1Introduction:

Bangladesh is primarily an agrarian economy. Agriculture is the single largest producing sector contributing about 18.6% to GDP (November, 2010) and employing around 45% of the total labor force. The performance of this sector, therefore, has an overwhelming impact on major macroeconomic objectives of employment generation, poverty alleviation, human resources development food security.

Despite the quite impressive growth in agricultural production during the last decades, significant obstacle and barriers continue to stand in the way of their optimal growth. This can be seen from the case of potato production. According to analyst, the supply of potatoes far outstrips domestic demand. However, every year, large quantities of output are spoilt because of the lack of storage facilities. In just 2007-8, almost 1.5 million tons went to waste. This is the case with vegetables and fruits too. Substantial quantities of output are spoilt, thrown away and/or sold at below their production cost because of the lack of preservation capacity. This situation points to the conclusion that it will indeed be difficult to sustain growth of high value and labor-intensive crops unless (a) investments are made in processing and storage facilities to stagger their supply potential throughout the year to match demand which remains more or less stable across seasons and (b) exploiting international markets for the surplus remaining after domestic consumption. Analyst suggests that potato production suffers from boom-bust cycle because of the volatility in prices leading to large year-to year fluctuations in production. They note that the lack of access to storage systems and services such as storage, packing and transportation is a major constraint in the production of larger quantities of potatoes, vegetables and fruits. Bangladesh, it is reported, had storage facility for only 2.Im MT of potatoes in 2008.According to available information, storage capacity has not increased much since then.

The lack of ability of farmers to sell their produce at cost-recovery prices has had a particularly perverse impact on the integrity of the food supply chain. Small and marginal farmers are often denied fair prices during harvesting season as they are forced to sell their products to profiteering middlemen, who stockpile and sell those at much higher prices later. This middlemen often resorts to spraying/injecting chemicals to increase the shelf life of the products in ways that are injurious to human health and safety. Availability of low cost storage facilities could help farmers to keep their produce fresh and safe, eliminating the use of formalin and other poisonous substances from food chain. Multiple independent studies point to serious infrastructures and logistic problems in the agriculture sector which have led to the widespread and unbridled contamination of food supplies. These include the lack of cold storage/dryer and transport facilities, premature harvesting, profit mongering by businesses and the absence of a licensing and monitoring authority. John Ryder, chief technical adviser of the Food and Agriculture Organization (FAO) in Dhaka stated recently that "the most effective way of preserving and keeping food items after harvest is to store those in suitable temperatures"

2.Background Information:

The Renewable Energy and Energy Efficiency Programme (REEEP) of GIZ has conducted a feasibility study of waste heat recovery from selected power plants for operating cold storage in support of Sustainable and Renewable Energy Development Authority (SREDA), Power Division, Ministry of Power energy and Mineral resources (MPEMR). The study has revealed that Power Plants specifically single cycle Power plant has large potential of recoverable waste heat in different scale. In general, the temperature of different power plants' exhaust flue gases varies approximately from 150^0 C to 570^0 C, e.g. in open cycle power plant at a range from 500^0 to 570^0 C, in combined cycle power plant from 150^0 C to 170^0 C, in engine generating set based power plants from 260^0 C to 570^0 C, in steam turbine thermal power plants from 105^0 C to 145^0 C etc. This waste heat can be used for drying air, serving industrial ovens, cooling and serving hot water.

Now –a- days, agricultural food/fish/fruits drying for export market purpose is becoming an interesting concept in some countries considering adequate demand for such products. For quality food this drying of food should be indirect drying by means of a Heat Exchanger where inlet air of a blower becomes hot by taking heat from waste heat of flue gas. In this regard, exhaust gas heat exchanger with bypass unit typically located adjacent to the engine mounting or mounted on the path/roof of exhaust gas chimney, is required to utilize waste heat from exhaust. Moreover, belt dryers can be used to take advantage of low-grade waste heat as they operate at lower temperatures than other dryers for food drying.

To design and finalize the position of such heat exchanger (dryer) in respect of exhaust port of engine generating set, a site specific study is required to develop conceptual design to capture the waste of the flue gas and to use it for heat exchanging to air to make it hot and flow over the food carrying dryer for food drying. For quality food, in the design the direct exhaust gas flow over the food could not be an option. Therefore, there should be a provision for controlled exhaust flue gas flow inside of pipeline of heat exchanger and surrounded air flow by means of motor operated blower through inbuilt pipeline can be considered. As this type of waste heat use for drying is very new concept in Bangladesh perspective, GIZ REEEP and SREDA have conceptually agreed to conduct a study to develop conceptual design of dryer incorporating exhaust gas heat exchanger bypass mechanism and food drying bed/belt to have a pilot project for food drying specifically for drying mango bar/banana chips/vegetable etc. The initial selection of single power plant for proposed pilot project will be among from public owned reciprocating engine based power plants located at Chapainawabganj, Khathakhali orSantahar in north western part of the country where there is potential waste heat source and demand/supply of considerable food feed stocks of exportable foods for drying purpose. Incorporating the study findings, GIZ want to develop a pilot project concept and business model of suitable dryer for agro foods drying using exhaust waste heat from selected power plants with support from individual Expert for site specific technological and resources assessment. The expert services includes survey, technological feasibility, conceptual design and layout, and cost estimation of such system considering best practice technological options, available land, existing site layout , potential heat source etc

3. Problem Statement:

The main challenge in the way of recovery and utilization of waste heat from three selected power plants towards drying of food stuff is combination of recoverable waste heat in relation to sourcing of food/fruits and space required .The power plants proposed for the purpose under study are Katakhali 50 MW power plant,Chapainababganj 100 MW power plant and Shantahar 50 MW power plant. Out of these three, Katakhali being located in

Rajshahi City Center has severe space constraint for which such a food drying sysyem can't be considered there. Chapainababganj & Shantahar have sufficient spaces but source of food is sufficient but seasona. Seasonal mango is available in chapainababganj and vegetable like tomato, cauliflower, potato, brinjal and bean are season specific,too. Market of dry fruits/vegetables are assured both locally and abroad. The plants were visited from October 18 to 20, 2017.

4. Study Objectives Scope of services:

To utilize the potential waste heat from exhaust gas of selected reciprocating engine based power plants, the proposed expert has to recommend site specific appropriate dryer configuration incorporating exhaust gas heat exchanger with minimum and maximum size, the processes, suitable position of the exchanger connectivity stack, suitable technological options of proposed dryer with a capacity range of drying food product per hour, drying temperature and other related parameters/issues. This specific conceptual study will analyze, in details, readiness measures, heat transfer mechanism and will generate reports with clear recommendation for a pilot dryer project for implementation. In this regards the assignment will have the following components.

Component 1: Base line study and Readiness measures for selected power plants:

The Expert(S) will survey, analysis and suggest a suitable power plant site among public owned single cycle engine generating sets based selected power plants in the north western part of the country considering the optimum heating capacity using recoverable waste heat of exhaust gas from the plant, drying utility etc. Considering the option of exhaust heating tapping, the Expert will provide the conceptual technical design of the modification required the capture the heat from the exhaust heat paths of stack or from suitable options of the plant which will be convenient for implementation and efficient operation. This component will incorporate desk study, communication with respective power plants, field scouting and will provide site specific basic data, existing design and proposed modification plan to capture the waste as well as its utilization for drying effect creation at required level. The Expert will recommend most promising food name for selected site that could be suitable for export oriented market as well as drying.

Component 2: Waste gas heat exchanger Unit and heat transfer mechanism:

The Expert(S) will identify the suitable technological option for food drying at selected power plant including installation of waste heat recovery unit based on specific site condition. The Expert will provide conceptual technical design, data and drawing of site specific waste heat exchanger unit /dryer including main component parameters, category of construction materials, cost estimation, example of potential service providers etc. along with pilot project implantation road map.

Component 3: Technical design of dryer system:

The Expert(S) will provide suitable technical options and lay out of belt/bed type dryer system to utilize the waste heat potential of that power plant considering future expansion provisions and preserving food quality. Each technological option will incorporate drying capacity (kg/hr), type of product(S) that can be dried, drying temperature, hot air flow rate from blower, energy consumption pattern, cost issues, service provider information along with environmental management issues.

5. Methodology of study:

1. Desk Research
2. Field visits at selected power plant site(s) and meeting power plant authority

3. Data gathering, consultation, analysis and support report preparation along with conceptual design, standard drawing incorporation, recommendation etc.
4. The Experts will provide necessary inputs to another co-operation expert to prepare the conceptual design, cost estimation for the recommended design, but will get GIZ technical input in developing the business model.
5. The Expert will work together with co-generation expert to achieve same goal and their work should be complementary to each other and deliverables should be specified for each expert.

6. Boundary of the study: Deliverables:

Draft conceptual design with system components, drawing in block diagram.

Draft final report on the above-mentioned scope of services.

Final report based on incorporation of feedback from REEEP and SREDA (Power Division)

1. Inception Report.
2. Delivery of collected data (through field visits) and information to co-generation expert for the required design.
3. Coordinated review on Final Report.

7. Desk Study:

(i) This is based on data received from the plants during the aforesaid visit and data received subsequently from the plant authority over phone

(ii) Drying system was originally being devised through steam. This was abandoned during a briefing at GIZ Office on 2/11/2017 when the focus was shifted to drying through exhaust heat

(iii) Theoretical calculation of recoverable waste heat:

CHAPAINAWABGANJ:

- Exhaust Gas Flow Rate= 8924 Kg/hour
- Exhaust Flow Gas Temperature = 356 Degree C
- Capacity of each machine = 8.92 MW
- Total Engine unused for waste heat recovery= 5 (Rest 7 are occupied with boilers for steam generation for pre-heating liquid fuel, Furnace oil).
- Specific heat of Flue Gas = 0.24
- Total Heat from Flue Gas= mst= 8924 x 0.24 x 356 x 5 = 38,12,332.5 Kcal which is sufficient to run 38,12,332.5 /96000 = 39 sets of Dryers.

SHANTAHAR:

- Exhaust Gas Flow Rate= 8924 Kg/hour
- Exhaust Flow Gas Temperature = 520 Degree C
- Capacity of each machine = 8.92 MW
- Total Engine available for waste heat recovery= 6
- Specific heat of Flue Gas = 0.24
- Total Heat from Flue Gas= mst= 8924 x 0.24 x 520x 5 KCal = 66,82,291.2 Kcal which is sufficient to run 66,82,291.2 /96000 = 70 sets of Dryers. NOTED:

  (a) Currently, all the six engines are occupied with boilers generating steam mainly for pre-heating Furnace oil;
  (b) Learnt that output of two boilers is enough for fuel pre-heating purpose. The output of the rest of four engines can be utilized for vegetable drying purpose

(iv) **System details as below :**

Exhaust Gas Driven Dryer

- Each Engine Capacity: 8.9 MW
- Engine Model: Wartsila 32
- Exhaust Flow Rate: 8924 kg/hr
- Exhaust Temperature: 356 Degree Celsius
-Dryer Capacity: 1 Ton/Batch
- Raw Materials: Fruits and Vegetables
- Total Heating Capacity: 4.5 Ton
- Moisture Rate of Raw Materials: 82%
-Drying Time: 12 Hours
- Moisture After Dry: 18%
- Working Temperature 20-80 Degree Celsius
- Temperature Difference Between Top
- Temperature Control: Automatic
- Heating Medium: Hot Air
- Heating Area: 160 sqm
- Dryer Inside Unit: 4
- Dryer Size: 4620mm X 2060mm X 2000mm

Equipment Cost: USD 40,000.00

System Installing Cost USD 10,000.00

Total Cost in USD 50,000.00

Steam Driven Dryer

1. Heating capacity: 3500~4000kg/d (drying time ≥ 8hrs/batch)

2. Moisture of raw material: 50~70%
3. Moisture after dry: 10~30%
4. Dryer size: 8400*2200*2280mm
5. Inner size: 8000*1700*1570mm
6. Working temperature: maximum 120℃; Temperature difference between top and bottom: ± 5℃
7. Temperature is automatic control in dryer, actual working temperature is 50℃
8. Heating medium: steam (consumption: about 500kg/h)
9. Dryer inside unit: 8 units
10. Circulating fan: 6 sets; each unit uses 1 set fan, fan power 2.2kw, air flow rate 4000m3/h, air pressure 1150pa
11. Material: dryer inner is SS304, outer is carbon steel with painting and insulation
12. Inside set wind adjusting plate to make hot air average flow on raw material
13. Control box uses Chinese famous brand element
14. Dryer cart: 20 sets, material SS304
15. Dryer plate: 480pcs, unit size: 640*460*45mm, material: SUS304
16. Dryer is separate to 3 wind room (each room uses 2 sets circulating fan), each room could manual adjust wind valve

Equipment Cost: USD 55,000.00

System Installing Cost USD 15,000.00

Total Cost in USD 70,000.00

Potential Service Provider:

- Green Tech Energy Industrial Co Ltd.Add:51 hailun Road,Qingdao,China.
- Anglo Straits Sdn. Bhd.Add:09,Jalan Pjs 8/9 46150,Selangor Darul Ehsan,Malaysia
- Z power Technology,Singapore

- **Implementation Road Map:**
- \- To obtain concurrence of Power Plant Authority as regards using unused waste heat from engine-gen sets;
- \- To select vendor;
- \- To award to the selected vendor;
- \- Awardee to complete the project in three (3) months on turnkey basis;
- \- Service Provider to ensure one (1) year warrantee from the date of Final Acceptance;
- \- Service provider to provide training including warrantee period engineeing service.

8.Field visit,datgathering,data analysis

Under took visits to three power plants located in northern areas of Bangladesh.The visit took place during the days of October 18, 19, 20/ 2017. Participated by:

- ❖ S.M. Zahid Hassan of GIZ
- ❖ Md. Siddiqur Rahman, Power Plant Expert.
- ❖ Atikur Rahman Nahid
- ❖ Hibibur Rahman, Project Manager, Wattson Group

The Plant Visited are:

- ❑ Katakhali 50 MW Peaking power plant
- ❑ Santahar 50 MW Peaking Power Palnt
- ❑ Chapainawabganj 100 MW Peaking power plant

- Katakhai plant being at Rajshahi City center was discarded for further study as the area allows no space for installations to be run with waste heat.

- 50 MW plants comprised of 6 identical Engine-Gen sets each with capacity 8.92 MW
- 100 MW plants comprised of 12 identical Engine-Gen sets each with capacity 8.92 MW
- Generators are run by Reciprocating engines with HFO (Furnace Oil) as primary fuel.
- Each plant utilizes waste heat to generate steam mainly for pre-heating furnace oil through Exhaust Gas Boilers connected at the exhaust of some of the engines.
- Each boiler generates steam at the rate of 2.5 T/H at temperature 165 Degree Celsius and pressure 7 bar.
- Engines releasing exhaust to the atmosphere might be potential sources of heat for food drying system.
- Number of engines without boiler-Chapainwabganj-5 Units
- All the 6 engines in Shantahar are occupied by Exhaust Gas Boilers.
- All this six engines are now occupied by Exhaust Gas Boilers . However, at least 66% of the steam generated might be used for food drying system
- Chapainawabganj produces mangoes in abundance and so this plant will have the mango drying system by using heat directly
- Abundant cauliflowers are produced in Shantahar where the drying system will be for cauliflower by steam
- Both the plants have enough vacant areas for dryer set up.

8. Study Findings

(i) Katakhali being at Rajshahi City Center has severe space constraint. So, this may be discarded from study;

(ii) All the liquid fuel based power plants are potential sources of recoverable waste heat suitable for food/fruit drying project;

(iii) Chapainawabganj is famous for high quality mangoes and so suitable for mango drying system;

(iv) Shantahar is famous for vegetable production and so a vegetable drying system can be considered there.

(v) For Pilot project initially one dryer machine is proposed for implementation. However, for direct exhaust dryer we can use the exhaust of any engines which remain unused for co-generation system.In that case no system modification is required just giving exhaust pipeline connection to dryer. The drier location can be within 50m distance from exhaust chimney point.

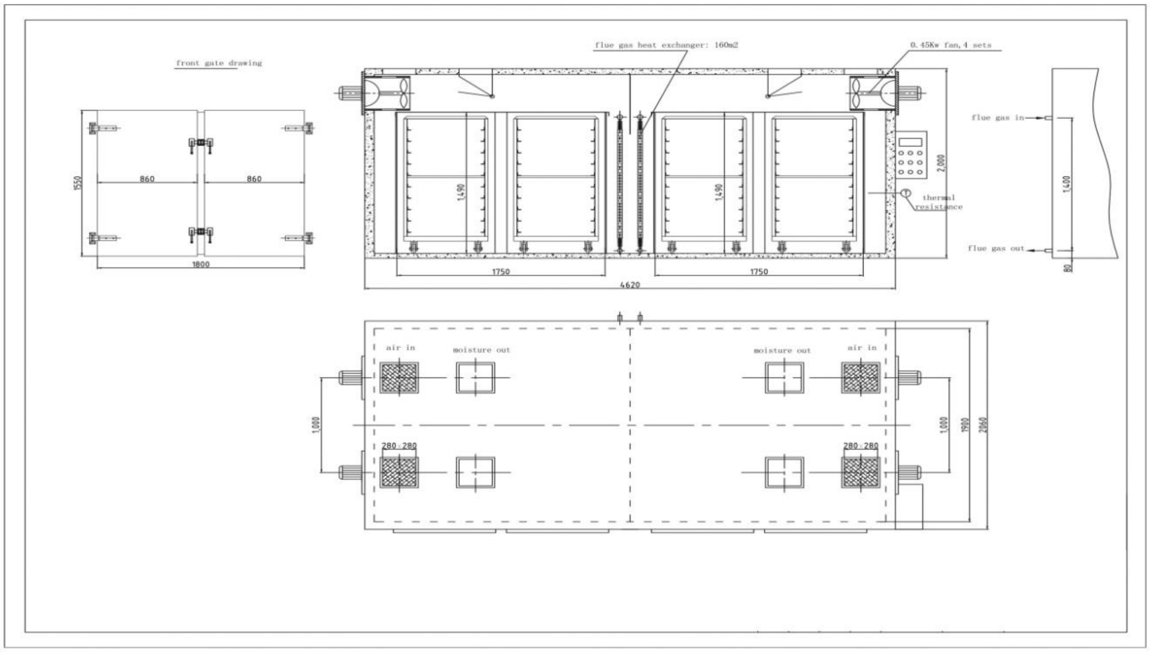
(vi) For Steam dryer :Existing steam line can be used for this drier.Just need pipeline connection with steam regulating valve.

(vii)

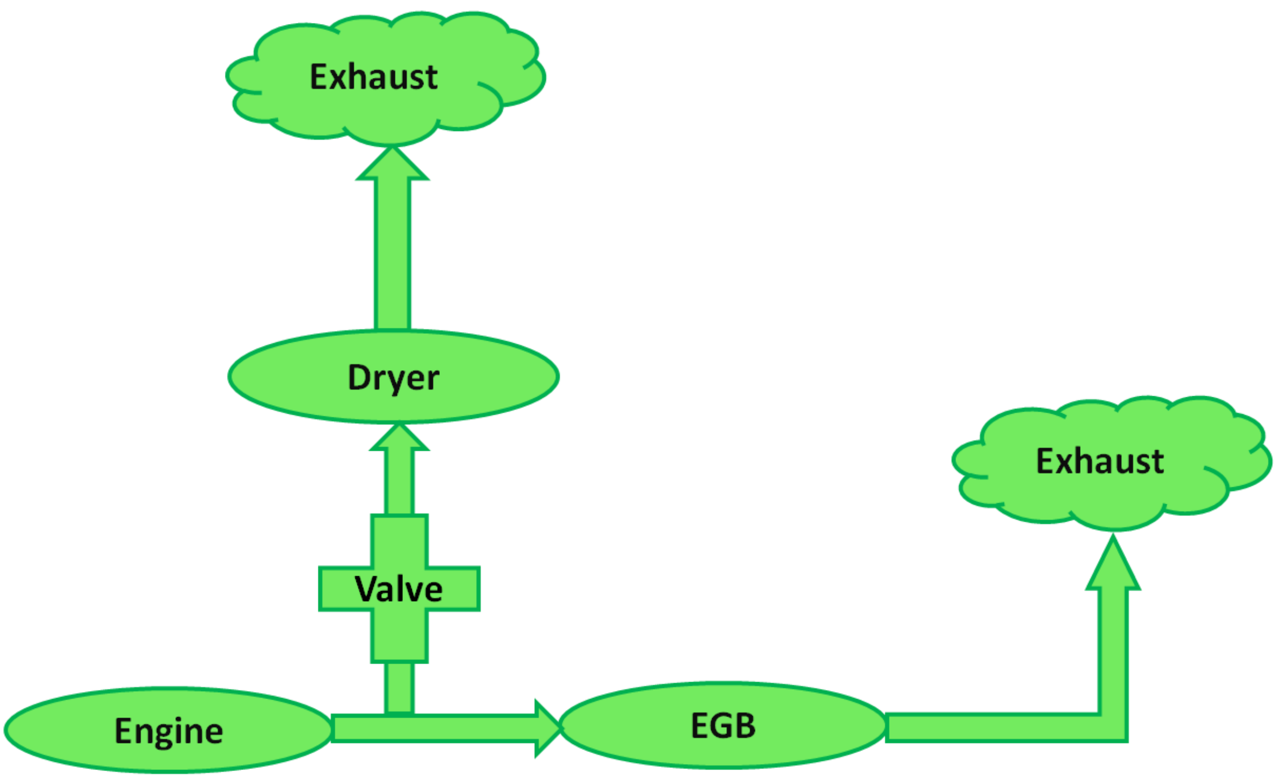
9. Recommendation/Conclusion:

(i) Pilot projects one each for Chapainawabganj and Shantahar for fruit and vegetable drying are recommended;

(ii) Since fruits and vegetables are seasonal, the two power plants should be allowed to run upto their availability agreement with full capacity during the season of fruits and vegetables.



front gate drawing
flue gas heat exchanger: 160m2
0.45Kw fan,4 sets
flue gas in
flue gas out
thermal resistance
air in
moisture out
moisture out
air in
280×280
280×280
1550
860
860
1800
1,490
1,490
2,000
1400
80
1750
1750
4620
1,000
1,000
1900
2060



Exhaust
Dryer
Valve
Engine
EGB
Exhaust