

# Thermochemical Gasification (TCG) Waste to Energy Summary of the Project Proposal – Jordan

## Part II

### Deir Ala and landfills Pilot Project

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## Executive Summary

The Thermo-Chemical Gasification Technology utilizes municipal solid waste, sewage sludge, residuals, and other carboniferous waste and materials in closed, zero-emission thermo-degradation, to generate clean energy in an environmentally friendly way.

This is a technical study concerning this thermos-chemical gasification and alternative energy technology, specifically tailored to Jordan's Pilot Project in Der Alla and Zarqa.

The main Thermo-Chemical Gasification (TCG) in Waste to Energy Project in Jordan, hereafter referred to as “**TCG W2E Jordan**” main proposal document, has already covered an overview of the global and national scene in addition to the basic technical information, knowhow, rationale and feasibility based on already-achieved models. **This document is a continuation** and covers the pilot project in Der Alla town (Al-Balqaa Governorate) and Zarqa city (Zarqa Governorate).

The economic cost of the project is 1.5 billion euros, with 5 units, so that the unit cost is 300,000 million.

This phase will attempt to first operate 2 units in Der Alla at 300 million each, or 600 million both, so that both units will consume 1000 MT on daily basis and process them in a clean environmentally safe operation.

## Overview

Jordan has a population of 10,478,335 [Worldometer - UN Data], 30% of which are non-Jordanian due to repetitive crises and refugee waves into the country, adding a burden on the already exhausted resources and over-burdened infrastructure, with an annual 2% population increase, all of which lead to increasing solid waste and the need for its optimal management.

Opposite Map: → Governorates of Jordan

[Source: Wikimedia Commons].

In Jordan, 1 kg of waste is produced per capita per day (1 Kg/Capita/Day), as per the Ministry of Environment (MoEnv), rendering about 3 MT of solid waste per year of which only 300,000 tons are recycled at a maximum of 10% of the total generated waste, with directives to “increase this percentage to 40% - 50% by 2030.



## Der Alla & Zarqa Operations

The following table by MOLA – Directorate of Solid Waste Management, suggests these amounts in Metric Tons (MT) per day foreach governorate, for the year 2020, in descending order:

| Irbid | Zarqa | Salt | Amman | Mafraq | Karak | Madaba | Ajlun | Jerash | Aqaba | Maan | Tafila |
|-------|-------|------|-------|--------|-------|--------|-------|--------|-------|------|--------|
| 1950  | 1450  | 630  | 624   | 600    | 410   | 280    | 250   | 246    | 225   | 178  | 169    |

Using old 2020 figures (and expecting that they increased in 2023), the total produced solid municipal waste amounted to 2,588,135 MT and the total produced solid GAM waste amounted to 1,277,500 MT leading to a total of 3,865,635 MT.

### Other Initiatives and Stakeholders

The **National Strategy for the Solid Waste Management** initiative attracted an EU grant and technical assistance on the level of infrastructure, facilities and governance. The **AFD** on the other hand intervened on the level of Al-Ekaider, Al-Hussainiyat and Al-Aghwar Al-Shamaliyah Sanitary Landfills in addition to the North-West, North-East and Central Transfer Stations.

The AFD is working with the Solid Waste Management Department of MOMA – Project Implementation Unit (PIU) in line with a nationally supported Stakeholders Engagement Plan (SEP) throughout the “Support to the Implementation of the National Solid Waste Management Strategy” Project, along with the Environmental and Social Commitment Plan. According to AFD communications, Jordanian stakeholders who affect or are affected by this initiative were identified and rallied from national government entities, local governmental agencies, non-governmental organizations, academic and research institutions, and local community representatives. These include, but not exclusively:

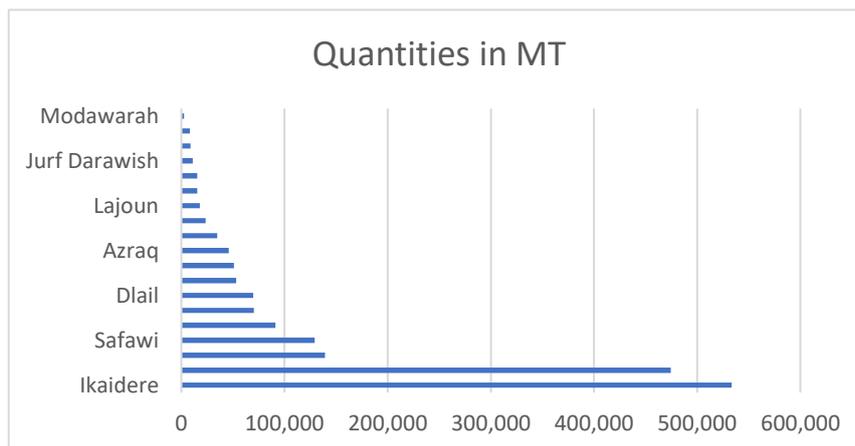
- **Ministry of Environment, MoEnv**, Validates Environmental Impact Assessment; Oversees municipal solid waste management.
- **Ministry of Health, MoH**, Monitoring professional Health and Safety.
- **Water Authority of Jordan, Waj**, environmental impacts on soil, groundwater and surface water solid waste disposal sites.
- **Ministry of Labor, Mol**, workers health and safety.
- **Joint Service Councils, JSCs**, Municipal solid waste collection and treatment.
- **Ministry of Finance, Department of Land & Survey, Mof**, registrations, issuing property statements.
- **AFD**, manages EU funds and supervises solid waste projects. It identified the following impacting / impacted stakeholders (in alphabetical order):
- **Nearby citizens**: Potential displacement or discomfort.
- **GIZ**: Solid waste collection, training, cash for work, sorting and recycling, integration of informal workers (waste pickers) into formal framework / employment, livelihood recovery plan for solid waste projects.
- **EU**: Partial solid waste projects funding.
- **MoMA**: Leads and implements, Central Bank account & payments through PIU, KPIs (with EU & GoJ), technical assistance experts, auditing, liaising with GoJ line ministries and agencies, reporting, etc.
- **Municipalities**: Responsible for MSWM (collection, transfer/transport); Paying Municipal contribution to the JSCs for further MSWM activities (mainly treatment).
- **Local economies**: Potentially impacted.
- **UNDP**: AL-Ekaider landfill upgrade, recycling, training, institutional support to municipalities and waste pickers integration into formal employment.
- **Waste pickers**: Manual sorting, utilize recyclable material (formal); source of conflict (non-formal).

**EDAMA**, a leading Jordanian NGO advancing Jordan’s green economy and water-energy nexus, is promoting a Mediterranean Dialogue for Waste Management Governance, (issued tender) towards environmental protection, climate change adaptation while prioritizing reduction of municipal waste generation, promotion of source separation and optimal exploitation of organic components. This initiative is funded by the ENI CBC MED-EU, and partnered by several universities in several countries.

## Rationale by TGC

The difficulties that are facing the Ministry of Environment (MoEnv), the Greater Amman Municipality (GAM), and the Ministry of Local Administration (MoLA), inclusive the municipalities in the Governorates of the Kingdom, include solid municipal waste with high carbon content that produces 100% carbon emissions. We noticed (and we stand to be corrected) that as advance-looking was the National Strategy, it may have reflected such **gaps** as: a low level of waste management efficiency and system, with a low number of qualified dumping sites, from engineering and environmental perspectives to safely treat waste; large daily quantities of animal dung and poor quality of treated dung; lack of appropriate sludge treatments; the urgency of treating the rising number of slaughter houses wastes; lack of appropriate disposal of dead animals and uncontrolled / increasing breeding; and finally, the accumulation of untreated agricultural waste.

19 dumping sites are still based on manual sorting, with variant levels of treatment, ranging from sorting by hand, improper disposal b dumping or burial, posing risks of air and ground water pollution, to more advanced donor-led initiatives →



GAM is taking on the huge burdens of the capital, in doing so it is working (often traditionally inclined) at Al-Ghabawi Dumping site, as an investment in turning dense solid waste into electricity through liquified natural gas (often containing methane, ethane and impurities such as carbon dioxide, poisonous hydrogen sulphide, water vapour, etc.). Normally, impurities are removed using acids or other treatment methodologies. However, GAM is generating electric power from untreated natural gas that has impurities for lack of the gas treatment device leading to CO<sub>2</sub> and H<sub>2</sub>S that erode internal gas torpedoes used to generate electricity hence decreasing its capacity. The H<sub>2</sub>S combustion with natural gas produces SO<sub>2</sub> that combines with water vapour in the atmosphere leading to acide rain, while increasing Cos emissions. If vapour is not removed it will create the OH hydrate causing inner pipe freezing and blockage – vapour can be removed using separators and scrapers (within GAM's capabilities). Moreover, the natural gas is attained through burial which is not seepage-proof of ethane into the atmosphere. Following this procedure, GAM would still have to transport the rest of the waste to another dump site, hence negating full waste conversion.

Normally speaking, the resulting 86% methane and 5-8% ethane are gaseous at room temperature, and liquified by cooling to (-) 162° C to facilitate transport. However, this is done after eliminating impurities that are harmful to the gas treatment units, such as acidic gases, CO<sub>2</sub>, H<sub>2</sub>S. But GAM is

generating electric power from unprocessed natural gas that includes impurities due to the lack of these treatment units. This causes damage to internal gas turbines, hence reducing the efficiency. Furthermore, the combustion of hydrogen sulfide with natural gas produces sulfur dioxide that combines with water vapor in the atmosphere leading to the acid rain phenomena, not to mention increased CO<sub>2</sub> in gas turbines, which is also harmful to the environment. Unremoved water vapour causes hydride formation in the form of frozen water inside pipes causing blockage and impairing feeding turbines whose functions include filtering, catching and separating impurities through water separators and scrapers.

Methane gas leads to higher temperatures and climate change. Transferring it to other dump sites does not get rid of the waste nor convert it to eco-friendly elements.

The amount of electricity generated, according to the covers 45% of the municipality's consumption. So the question remains: how many tons of waste were used to produce 4.5 MWh?

Ghabawi has 3 generators drawing methane and generating energy. Each unit produces about 1.6 MWh. The maximum is 4.8 MWh, so that the area of each generator is 5 ML x 4 ML. The area of Al-Ghabawi is 2000 Donums of land per cell, about 170 – 190 dunums, yielding a capacity of 4 million tons of mixed waste, this means that the efficiency of methane gas is low compared to the organic waste volume.

Scientifically, organic waste need 6 months to ferment and produce methane, but that is not happening given adopted landfill process.

In conclusion, the Ghabawi project does generate energy but not in an environmentally friend way, furthermore, the costs related to malfunctions and maintenance are very high. The fact that 3,000 MT of waste is used to produce 4.5 MWh, is indicative of system inefficiency and environmentally unfriendly.

In comparison, the TCG technology, will yield 130 MWh – in addition to biofuels, from 3,000 MT of solid waste and yield environmentally friendly products.

As for gas liquification, this is expensive for GAM, and cannot be afforded, as it needs intense cooling and special equipment. Undoubtedly, a lot of legislative changes are needed without delay, that is costing dearly on the level of human health and environment protection.

According to official sources, approximately 3,000 metric tons of waste are delivered daily to the Al-Ghabawi landfill; however, recycling rates do not exceed 7% of the total waste stream. Of this limited recycling activity, only about 900 tons originate from the commercial sector, resulting in an effective recycled quantity of approximately 63 tons. The current waste-to-energy approach at Al-Ghabawi generates only about 4.5 megawatt-hours, which does not reflect optimal utilization of the available waste volume. More advanced technologies are available that can generate more than twice this level of electricity, with each unit requiring only 500 tons of waste, highlighting a significant opportunity to improve efficiency, energy recovery, and overall waste management performance.

When it comes to the declared electricity coverage of 45% of GAM's own use, the question is how many metric tons of waste were used to produce 4.5 Megawatt/hour (MWh)?

Al-Ghabawi Project is based on 3 generators that suck methane to general electricity at 16 MWh each reaching the maximum of 4.5 MWh. The dimensions of each generator is 5 ML (length) x 4 ML (width), given the large Ghabawi area of 2500 Donums land. Each cell needs about 180 Donums. Total waste capacity is 4 million MT of mixed waste, with low methane efficiency in comparison to

organic waste. Scientifically speaking, pure organic waste needs 6 months to ferment and produce methane gas. At the end of this process the methane gas is not efficiently dealt with. Yes, the project is producing energy but it is neither environmentally friendly nor easy nor cheap to maintain, nor is it feasible to enter 3000 MT of waste to produce 4.5 MWh without efficient comprehensive disposal of waste. What is produced is natural impure gas as opposed to (costly) liquified, causing cell damages. Using the TCG technology, a 3000 MT of waste amount will be fully converted to environmentally friendly outputs plus 130 MWh of electricity in addition to fuel. At the end of the day, the waste of 3000 MT that reach Al-Ghabawi is recycled at 7% of potential commercial sector production leaving untreated 2,937 M.

As for sludge that is resulting from treating sewage and used to create biogas to generate electricity, as according to the Minister of Water and Irrigation and the Secretary General, 10 wastewater treatment plants are required to produce biogas from sludge by 2040, with a fund of 69 million Euro. Our question is “can you define biogas and how it is going to be produced? Moreso, what are the health and environmental impacts – not to mention the feasibility of its production?”

Biogas results from anaerobic organic matter decomposition; it contains impurities, over and above methane, carbon dioxide, nitrogen, sulphur dioxide and hydrogen as follows: CH<sub>4</sub> (50-75%), CO<sub>2</sub> (25-50%), N (0-10%) SO<sub>2</sub> (0-3%) and H (0-1%). This composition is based on the anaerobic process.

#### **Drawbacks of this system that compromise biogas production efficiency, feasibility and pose threats to the environment and health:**

- biogas can yield Siloxanes (from detergents), whose combustion can lead to precipitation on surfaces causing erosion that are costly to fix.
- harmful gases to equipment and environment must be removed prior to processing for energy production through: water rinsing, pressurized succession or chemical treatment. This will elevate its purity to 98% using 3-6% of total produced energy from biogas.
- purifying biogas from impurities is costly and requires high energy. If we were to apply this process what about the harmful H<sub>2</sub>S and CO<sub>2</sub>? Are biogas quantities economically feasible? What sludge volumes must be used by MoWI to be produce sufficient electricity – for sure it cannot produce more than 1 – 2 MW, at its best.
- manufacturing biogas in this way has not technologically progress, due to its shortcomings; thus far there has been no effective methodologies to simplify the process and render it feasible and less costly.
- once again, this type of production yields impure biogas that harms equipment and calls for repetitive maintenance and high costs.
- this process can only take place in specific high raw material dense locations.
- producing biogas this way is sensitive to temperature and weather; the concerned bacteria for producing natural gas requires an optimal temperature of 37 Degrees Centigrade.
- in conclusion, given MoWI R&D activities, why haven't there been any changes over long periods of time?
- According to the Ministry of Energy, we have a surplus of electricity production, why would MoWI waste 69 million Euro to carry out a project till 2040 whose impact and outcomes on beloved Jordan we do not know.
- TCG can give solutions to get rid of the sludge in eco-friendly ways – heading safety standards and good energy yields.

The Minister of Energy is negotiating 600 million USD with the Banks Association to produce hydro-electric power from dams. Our comment here is that Jordan has relatively small dams, and to produce feasible hydro-electric power one needs to convert the kinetic energy of moving water using water

turbines. Our concern is that Jordan does not have sufficient dam volumes to yield large quantities of electricity; nor the luxury of using and compromising potable (drinking) water; not to mention we do have electricity surplus as declared by MEMR officials – unless we export electricity to neighbouring countries but NOT on account of potable water – not to mention weather restrictions.

If electricity is sought for, TCG can avail 136 MWh – without any cost born by Jordan, quite the contrary, it will create high income reaching billions and avail youth employability.

The TCG comes with added values that focus on the green economy, green buildings and land, caution to water scarcity, and food security, green tourism, climate change adaptation and mitigation, sustainable vegetative lands, etc.

### Legal overview

The Original owner of the TCG technology is the SYNEN Group, headquartered in the US. SYNEN has communicated officially with the Government of Jordan (GoJ), Ministry of Environment (MoEnv), copying the Ministry of Local Administration (MoLA), Royal Court, Prime Ministry (PM), Ministry of Energy & Mineral Resources (MeMR) Greater Amman Municipality (GAM), to introduce the TCG-UC500 W2E Projects (*Thermo-Chemical Gasification Unit Capacity 500, Waste to Energy*), so that it is intended to build and invest on Jordanian land with secured donors financing. The communication attests to the fact that Far East Project & Development Company, represented by Director Engineer Mohammed Al-Khatib and Regional Director Mr. Khalif, is a standing member of the SYNEN Group, who represent the TCG-UC “the technology provider” with the TCG-UC W2GE, mixed waste to energy and treatment project. The same project is being implemented through several companies in the US, UK, UAE, Switzerland, Hungary and others.

### Project objectives and economic impact:

- Contributing with the Ministry of Environment to preserve the environment
- Contributing to energy security
- Creating more than 5000 job opportunities
- Promoting employment as a priority
- Streamlining gender and empowering women in decision-making
- Secure jobs for persons with disabilities (PWD) and vulnerabilities
- Education, training and capacity building
- Production of main energy
- Stimulating the Jordanian economy
- Creating infrastructure for the governorates
- Operating local companies.
- **Social Corporate Responsibility:** Empowering the local community, creating ownerships and partnership, focusing on diversity and inclusion, specially women and youth by raising awareness and building capacity in relation to solid waste, recycling, and initiating community resource-based small business.

### Comparative advantages:

- Flexibility of the project by converting from one product to another as needed

- Contributes in driving the Jordanian economy by pumping 1.5 billion euros and aid to the infrastructure and local communities
- Adds to the importance of production lines in Jordan as a pioneer in climate change (CC)
- Compatible and in line with national legislations, laws and priorities
- In line with the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement (PA)
- The module is a modular system, which is easy to disassemble and re-create on different sites
- Reduces Carbon Dioxide (CO<sub>2</sub>) from 100% to 20%
- Does not require specific or unique infrastructure, facilities or support units other than those that are an integral part of the system. It is designed for continuous operation and is self-sufficient (after initial start-up with an external heat power source, the system uses a small amount of synthetic gas produced to maintain the process).

### Active steps forward

- The State is a main partner without any financial or international obligation.
- The duration of the project is 25 years (2,500 tons of waste per day), valued at 6 billion Euro
- Jordan will be the focal point of the project, which will be branched out to neighbouring countries, such as Iraq and Lebanon
- Creating green cities, especially in industrial cities zones, completely greened with competitive electricity prices through partial connection to the network. Target groups: investments and new investors.

### Expected challenges

- Sorting waste and transferring for recycling or exporting abroad
- Waste pickers and bidders that rely on sorting and selling scrap.
- Grants provided for landfill rehabilitation projects, that do not promise eco-friendly solutions and high efficiency. These grants can be re-directed to other areas of concern mentioned in the national strategy.

## TCG W2E Jordan Der Alla

The TCG aims to have 5 or more operating units in Jordan, at the rate of 500 MT of solid waste per day, as part of a mega-national project over 25-30 years with an expected return of 5 billion US\$. This project is a public-private partnership together with the Government of Jordan (GoJ) and its line ministries, so that a complete transfer of know how is exercised and revenue is created for the GoJ.

There are two ways to start:

- Rely completely on the donor to establish the project
- Take initiative and cover some of the preparatory steps which means that we are investing our own funds and resources in what we believe is a successful and rewarding pilot that can be scaled up and rolled out in the hands of the Government of Jordan.

We decided to get the project started on the grounds, albeit modest steps, yet in the right direction through gradual and prudent progress in order to:

- Get instant feedback that feeds into next steps

- Showcase and prove the merits and positive impact of the project, as intended, to get further support into appropriate expansion, as deemed fit.

## Phase Zero - Preparatory Phase

**On the 4 Dec 2022:** We received approval on Solid Waste Dumping Site Renter against 22 K JD  
Reference: HKJ Ministry of Local Administration (MoLA). Joint Services Council. Al-Aqhwar Al-Wusta No. 22/1/- Dtd 4/12/2022

**On 23 Jan 2023:** We Received approval on the requested rehabilitation works:

- Caravan at the entrance
- Solar panels for lighting
- Solar panels for industrial devices (3-phase electric power)
- Identify an area of 50 ML (façade) 30 ML (depth) for final sorting and dispatch
- Plant area into green land
- Staff room (dismantlable)
- Build a hangar with its infrastructure, area of 20 ML (facade) 40 ML (width)
- Use small bulldozer to sort and move waste
- Place and use crusher for plastics, cardboard, aluminium
- Place and use modern electrical sorting machines

Reference: HKJ Ministry of Local Administration (MoLA). Joint Services Council. Al-Aqhwar Al-Wusta No. 22/1/32 Dtd 23/1/2023

**On 15 Dec 2022:** We signed a one year rental contract from 15 Dec 2023 – 15 Dec 2024 (where the future Der Alla TCG Unit will be installed)

Reference: HKJ Ministry of Local Administration (MoLA). Joint Services Council. Al-Aqhwar Al-Wusta

The most economic and effective utilization of solid waste and optimum operation of the unit requires that the feed is pre-sorted (**rocks and other non-carbon materials, silica, glass and minerals must first be removed** and the pre-sorted waste must be passed into inch-size feed). **Shredder systems are readily available in the market** and do not require a large amount or excessive investment. Many, if not most, solid waste collection and treatment companies have pre-sorting systems readily available at their sites. If a pre-screening system is not available, the supplier will provide such a system at a very reasonable price.

## Phase 2 – Pilot Projects in Der Alla and Zarqa

**Der Alla and Zarqa TCG Four Units** will sample and demonstrate the production on firsthand basis for the Government of Jordan, with the intention of replication in Jordan, each with the capacity of 500 MT daily that only covers a mere 20% of the total waste, without counting daily 3500 MT from Greater Amman Municipality (GAM). This means that there is a margin for growth in this technology AND that there is a huge space left for any other waste-to-energy initiatives, in order to diversify experiences and derive at the optimal human health and environment friendly solutions to Jordan. In the TCG Model, it is a win-win situation were waste is cleanly gotten rid of void of adverse impact on humans, animals, plants, ground water, the environment in Jordan at large and mainly reducing eye-sores. In fact, and (maybe we are getting a bit ahead of ourselves here), it is envisioned that in 3 years' time, one enters the TCG-Unit grounds to see ZERO waste, unlike the 19 municipal (rented-out) manually sorted dump areas that are not only a sore to the eye, but pollute air and ground, as waste persists on the grounds or is disposed of (somehow). This document skims over the situation in Jordan and zooms on the two intended locations technical and financial details, in order to lead pilot projects

into national rollouts with substantial impact on the health of people and environment, with sustainable income to the treasury of the Government of Jordan (GoJ).

Simply said, the TCG technology is using pyrolysis based on heating and NOT incineration, hence eco-friendly with almost zero emissions. The system's efficiency allows it to cover come all aforementioned gaps seen by the National Strategy. Moreover, we will rid the Ministry of Water and Irrigation (MoWI) of sludge that adversely affects water treatment plants; ease the load on local administration in acquiring large pieces of lands and constructing more dumping sites. Using this technology, a break-even point will be reached in Three years so that the entire incoming waste is fully consumed, leaving no chance for storage or burial at all!

Given the total solid waste of 3,865,635 MT in Jordan / year (2020 figures –expected to be more in 2023), and given that the TCG Project will cover 766,500 MT in 2023, then it would be fair to say that the total coverage amounts to more than 20% of the totally produced waste in Jordan. Should 2 more units be added, **the coverage may reach more than 30% of the total**; leaving plenty of space for either a national roll out or diversification of different waste treatment methodologies, all of which MUST have positive environmental and health impacts.

### TCC Units Locations

#### Der Alla Town in Deir Alla District in Al-Balqa Governorate

- Der Alla is a town in the Der Alla District, Mid Region of Jordan, between the northern and southern valleys, bordered by the Governorates of Irbid, Ajloun (North), Jerash (East), Salt (East) and Southern Shouneh (South) Districts and River Jordan (West).
- It has an area of 240 Km Squared, approximately and a population of about 75,000 approximately, at the rate of 300 capita / KM Squared.
- Der Alla is famous for its agricultural nature being a 'valley area', famous for its fruits and vegetables for local and export production
- Historically Der Alla hosted an Aramaic temple (2500 BC) hence the name Der (*temple*) Alla (*high place*), where the Canaanites went for their pilgrimage (1500 BC).

Source: GoJ-MoI



#### Zarqa City in Zarqa Governorate

- Zarqa is a major city in Zarqa Governorate that is adjacent to Jordan. Together with Amman and Rusaifeh, it creates a huge population density.
- The city has an area of 60 Km Squared, with a population of 572,690.
- The Governorate has an area of 4,761 Km Squared with a population of 1,509,000.
- Th unemployment reached 23.4% in 2019 (*unemployment does not include economically inactive*)
- Zarqa is a heavy industrial area, with half of the nations industries, some are solar powered
- Historically, it was named after Zarqa (blue) River, which was the 3<sup>rd</sup> largest in Bilad Al-Sham, Zarqa being an ancient Akkadian word so that zar means water and ka means area (Acadians are ancient Semitic Arabs)

Source: GoJ-MoI



The **comparative advantage of Der Alla** location is that it is in Mid Region, to be replicated in the Northern and Southern Regions, as part of the **First Phase of the TCG Waste to Energy Pilot**. It has also good agricultural resources and good tourism attraction. This is way the TCG project wants to go further than that. By working with the local community, it will focus not only on turning municipal and agricultural wastes to energy, but working with the local community to empower its resource-based small business, targeting women and youth, boosting diversity and inclusion, in addition to awareness raising and technical capacity building in saving water and resources, eliminating / reducing waste, recycling waste, using recycled material to create innovative businesses, taking advantage of tourism attraction to create and market products and small businesses and most importantly, creating a healthy environment and experience for the people of Der Alla and their visitors, in addition to creating the sense of ownership as partners in creating and preserving a clean Der Alla environment, to be replicated in 5 other Unit locations, before national rollout. This is to be achieved through CSR and donor support.

The **comparative advantage of Zarqa** is that is an industrial heavily populated area which means the pollution is high and possibly affecting the health. Proper disposal of the waste will particularly improve ground basin and river waters. The high employment is indicative that CSR can provide opportunities through saving, recycling and creating innovative small business initiatives and homebased women-run projects.

It is a win-win situation, so that the entire government and people of Jordan at large together with the environment will benefit on long-term and sustainable bases. Specifically, that the TCG-Units together with other existing waste treatment initiatives will expand to cover an entire eco-system, that pays back in the form of socio-economic benefits and healthier people and lands. It no only looks at mechanical sustainability but human behavioral changes, by engaging each local community differently based on their resources and needs. Systems can be built, sustained and maintained but knowledgeable communities. This means that communities will fight for the sustainability of these initiatives in challenging times.

#### TCG Units Coverage

|                                    |  |
|------------------------------------|--|
| 2 TCG Units in Der Alla will cover | 800 MT from Irbid + 200 MT from Salt     |
| 2 TCG Units in Zarqa will over     | 800 MT from Zarqa + 300 MT from Rusaiifa |
| Total TCG Units                    | 2,100 MT per Day, 766,500 MT per Year    |

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The Project yields the following products, provided that each UNIT is fed with **500 tons of waste per day**:

| Final Output (English) | Final Output (Arabic) | Quantity                    |
|------------------------|-----------------------|-----------------------------|
| Electricity            | كهرباء                | 24 MW/hr (24,000 kw / year) |
| Heat energy            | طاقة حرارية           | 18 MW/hr                    |

|                   |                      |   |
|-------------------|----------------------|---|
| Ash in solid form | رماد في صورة صلبة    | 75 TPD (Tons per day). <i>Used for construction, cement making and road constructions</i> |
| Biofuel products  | منتجات الوقود الحيوي |   |
| Ethanol           | الإيثانول            | 113,549 Litres/day and  |
| Methanol          | الميثانول            | 38,155 Litres/day, or   |
| Petrol            | بنزين                | 107,000 Litres/day, or  |
| Diesel            | ديزل                 | 90,275 Litres/day, or   |
| Jet fuel          | وقود الطائرات        | 95,810 Litres/day, or   |
| Hydrogen gas      | غاز الهيدروجين       | 214,958 M <sup>3</sup> / day  |

**Electricity:** The price of a kilowatt-hour is less expensive than the signed prices with national electricity entities.

**Hydrogen:** The product from the TCG units is a part of the syngas mixture, as the TCG units produce industrial gas by pyrolysis in an almost oxygen-free environment. Syngas consists of (CO, H<sub>2</sub>, CH<sub>4</sub>) as a mixture used to generate electricity by burning it in direct internal combustion engines or gas turbines, and it is also used to produce liquid hydrocarbons such as diesel, gasoline, methanol, and ethanol by applying operating conditions and catalysts to achieve the condition of the Fischer-Tropsch reaction.

The produced Hydrogen by electrolysis is of high purity, reaching 98% and higher, while the hydrogen produced by TCG units is part of a mixture of several compounds, including hydrogen, and industrial gases (CO, H<sub>2</sub>, CH<sub>4</sub>). The industrial needs a spark with the availability of combustion conditions, furthermore, the gas will be in a safe place in spherical tanks as mentioned below. High purity hydrogen can be produced from industrial gas using membrane filters, if necessary, but production of high purity hydrogen is not the objective of this project.

*To clarify:* this project does not directly produce pure hydrogen, but rather an industrial gas consisting of several compounds, including hydrogen as/in a mixture. The information we want to establish is that hydrogen is a clean fuel and liquefies under high pressures and any leakage causes a fire, and ignites under atmospheric conditions, but using crocheted tanks designed according to specifications and special safety equipment used in such a case makes dealing with this product easy.

**Storage of syngas:** The industrial gas (syngas), can be stored in tanks, especially Korean, similar to LPG tanks, and home gas. These tanks are designed to store gases in a safe way, are designed for this purpose and have safety and control systems that make gas storage safe both environmentally and for humans.

#### The TCG Units therefore generates:

- Electricity by direct burning in internal combustion engines or gas turbines.
- Conversion of industrial gas to liquid hydrocarbons (diesel, gasoline, methanol, ethanol).
- Pure hydrogen - if necessary, through a filtration method.
- Ethanol & Methanol: high quality liquid sterilization substances, used in hospitals and health centers.
- Ash: used for cement factories and cement products.
- Diesel and petrol: of high quality, and the sulfur content in the products is almost 80% less than that of refineries - CO<sub>2</sub> and SO<sub>2</sub>.

## TCG Unit Cost

The economic cost of the project is 1.5 billion euros, with 5 units, so that the unit cost is 300,000 million.

This phase will attempt to first operate 2 units in Der Alla at 300 million each, or 600 million both, so that both units will consume 1000 MT on daily basis and process them in a clean environmentally safe operation.

**Indirect costs:** The water sector consumes 15% of Jordan's energy bills while the agricultural sector consumes 60% of Jordan's water. The transport and tourism sectors are also heavily dependent on the energy sector, in addition to the industry and many other sector that are either directly or indirectly impacted by the prices of energy and electricity, over and above the savings in sectors using the project's by products.



**Sincere Regards,**

Mr. Mohammad F. Al-Khatib,  
General Manager

Signature, 

