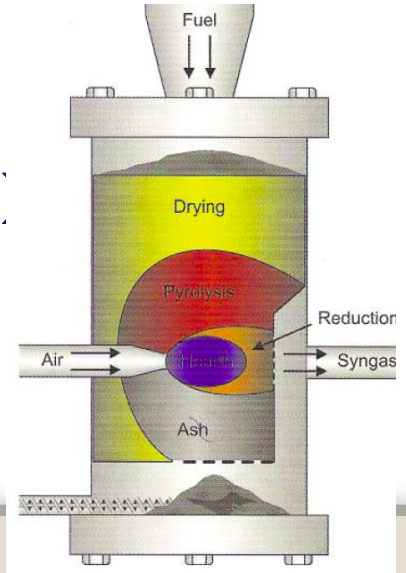
Up-draught (counter current) ⇒



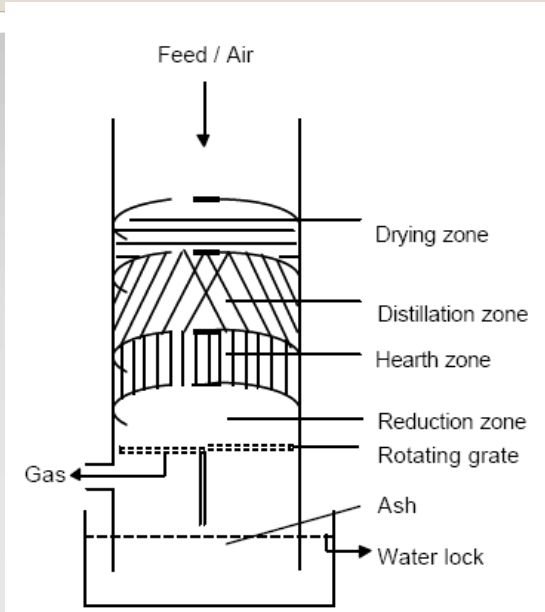
Down-draught (co-current)



Cross-draught (cross-current)

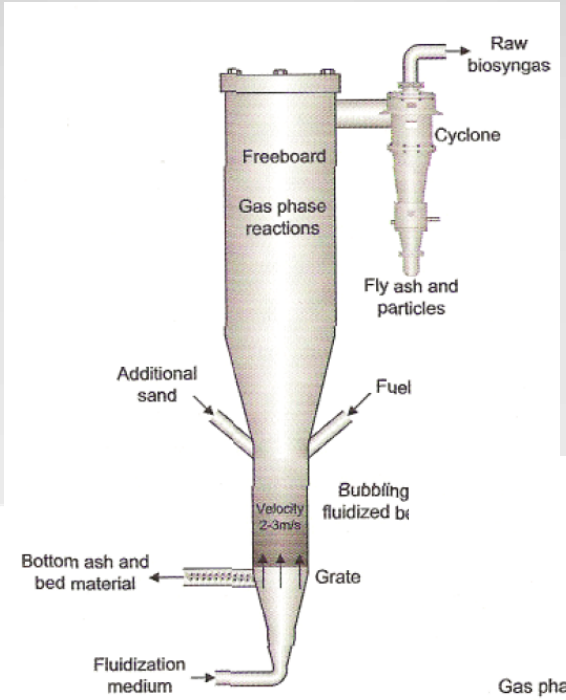


Open core gasifiers ⇒

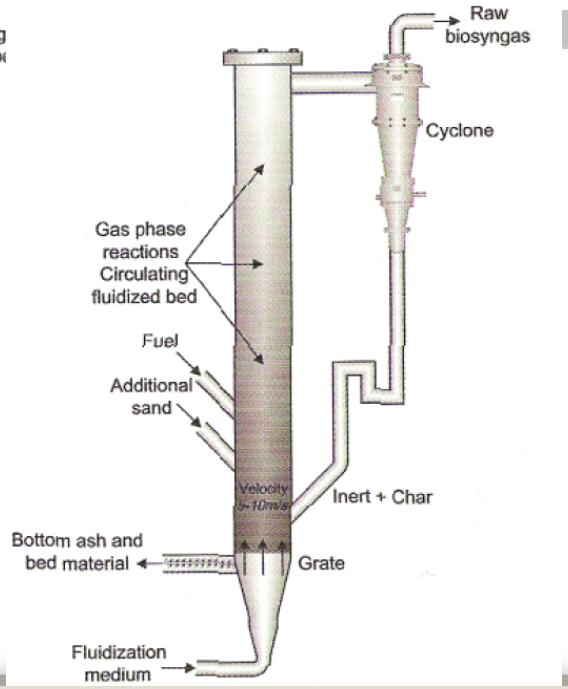


Fluidized bed gasifie

Bubbling bed ⇒



Circulating bed ⇒



- **The main objective of this study:**

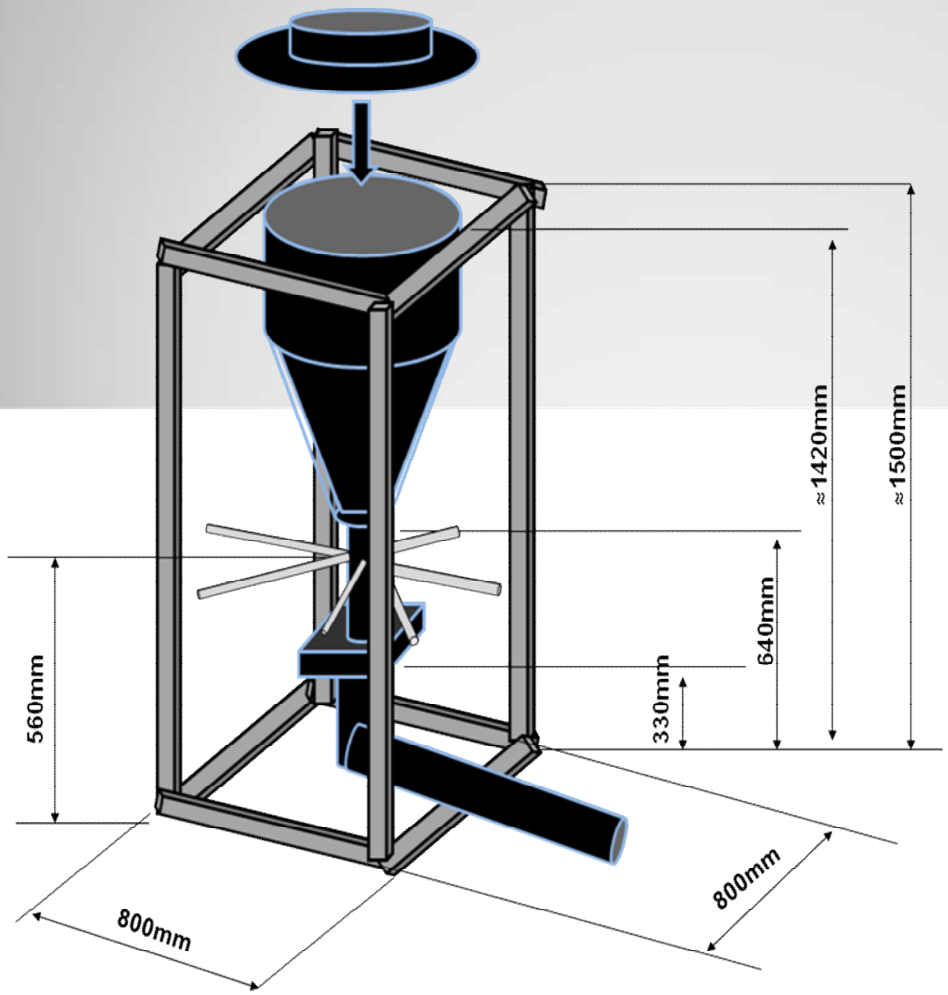
- Biomass energy is renewable energy. Also thus prevents global warming because carbon dioxide is not increased;

-To make low cost gasifier stove by using materials are available in local;

- To Test the producer gas integrated with diesel fuel for running the diesel engine with various speed.

- **Design Concept:**

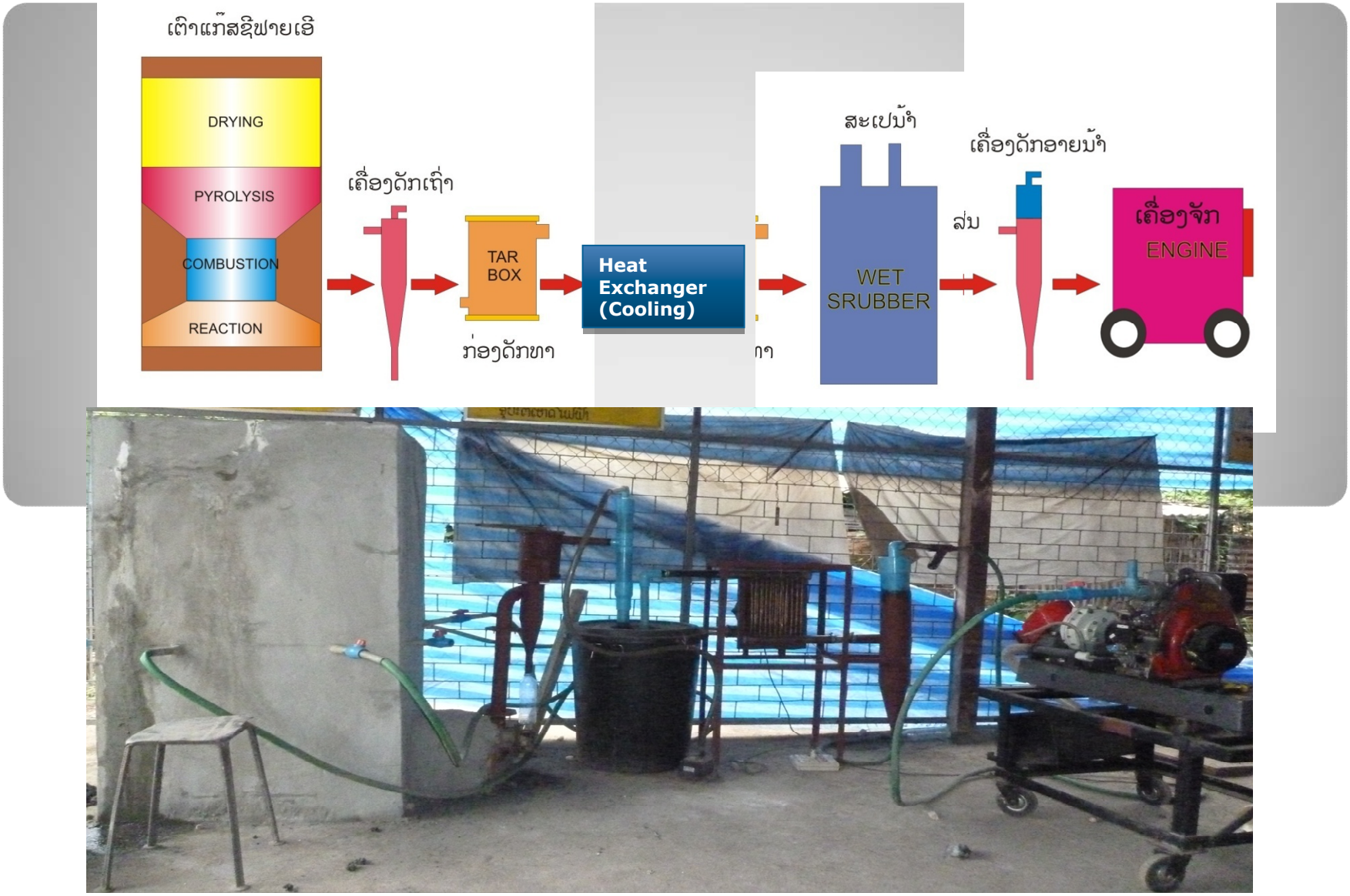
-Select down draft gasifier to design;



- **Used low cost material to make stove body and its Insulation.**

Load testing

Insulation testing



Down draft Biomass Gasification System

- **Experiment :**

-Fuels used for testing: Corn cob; Wood waste, and charcoal;
- The moisture content of fuels used should be less than 12%;

◦Experiment (Continue)
Change the sizing of fuels and we obtained results of experiment as below:

Used corn cob as fuel

No.	Size,(cmxcm)	Mass, (kg)	Gas production time,(min.)
1	1x2	5	140
2	2x2	5	150
3	2x3	5	160

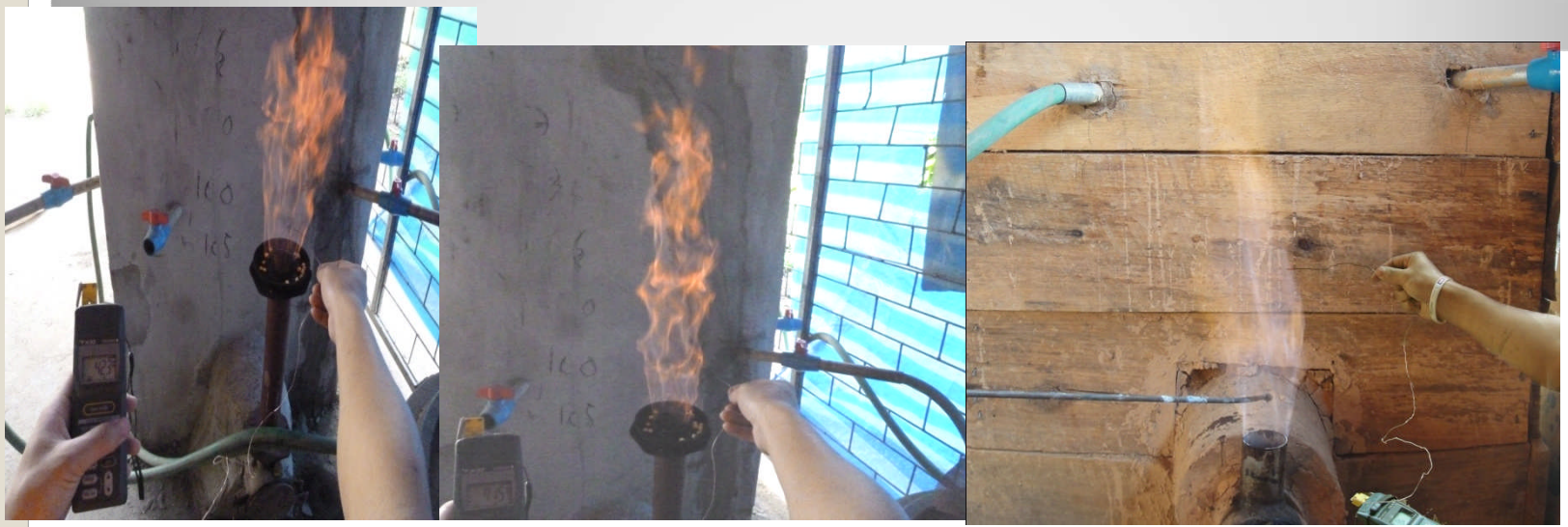
Used wood waste as fuel

No.	Size,(cmxcmxcm)	Mass, (kg)	Gas production time,(min.)
1	0.5x3x2	5	130
2	1x3x2	5	150
3	4x4x4	5	No

◦Experiment (Continue)

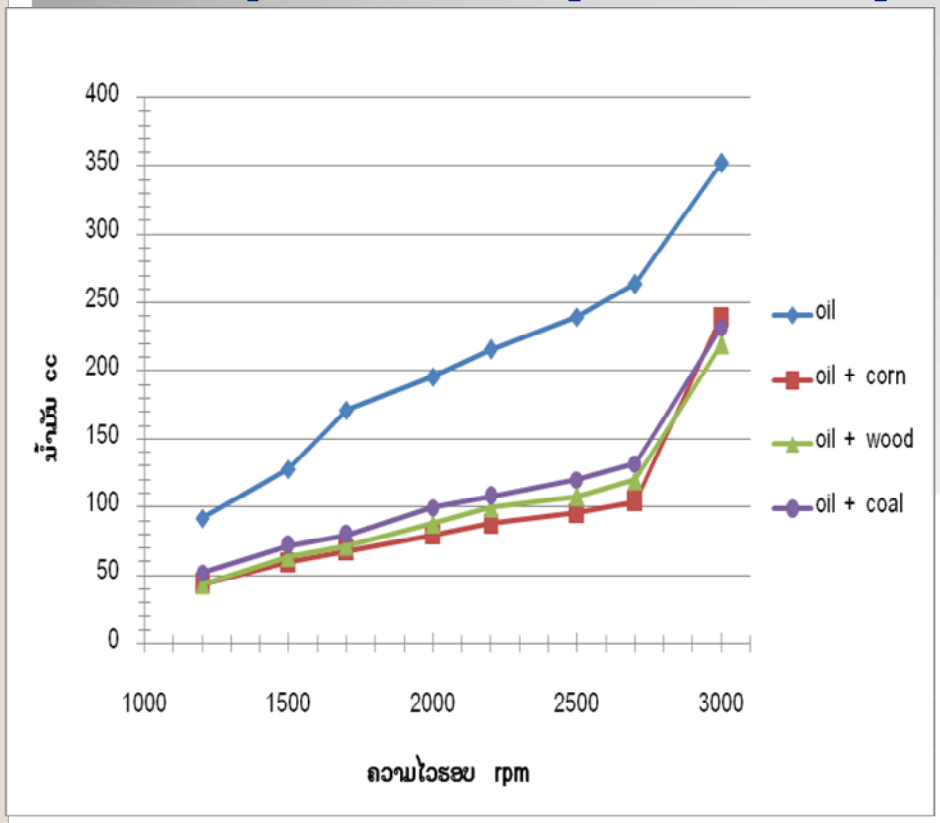
Used charcoal as fuel

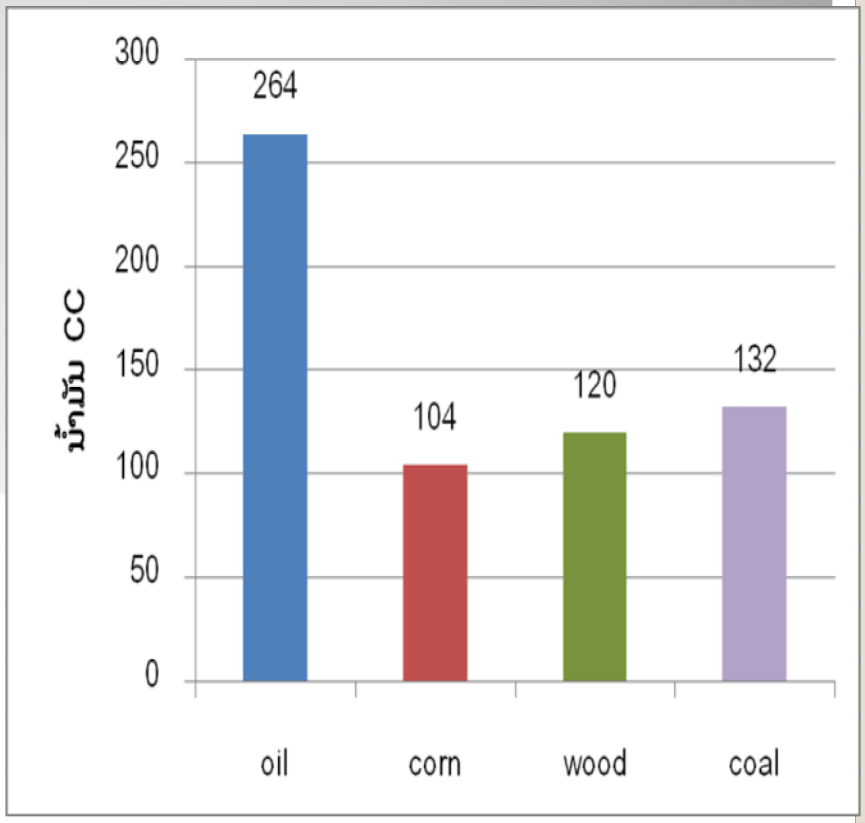
No.	Size,(cm)	Mass, (kg)	Gas production time,(min.)
1	〈 0.5x2	5	No
2	(1-2.5)x2	5	160
3	〉 2.5	5	180



The Flame of combustion producer gas for cob corn, wood waste, and charcoal as fuels respectively.

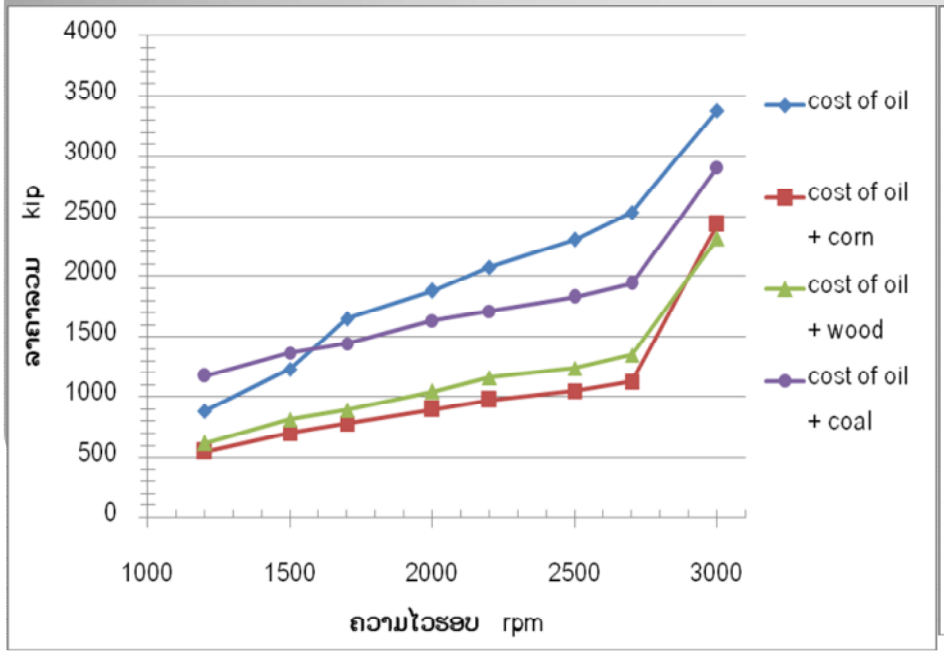
◦ Experiment (Continue)

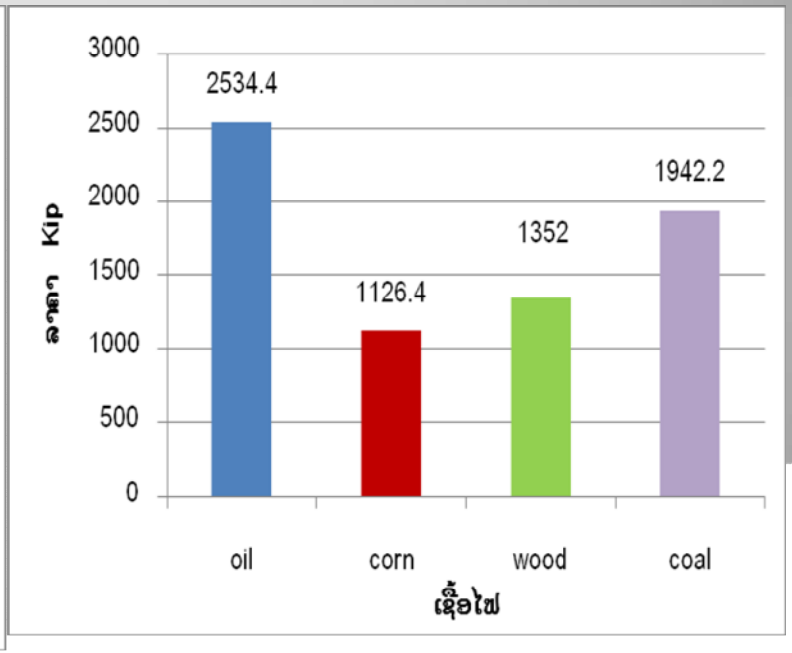




These figures show the results of experiment how many CC can save diesel oil when used producer gas from corn cob, waste wood and charcoal integrated with diesel fuel as dual fuel for running diesel engine with different speed

◦ Experiment (Continue)





Left figure shows the results of experiment how much money should pay for fuel when used producer gas from corn cob, waste wood and charcoal integrated with diesel fuel as dual fuel and also for diesel oil alone for running diesel engine with different speed.

◦ **Discussion**

-We used corn cob, wood waste, and charcoal as feedstock for biomass gasification system. From the above experiment the fuels used should have moisture content 8%-20%, and also our design apparatus is down draft gasifier then one important thing we must consider is the sizing of the fuel:

- Big size of fuel ⇒ No producer gas (only Carbon dioxide will be produced, because to much air in the gasifier)

-Very small size of fuel ⇒ air is not sufficient for combustion ⇒ No producer gas.

-Used producer gas integrated with diesel oil to run diesel engine can reduce diesel oil , and from experiment also shows at what speed of engine should be running for saving diesel oil, and we can save diesel oil 50%-70%

- **Conclusion**

-Biomass energy is renewable energy. Also thus prevent s global warming because carbon dioxide is not increased.

-From this study we conclude that biomass gasification can be produced electricity by using producer gas as fuel (alone or dual fuel) to supply for IC engine, and then generate electricity.

-This technology is very suitable for our country to generate electricity for the rural area where they have huge potential of biomass energy as feedstock.

- However from this study is not yet connect diesel engine to the generator, but at least it can generate electricity more than 2 kW .

Thank you very much for your kind attention.