WASTE-TO-FUEL TECHNOLOGY IN ALBANIA – DEVELOPMENT SYSTEM TO SUPPORT AN ACTIVE DRILLING INDUSTRY

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ABSTRACT: Albania has historically been known to have an active but challenging drilling activity that demands the most innovative technology to develop, predominantly, medium-heavy oil reservoirs. Although recent efforts have been made by the government to stimulate and expand the largest onshore European oilfield, technical and economical obstacles are prevalent. These obstacles make it difficult to fully develop reliable and profitable hydrocarbon bearing zones in a downturn economy, especially since Albanian oil can be costly to produce and refine. Due to these typical issues that affect many local energy sectors, many developed countries diversify their energy production to avoid strict dependency on crude oil. An emblematic and modern option that is extensively gaining popularity in Europe focuses on renewable energy from sophisticated recycling programs. All though Albania is a relatively "green" country when it pertains to its electricity production (97% hydropower and 3% fossil fuels), it has yet to develop energy-recycling programs that it can salvage for self-sustainable energy sources. The past years have seen a conscious revitalization and stimulation in the mentality of green economy in Albania. But, in comparison to the rest of "western Europe" that are leading world examples in efficient recycling, it is significantly lagging with initial strides just now focusing on aligning national legislations with current EU models. Furthermore, two crucial reasons that should motivate Albania to investigate new applications for energy recycling are (1) alternatives to crude oil and petroleum products that can be supplemental and provide stable access to fossil fuels (2) industrial and municipal recycling via waste management to reprocess waste and produce industrial raw material- spawning the emergence of a "circular economy" to develop the backbone needed to strengthen the industrial and manufacturing markets for a self-sustaining economy. Accordingly, in this paper, the topic that will be addressed, given the recent decrease in oil & gas prices, focus on the Albanian energy sector's capability to sustain and develop a supplementary recycling program via "waste-to-fuel" (WTF) technology (biofuels and/or inorganic waste). Moreover, the intent being cooperative function with Albania's active drilling program to mitigate dependency on a single fuel source and produce enough fossil fuel in an effective and sustainable manner.
Keywords: renewable energy, pyrolysis, waste-to-fuel technology, plastic-to-fuel, alternative energy

1 BACKGROUND

As world energy consumption is projected to increase from 549 quadrillion Btu in 2012 to 627 quadrillion Btu in 2020 (International Energy Outlook, OECD, 2016), most developed countries are striving towards diversifying their energy production during a downturn economy and avoid unfavorable consequences.

Consequently, reducing major risk by investing in multiple energy resources and thus maximizing energy profiles in different areas that would each respond differently to the same economic incident.

The most recent oil & gas fallout experienced in 2015, globally affected the whole energy sector. Circumstantially, the energy sector has focused on new ways to alleviate the burden of volatility of fossil fuels dependency on a single limited source. Fig. 1 shows projection of energy consumption worldwide with renewable gaining the most growth (5% increase), coal essentially plateauing, and large emphasis and support placed in production and development of natural gas (which should surpass coal by year 2030) and petroleum slightly decreasing by 3% but maintaining a general relative range. The major consensus agrees on the continual forthcoming necessity for petroleum with current world reserves are still bountiful and surpass any previously forecasted projections. It is important to note that, historically, energy forecasts have proven to be vague, defective, and sometimes imprecise. Nevertheless, this does not impede motivation in energy diversification, considering the energy sector needs to adapt to overcome economic challenges influenced by geo-political and socio-economic factors. For this sole reason, many countries are developing self-sustaining energy programs that are prevalent in all types of circumstances.

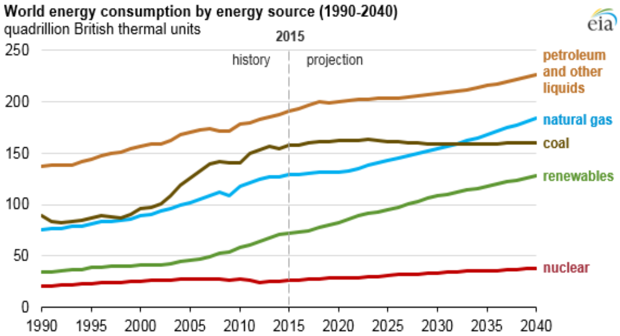

Figure 1: Projection of global energy consumption.Source- EIA 2016**.**

As human civilization inevitably multiplies, it will be forced to modernize and develop. Thus, two things will be certain, increased waste generation and need for management of generated waste. Accordingly, the need for energy will also increase, and intuitively should focus on renewable energy, as our natural resources will begin to exponentially deplete.

Most scientists consider wind, solar, aero-thermal, geothermal,hydrothermal, ocean energy, and hydropower to be renewable energy. However, very few are familiar with waste material also being a renewable energy as it will continually replenish, such as , biomass, landfill gas, sewage treatment plant gas, biogases, thermoplastics, rubber, and paper can all be considered potential material for "waste-to-fuel" technology that can use organic and inorganic waste. Both recycled and reused/salvaged materials can be considered sustainable as they can reflect resource efficiency that can use all products to their full potential. They can decrease landfill waste, reduce air and water pollution, reduce the need for raw materials, and lower environmental impact. For example, when a recycled material is used instead of a new raw material, natural resources and energy can be conserved.

Thus, the recycled materials having been initially refined and processed, will be re-manufactured for a second time resulting in cleaner and less energy-intensive method.

The utilization of waste to fuel technology is dependent on the collection of recyclable materials and relies on a steady flow of consistent supply generated from recycling programs. Thus, government support and public-private investment into the recycling activity structure (such as door-to-door segregation, collection points, distribution points) is critical in creating a self-sustaining "circular economy". The european commision descirbes circular economy as making use of resources to the maximum extent; extracting the maximum value whilst recovering and regenerating value through the resource life cycle (see Fig. 2). This cycle is an alternative to linear economy that focuses on manufacturing material, consumption, and disposing the material. The ideology focuses on exploiting the synergies of the resource life cycle to overcome barriers and add the highest amount of value to the circular "chain of waste-to-resource" that the hierarchy method focuses.

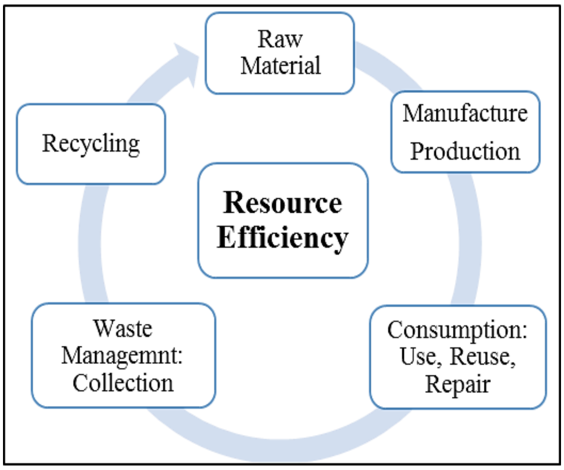

Figure 2: Circular economy diagram (modified by Hoxha and based of European Commission model, 2015).

In this paper, material is examined via a feasibility study to show how Albania, with Europe's most prominent onshore oilfield, can diversify its fuel production in order to become a regional energy powerhouse and become an example for its neighbors.

2 WASTE-TO-FUEL TECHNOLOGY

Waste-to-energy (WTE), waste-to-fuel (WTF) technology is the process of generating some type of fuel from the primary treatment of waste and can be considered a direct form of energy recovery. The concept and its implementation have caught the interest of international conglomerates and government agencies in the past decade. Many developed nations have begun using the technology (U.S.A., U.K., Netherlands, Germany, etc.) but even more surprisingly, large scale utilization has come from China and India; where plastic waste is rampant and problematic, thus turning their waste problem to a profitable industry.

A report from the American Chemical society (April 2017), describes various types of WTF technologies, all focused on specific waste sectors or fuel applications. The predominant efforts are on recycling biomass that converts organics (food, wood, paper, textiles) to biofuels (bioethanol, biodiesel), and in the industrial scale are generated from corn, sugar cane, and grain.

2.1 Pyrolysis (fuel) oil

Reprocessing of waste material such as plastics and rubber (via gasification, pyrolysis, etc.) to generate a "synthetic diesel" (industrial diesel oil) or "synthetic gas" (i.e., syngas can also be an intermediate in creating synthetic petroleum to use as a lubricant or fuel). The technique involves breaking down plastic and/or rubber (mainly composed of hydrocarbons) to a molecular level of their original components (hydrogen and carbon), rearrange them and convert into readily usable fuel like that of diesel via various refining techniques (see Fig. 3).

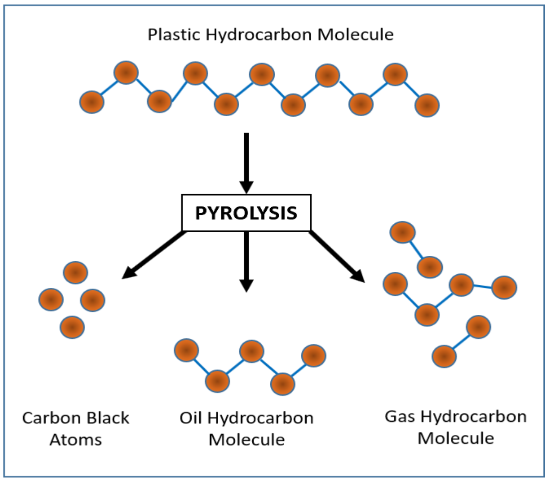

Figure 3: Diagram of Pyrolysis mechanism.

The manufacturing of thermoplastics used in our everyday lives have significantly increased in parallel to population growth, and with this increase so has disposal of waste - more than 60% of the gloabl plastics end up in landfills with only 15% being recycled. Recent advances in chemical engineering technology have focused on turning this unfavorable and detrimental environmental hazard into an economical benefit. In fact, the ideology has drawn major interests from reputable agencies such as the American Chemical Society & American Chemistry Council. Important milestones have been reached when pertaining the advancements in the technology, especially in the topic of pyrolysis processing that focuses on using cheap, inorganic material such as plastic and rubber waste that are robust and non-degradable.

Pyrolysis is a specialized classification of WTF technology that is based on thermal degradation (or thermal chemical processing) of the raw material (recyclable material) by introducing heat at extreme temperatures in the absence of oxygen. Due to lack of oxygen during the procedure, the material itself does not combust but the chemical compounds that make up that material thermally decompose into combustible gases and vapors. The combustible gases can then be cooled and condensed into a combustible liquids by-product called pyrolysis oil. Pyrolysis can be performed on biomass (organic material) or on inorganic waste (plastic, rubber etc.) as previously mentioned. The process decomposes the material into three fractions: one liquid (pyrolysis oil), one solid (char) and one gaseous (syngas). Fig. 4 depcits various types of liquid hydrocarbons fuels and shows the ranking of fuel oils (derived from pyrolysis oil) in comparison to other types of liquid hydrocarbon.

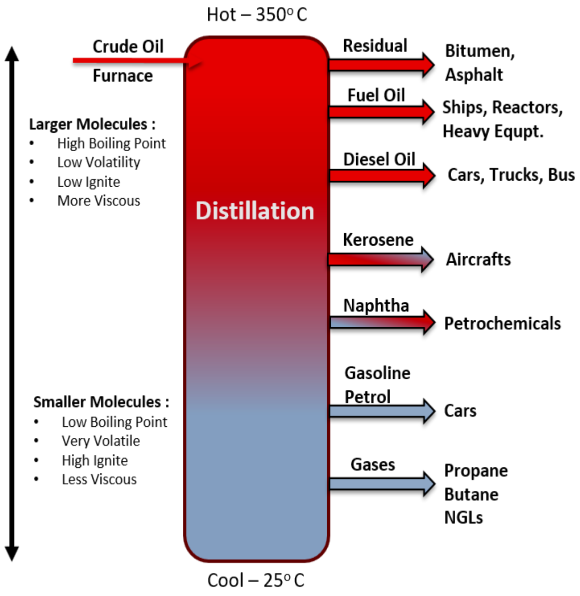

Figure 4: Diagram depciting the various grades of fuels.

It is important to remember that not all pyrolysis oils (fuel oils) are created equally - fuel derived from biomass are less efficient than those derived from plastics and rubber (see Tables I, Table II, Table AI, Table AII, and Table AIII) for standard specifications for pyrolysis oil and various other fuel oils in comparison based on ASTM, 2016. The yield of the oil (pyrolysis oil & industrial diesel oil) is highly dependent on the conversion parameters such as the quality of the material, purity, methods (catalyst or non-catalyst), and process undertaken to condense/distill/refine the products. After pyrolysis oil is obtained, it can be further refined to produce different types of diesels or can be blended.

Table I: Typical properties of various fuel oils (1).

Parameter	Gasoline	Diesel	Kerosene (K1)
Density (g/mL)	0.71–0.74	0.83	0.78–0.81
Specific gravity	0.70	0.85	0.78
API gravity	65	23–30	39–42
Viscosity (cP)	0.77–0.84	2.0–4.5	0.9–1.5
Kinematic viscosity (mm^2/s)	5.0	3.7–5.0	2.2
Aniline point (ºC)	101	107	98
Flash point (ºC)	73–74	54–60	50–54
Freezing point (ºC)	-58	-54	-40
Diesel index	83	54	60
Gross calorific (MJ/kg)	47–56	43–56	43–46
Sulfur (wt. %)	0.05–0.15	0.7	0.04

Table II: Approximate oil yield from raw materials (Pyrocrat, 2016).

Polyethylene (PE)	95%	**Rubber cable**	35%
Polypropylene (PP)	90%	**Big tires**	45%–50%
Polystyrene	90%	**Small tires**	35%–40%
ABS resin	40%	**Polyvinylchloride (PVC)**	Not suitable
Leftover paper	Wet 15%–20%, dry 60%	**PET**	Not suitable
Plastic	75%–80%	**Polyurethane (PUR)**	Not suitable
Sole	30%	**Fiber Rnfd. plastics (FRP)**	~50%
Plastic bag	50%	**Organic/bdgrdbl**	35%–50%

3 OIL & GAS INDUSTRY IN ALBANIA

The history of petroleum in Albania dates 2,000 years ago as several Roman writers account Illyrian tribes exploiting bitumen as a warfare tool during the Roman-Illyrian wars. In modern times, one of the first wells drilled was by Italian geologist Leo Madalena near Drashovice (Vlorë) in 1918. Since then, Albania currently has 19 known oil fields and 5–6 natural gas deposits with the deepest well drilled to date is the “Ardenica 18” at 6,700 m (22,000 ft).

Most geologists agree that there are currently two petroleum systems with 3 types of plays in Albania (Barbullushi, 2013; Bega, 2010 and 2013; Graham Wall et al. 2006; Balluri et al., 2002; Marko et al., 1995; Sejdini et al., 1994; Curi, 1993; Shehu et al., 1991; Meco, 2000). The most famous and most developed of the Albanian oilfields is the Patos-Marinza, projected to be the largest oilfield in continental Europe. It is comprised of three oil-bearing sandstones, Driza, Marinza, Gorani (see Fig.5). Additionally, Patos-Marinza has mainly shallow sands with heavy oil approaching tar and bitumen (Weatherill, 2005; Bennion, 2003; Kotenev, 2014; Hallman, 2015).

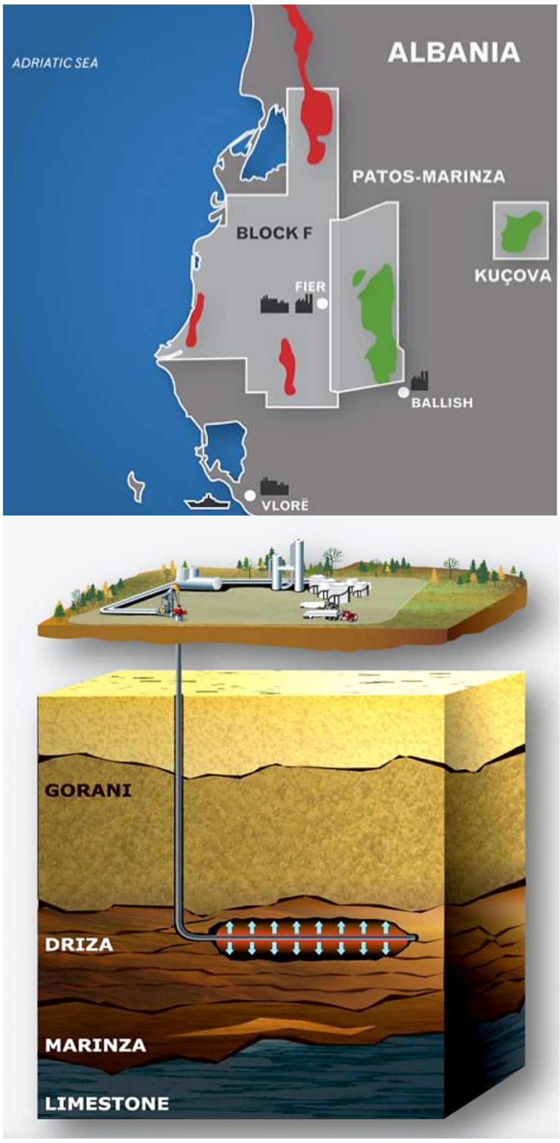

Figure 5: (a) Primary oil blocks in Albania; (b) Depiction of oil-sands layers in Patos-Marinza.

Patos-Marinza is estimated to have roughly 2 billion barrels of crude oil in place geologically. The country total is estimated at 3.4 billion barrels, and total natural gas reserves at approximately 4–5 billion Nm^3 gas (Hoxha et al.,2018), exporting more than 900,000 tons of crude oil in 2016 (AKBN&AlbPetrol Report, 2016).

Medium to heavy oil accounts for more than half of the oil production in Albania with most of the production coming from the Patos-Marinza oilfield. In contrast, the Shipragu, Mollaj oil is predominantly light oil.

Production of oil in Albania was significant prior to 1990's with maximum production reaching up to 75,000 bbls/day in 1983 (see Fig. 6). After the fall of communism, total production of oil decreased significantly due to instable politics, depletion of shallow wells, and poor reserve managment. In modern times, the highest producing field is Patos-Marinza with an estimated 12,000 to 13,000 bbls/day whereas the typical total country production is approximately at 22,000–27,000 bbls/day, ranking 60/100 countries right behind Syria in 2016 and exporting roughly 85% of the total crude oil it produces.

As explained by Hoxha et al., 2018, in comparison to other major oilfields in the world, Fig. 7 illustrate main Albanian oilfields and compares them head-to-head with other leading oilfields in the world, considering API gravity (petroleum liquid's density relative to that of water) and sulfur content (impurities in the crude oil that dictates quality) of the oil. Some of Albania's crude oil does show to have equivalent quality compared to other major producing countries with medium-heavy crude oil reserves.

Nevertheless, Albania still has predominant medium-heavy crude oil reserves that is not comparable to other benchmark crude oil such as WTI (West Texas), Brent (North Sea), Ural (Russian)—all light sweet crude oil that are extremely profitable. One of the most widely known heavy oil fields is the Athabasca oil sands in Canada, which contains API gravity of 8°– 9°, literally heavier than water and has 4%–7% sulphur content – but still has become economically viable to sell with careful field development whereas in contrast, the Bati Raman oilfield in Turkey also produce heavy oil (10°–15° API with 450–1,500 cP) but proven mostly un-economical to produce.

Producing and refining Albanian crude oil is generally costly to refine for the small southeastern European country. So the question begets, in comparison to other heavy oil producing countries (Venezuela & Canada & Turkey), why does Albania with one of the largest onshore reserves (Jacobs, 2015) in Europe have high gasoline/diesel prices (see Table III) ? The simplest explanation has to do with high tariffs, complexity, storage/ capacity, logistics, and cost of refining heavy oil in a country where the oil & gas industry is still, relatively, in the infant stages. The reservoirs still need major investments in order to develop and mature.

Nevertheless, it should be noted that compared to the rest of its Balkan neighbors, Albania has clear advantages in the oil & gas industry but does not yet match other oil & gas producing countries (see Fig. 8). And thusly, until it has the ability to parallel and match these countries, it should not only rely on drilling as the primary necessity to produce fuel.

Table III: Typical Petroleum prices in the world (Autumn 2017). Source- (globalpetoleumprices.com & fuel-prices-europe.info).

Country	Diesel ($/liter)	Gasoline ($/liter)
Saudi Arabia	0.12	0.24
USA	0.66	0.70
Macedonia	0.90	1.16
Bosnia	1.01	1.03
Kosovo	1.18	1.21
Montenegro	1.21	1.38
*Slovenia	1.29	1.40
*Croatia	1.31	1.38
*Germany	1.31	1.47
*Cyprus	1.32	1.31
Albania	***1.34***	***1.37***
Serbia	1.36	1.32
*Greece	1.4	1.66
*Switzerland	1.49	1.42

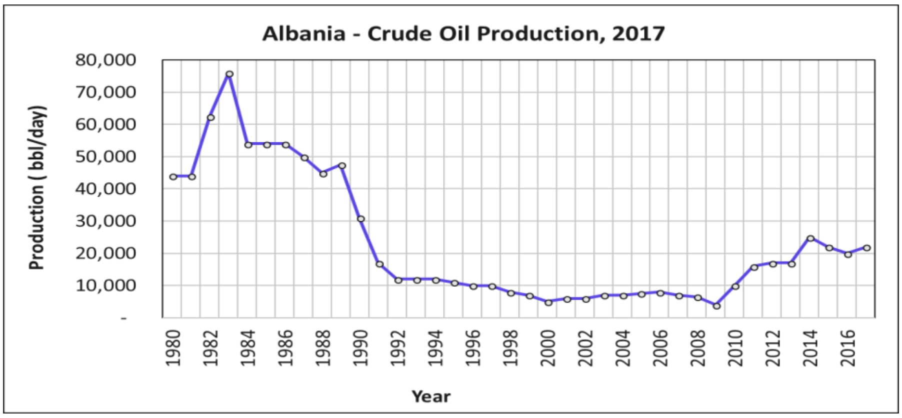

Figure 6: Albanian crude oil production. Source - AlbPetrol, 2017.

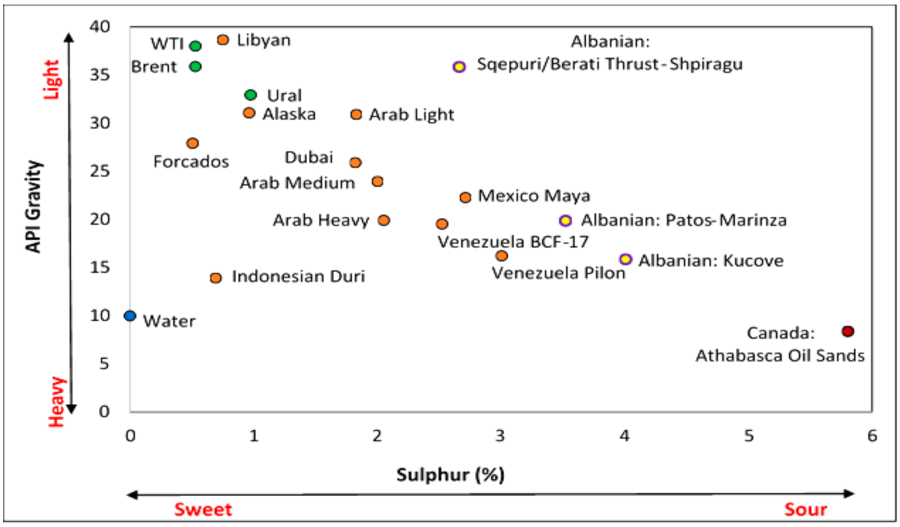

Figure 7: Graph Comparison of Albanian oil to other leading oil producing countries. The fields noted in green are benchmark crude oil widely used in the industry, thus desirable crude oil is preferred to be in the top left corner of the chart, and undesirable in the bottom right corner. Note that most global crude oil is somewhat, generally, sour (higher % Sulphur) and at 5 ppm is enough H_2S to kill a man. Also note that water has an API gravity of 10, API gravity 10-20 is considered heavy crude oil, 20-35 medium crude oil, and 35 and above is considered light crude oil. Source - modified by Hoxha 2018.

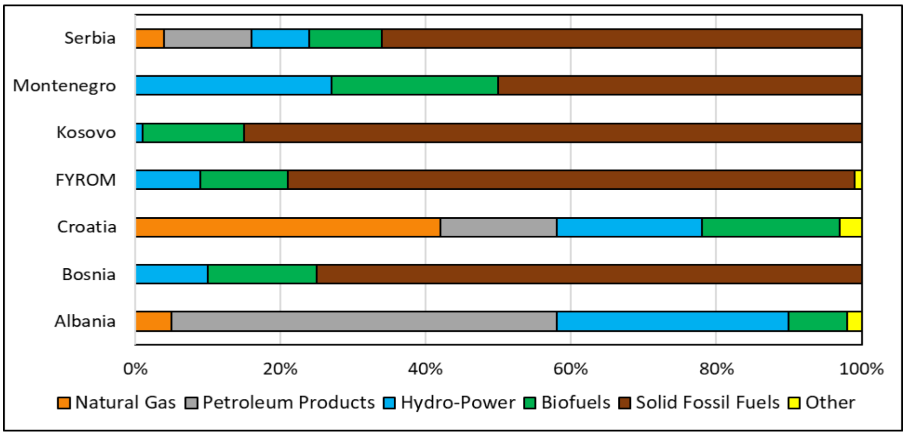

Figure 8: Energy production in the western Balkans. Source – modified by Hoxha et al., 2017 & Albanian ministry of energy, 2016. Note- Albania has the highest production of energy via petroleum by-products and hydropower, making it the "greenest" country not only in the Balkans (Source- EC, EU, EII&T, 2015).

4 WASTE MANAGEMENT IN ALBANIA

A comprehensive study was performed that assessed and evaluated the historical and current situation of waste generation and its management/recycling at the local and federal level. A 5-prong approach was undertaken to accurately understand the complex condition, (1) literature review from the scientific community {universities}, (2) government initiatives by both Albania and EU/EC programs, (3) commercial corporations & environmental service companies, (4) status to date of excising recycling companies, and (5) environmental activists. The information obtained and described here-in resonates the potential in the waste management and recycling initiative is well funded and professionally implemented, small countries such as Albania could become greener, more self-sustainable, and more economically independent.

Renewable energy in Albania ranges from biomass, geothermal, hydropower, solar, and wind energy. Albania relies mainly on hydropower resource and accordingly faces complications during droughts (low rivers levels), and as a result, demonstrates the obvious problem when relying exclusively on hydropower energy (Saraci & Leskoviku, 2009; Karaj,2010). Furthermore, the Mediterranean climate in Albania possesses considerable potential for solar energy with roughly 2,100 – 2,700 hours of sunshine in a given year (Xhitoni, 2013; O'Brien, 2010; Frasheri, 2005). In fact, the United Nations Development Program began a platform in 2012 in supporting a program to install approximately 50,000 m^2 of solar panels in Albania by the end of 2018.

The status of waste management in Albania can be best described by a report written by "Green Economy in Albania" (Bino et al., 2012, report for UNDP) that describes the development of waste management infrastructure and institutional capacity in Albania being unsatisfactory and not able to keep pace with rapid economic growth and urban expansion. Further efforts described in the studies by Alcani et al. (2015, 2013), Lico et al. (2015) and Dedej (2012) explain the status of waste management in Albania and all come to a consensus that waste recycling is sub-standard and partial as there is no separated/segregated collection of waste—the primary method of waste treatment is dumping and as of only recently (2015–2016) incineration technology has been introduced. However, it must be noted that recent legislative advancement, motivated and assisted by the European Commission regulatory agencies, Albania has adopted waste management legislation, standards, and compliances aligned with that of the EU and in 2016 has attempted to implement these laws (Gordani, 2015).

Deputy Minister of the Environment of Albania, Olijana Ifti, presented a plan at the 24th OSCE forum in 2016 where the government had proposed a fully integrated strategy monitoring system that focused on plans for education, resourcing, and legislation that focused on tax/fees. With the proposed plan in focus, the projection had forecasted that by 2020, 25% of municipal waste would be prevented from reaching landfills and recycled and composted, and additionally, by 2025 energy recovery (reclamation) reach 25% from municipal waste—the present recycling in Albania is declared to be at approximately 10% (Kodra et al., 2013).

Observing Fig. 9, it can be clearly seen that municipal urban waste has increased, as it is expected to do so. In 2016, it reached up to 1.02 million tons (note that these physical values are greater than what was projected by the government in 2009 by about 100, 000 tons) for a population of 3 million (2016 estimated census). However, considering that there is a lack of control and proper "book-keeping" in rural areas, the actual total is most likely inflated higher than the values reported. Furthermore, it has been reported that approximately 350,000 tons of industrial waste annually is produced (estimated from values and figures from Kodra et al., 2013; Source: Ministry of Public Works, Transport and Telecommunications), totaling an overall waste production of approximately 1.37 million tons annually for the year of 2016 which of 212,000 tons was inert. The value reported, realistically speaking, regarding the amount of waste produced, is relatively similar to the waste production of neighboring countries.

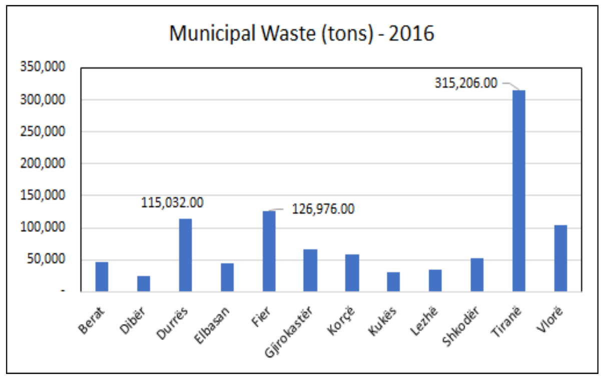

Figure 9: Municipal waste in Albania. Source - Albanian Ministry of Transport & Infrastructure, INSTAT 2013– 2016 report.

5 FEASIBILITY STUDY

The feasibility section of this study focuses on the main question—can Albania sustain WTF technology by means of a circular economy model? This question needs to be answered whilst taking in consideration the two major factors, raw material resource (input) and the output being an industrial and/or synthetic diesel fuel, thus, being able to fulfill two critical requirements, (1) is there enough waste as a supply (municipal and industrial), (2) is there enough demand-appropriate market to sell the product?

Fig.10 shows the categorized municipal and urban waste that is typically produced in Albania. Particularly, 66% of the waste is biodegradable with roughly 47% being organics that can be easily composted (organic waste, cardboard, paper, wood, and certain textile residues).

Conversely, glass and metal, totaling 7%, can easily be recycled (recycling in Albania is reported to be roughly 10%, comparatively in region Serbia has the same %). As far as reprocessing waste for the application of turning waste into energy (producing pyrolysis oil and eventually industrial synthetic diesel) the overall components are 2% rubber, 14% paper, and the most important element, 15%

plastics, totaling 31% overall. Taking in consideration these two primary waste categories that constitute the raw materials needed to recycle waste into fuel, Albania has multiple viable options.

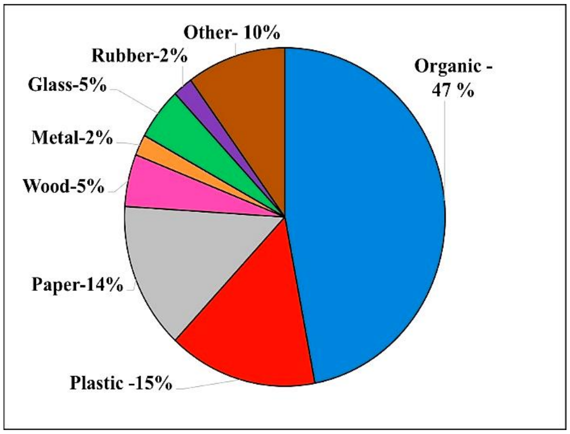

Figure 10: Waste stream composition in Albania. Estimated based on results from various sources, plastics is projected between 13.5%–15.5% (Lico et al. (2015) reported 13%, Dedej (2012) reported 14.4%, whereas Alcani et al. (2013) reported 17% plastic waste stream).

5.1 Organics

Bucpapaj, Jaupaj, Lushaj (2009, 2010, 2011, and 2012) have paved the way for exploring the use of biomass to energy (BtE) and renewable energy potentials in Albania.

Their comprehensive work details, methodically, wide-ranging aspects on how Albania can assess, implement, and benefit from their own natural and recycled waste (Toromani,2010). Bucpapaj frequently mentions in his studies, Albania's capability to turn biomass residue in to energy is a possibility with high potential to benefit. For example, from the values reported in Fig.9 and Fig.10, annual municipal waste in 2016 was 1,022,312 tons, which of 66% was biodegradable (organics, wood, and paper) — therefore 674,725 tons can be used to turn biomass into fossil fuels via WTF technology. From Table II, explained that biodegradable products can yield approximately 40% "pyrolysis oil". According to industry corporations, Pyrocrat LLC, Jinpeng Industrial, Huayin group, and Doing industries, a typical pyrolysis plant can process, at a minimum, 10 tons of waste a day. Thus 10 tons of biodegradable/organic waste at 40% pyrolysis oil yields, theoretically, can produce 4 tons of pyrolysis oil.

Considering 85% waste oil distillation plant efficiency to refine the oil, the output to industrial/synthetic diesel oil, is calculated to be 3.4 tons/day.

5.2 Inorganics

Looking at Fig. 10, it was mentioned that 15% of the total municipal waste is plastic waste and 2% is rubber waste, consequently amassing 153,347 tons and 20,447 tons respectively for the year of 2016 (not considering the addition of industrial/construction waste which can be expected to increase the percentage of the resource allowable to be reprocessed to WTF). Once again, according to Table II, plastics, in general, yield 90%–95% pyrolysis oil and rubber/tires usually yield 40% pyrolysis oil. Performing the same analysis as was performed for the biodegradable & organics waste, plastics can yield 123,828 tons and rubber/tires can yield 6,952 tons of industrial diesel oil for the year of 2016. Note that this investigation is not taking into consideration the reprocessing of waste oil, which pyrolysis plants (when properly fitted with the appropriate components) can also convert to diesel oil, nor does it take into consideration the import of waste plastics or plastic packaging material (values of import and export are detailed in Lico et al., 2015).

Thus, according to the calculated conservative estimates, the total production of industrial diesel oil in Albania for the year 2016 is 360,186 tons of industrial diesel oil, roughly 36% of the total oil produced from drilling for the year of 2016.

6 GUIDELINES FOR IMPLEMENTATION

6.1 Wte In Albania

a. WtE Incinerators that produce electricity: First waste-to-energy (WtE) plant in Albania has been inaugurated in the city of Elbasan in summer 2017. Owned by Albatek, a 2.85 MW power plant located in Elbasan, one of the most polluted towns in Albania. Integrated Technology Services has built the second 3 MW plant in Fier during 2018.
b. Pyrolysis plants - most of the current Pyrolysis reactors in Albania are outdated, open to the environment and consist of tire pyrolysis (very limited waste source).

6.2 Supply-Demand-Price

a. Municipal waste has increased in Albania since 2014. This is evidence of the increasing consumer behavior of the population which inevitably leads to more municipal waste, and if properly managed could become profitable WtF expenditures.
b. Markets that require the need for fuel oils and industrial diesel oils in the proximity of Albania:
   i. Shipping industry: Greece, Italy, Croatia, and northern Africa.
   ii. Industrial, manufacturing, and agricultural sectors (2).
c. In Europe, since 2014, fuel oil specifically for industry purpose has had consistent, average price at \$0.5-\$0.6 per liter and automotive diesel at \$1.5/liter & domestic heating oil \$0.85/liter for May 2017 (IEA monthly report June 2017).

6.3 Challenges

a. Biomass and other inorganic solid waste (municipal and industrial) is a reoccurring and maintainable source stream in many countries. However, for developing countries with poor environmental administration and infrastructure, the key struggle lies in mass collection of the waste material and segregation of overall waste stream, especially door-to-door separation. Unfortunately, most of the waste material is predominantly found in landfills. Without proper waste management programs, most recycling enterprises will face massive challenges in obtaining enough material to reprocess into fossil fuels.

6.4 Options

a. Development and re-organize waste management programs:
   i. Support the recycling industry via tax incentives. Such as but not limited to, physical and legal entities, foreign or local, whose undertaking creates waste, are obligated to pay taxes for creating waste and discharging it in the environment.
   ii. Establish private-public enterprises.
b. Appropriate and competent regulatory agency:
   i. Obligation to monitor and enforce waste segregation, and collection.
   ii. Prevent waste pollution and educate.
   iii. Waste rehabilitation of existing waste sites.
   iv. Processing and elimination of industrial waste.
c. Considering the large amount of raw material needed to “feed” an efficient pyrolysis plant, gathering waste/trash that has been disposed in landfills, urban developments, and waterways is not a practical method to sustain a recycling industry.
   i. Waste management should feed the recycling industry and the recycling industry needs to enforce waste management.
   ii. Trash in the streets/waterways is an environmental issue not a recycling nor energy recovery issue.
   iii. As per discussion with “Green-line Albania”, an environmental NGO organization based in Albania, they collected approximately 10,000 tons of waste from beaches and waterways in 2015–2016. In this scenario, where collection is informal, but intentional and most ideal with experienced personnel with proper equipment, shows that manual collection of waste is not enough to sustain a pyrolysis plant (and recycling in general) for even one day’s operation. Thus, collecting waste disposed from the environment will not sustain a recycling industry.
d. Import raw material, legally and responsibly, to be reprocessed into fossil fuels:
   i. The challenge lies in properly monitoring the raw material waste that is being imported via advanced scanning equipment to prevent illegal, hazardous, and toxic waste from entering the country and evading tariffs.
   ii. The policies to enforce these laws are the most difficult according to the EC as it is difficult to monitor all the cargo-entering ports.

7 SUMMARY & RECCOMENDATIONS

From the study incurred, it is evident that Albania does indeed have an abundance of renewable energy sources and so far, much of evaluation in terms of scientific, technical and economical has seen minimal implementation. There has been a recent effort in 2016 to entice and stimulate this industry, but the lack of transparency and experienced personnel to lead the efforts has proved the topic slow to gain traction. The efforts for using WTF technology will assist in multiple industries bilaterally as waste from agro-industrial; animal and urban/municipal categories will help in creating job opportunities in the rural sectors. By exploiting available waste and carefully utilizing waste management practices, the Albanian populations can rely on the country’s own renewable resources for bio-fuel or pyrolysis fuel. This improvement in efficiency and can decrease the import of energy and increase the internal production of fossil fuels which is impacts harshly the average consumer.

Fossil fuel dependency in Albania can be characterized in Fig.11 and Fig.12 (shows Albania’s refined product import as forecasted by HIS CERA consultation for the government of Albania in 2013). The graph demonstrates fuel oil (similar to pyrolysis oil) increased from 2000 to 2015 and is expected to be in constant demand until 2030. Additionally, diesel oil (used vastly in the industrial sector) is projected to practically double in the next 15 years. So, it is important that fossil fuels obtained from WTF technology and fossil fuels attained from traditional drilling operations remain two industries that will not compete with each other but to become simultaneously symbiotic, separate, but supportive.

This methodology will assist in “buffering” any economic impact that each industry might face.

The practice of WTF implementation indefinably will assist the economy of Albania become a circular economy.

An economy where materials that can be recycled are injected back into the economy as recovered secondary raw materials which can then become tradable and shipped under the same conditions as primary raw materials, thus increasing the security of supply. It is significantly important to mention that waste management practices have a direct impact on the quantity and quality of these secondary raw materials recovered from the waste stream.

This in turn depends directly on the implementation of the waste hierarchy, which establishes a structure and prioritizes waste treatments beginning with prevention and moving through preparation for reuse, recycling and finishing up with energy recovery with the intention of minimizing disposal.

The “waste hierarchy” schematic (see Fig.13) created by the EC is designed to demonstrate the grading of importance when it comes to waste management and its recycling. The first step being to avoid/prevent any actual waste to begin with, achieving the maximum conservation of the resources. Later in the pyramid focuses on recycling programs that encourages the reuse of the products and thus implementing a WTE-WTF platform that ensures energy recovery prior to actual disposal of waste (zero conservation of resources). The target aim by EC are intended to show clear obvious benefits - reduce the amount of waste sent to landfills and incineration facilities, conserve natural resources such as timber, water, and minerals, prevent pollution by reducing the need to collect new raw materials and reduces greenhouse gas emissions that contribute to global climate change.

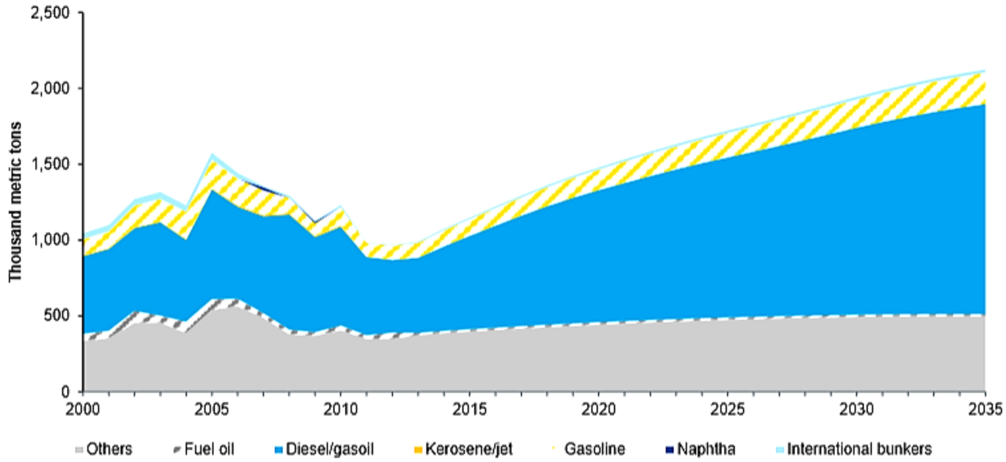

Figure 11: Refined product demand in Albania (IHS CERA, 2013). Government statistic and IHS consulting projections are based on algorithm/models and are not direct representation to actual physical demand. Recent government results fully reflect the actual consumption for the following categories to be slightly higher given the increase in industrial applications.

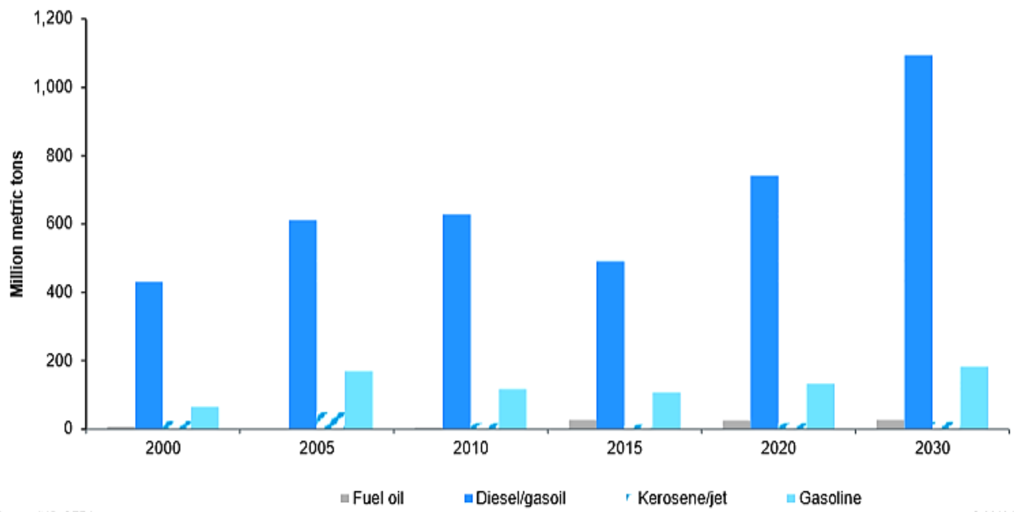

Figure 12: Albania refined product import as forecasted by IHS CERA consultation for the government of Albania in 2013. AS it can be seen, fuel oil (similar to pyrolysis oil prior to refining) has increased from 2000 to 2015 and is expected to be in constant demand until 2030. Additionally, Diesel oil is expected to practically double in the next 15 years.

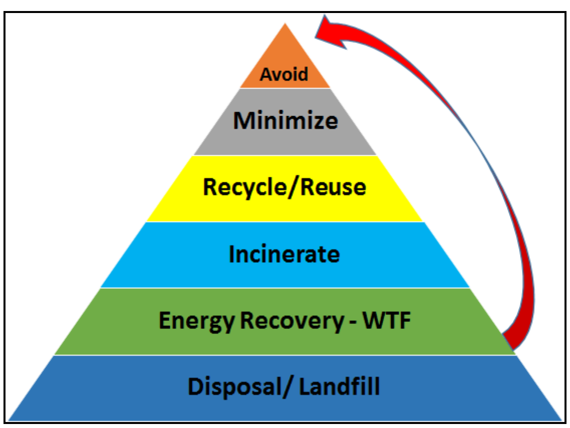

Figure 13: Schematic of municipal waste management. Based on the recommendations of the European Commission & European Environmental Agency annual reports, 2008–2016.

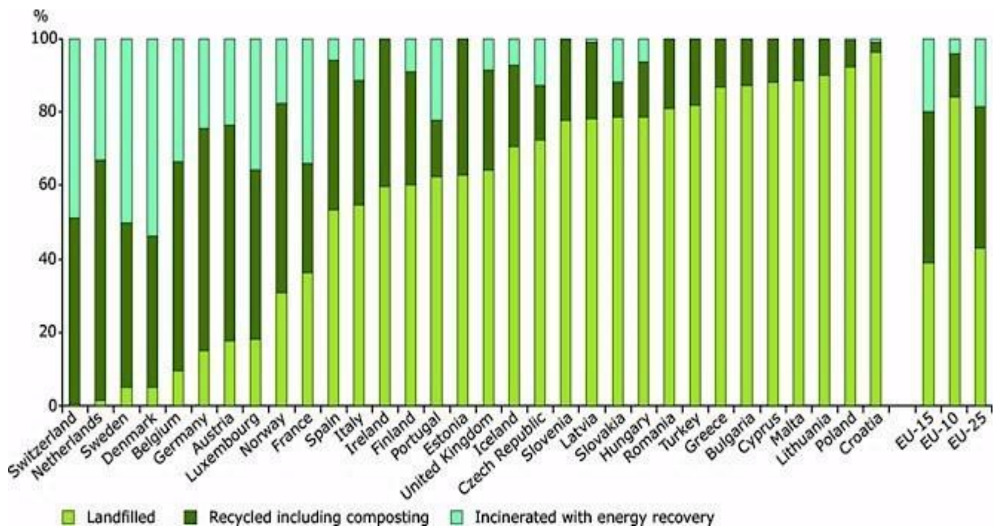

Figure 14: Municipal waste treatment in EU (Herczeg and Seyring, 2016, from EEA and Eurostat report in 2015).

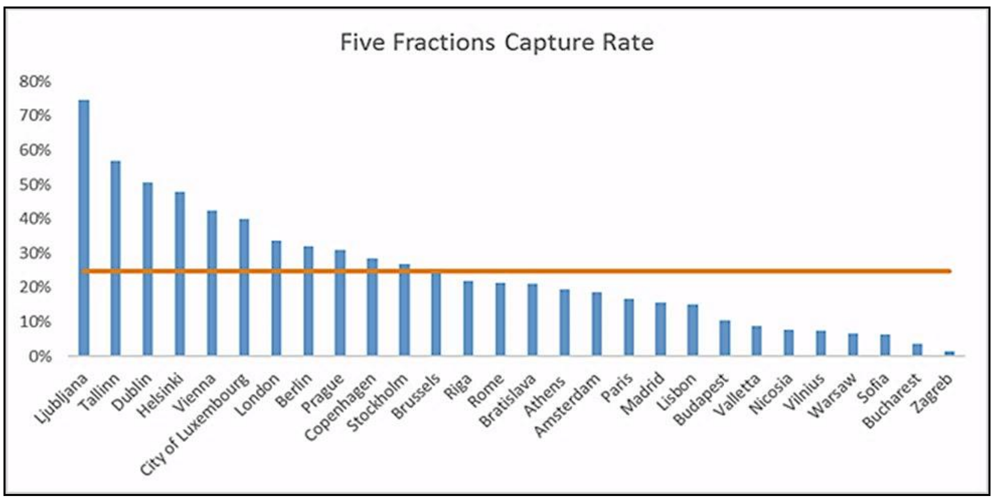

Figure 15: Capture rate for sum of paper, metal, glass, plastic, bio-waste for EU-28 capitals. Note that at the current moment only 11/28 EU capitols meet the requirements for capture rate for the five fractions set by the EU standards (Herczeg and Seyring, 2016).

Furthermore, the information was reported from a comprehensive description that was written by Seyring and Herczeg (2016), where a study was presented by the Copenhagen Research Institute in collaboration with a waste management consultation company, BiPro from Germany, in which they highlight and map out waste management trends from 28 capitals of the European Union. Fig.14 and Fig.15 depict remarkable insight into the EU member countries and their capitals regarding data on waste management and collection strategies. As it can be seen Germany, Switzerland, Austria and Belgium recycled over 50% and Netherlands leading with over 60% and Romania, Bulgaria, Greece, and Malta showing less than 10% for the year in 2013 (note these values have recently changed, mostly on the left side of the table where the Scandinavian countries have shifted to become top in recycling). The highest values for incineration for energy recovery at where depicted by Switzerland (50%), Sweden (55%) and Denmark (57%). In addition, worst results were shown by Poland, Lithuania, Romania, Malta and Croatia, with most of its waste, over 90%, ending up in landfills. Albania is estimated to have similar landfill % and recycling (90-95% of the waste being disposed and informally recycling 7-10%). Furthermore, Fig. 15 shows capture rate for sum of paper, metal, glass, plastic, bio-waste for the EU-28 capitals. It is surprising that the top cities are not from Germanic or Scandinavian countries, but are sporadic-Ljubljana, Tallinn, and Dublin leading the pack and Zagreb, Sofia, and Bucharest in the back with significantly low capture rates of waste. Note that at the current moment only 11/28 EU capitols meet the requirements for capture rate for the five fractions set by the EU standards. It should also be noted that correlation should not equal causation and as such this figure show that each city has its own method for waste collection and separation i.e., Ljubljana, Tallinn, and Dublin have remarkable collection capture rates but does not equate to higher rates in recycling/composting/energy recover.

8 CONCLUSION

In retrospect, Albania's primary focus should be on avoiding an environmental calamity and evade incidents such as the environmental disaster of Campania in Napoli, Italy. Slaybaugh (2017) and Livesay (2015) describe in well-accounted detail the crisis that has plagued the area since the late 1980's. The issue has caused a huge problem of illicit/illegal dumping from organized crime syndicates that have turned waste dumping/landfills into an extremely lucrative business. Hazardous and toxic waste from all over Italy and certain parts of Europe has now amassed large volumes that has become difficult to control. The outcome has been catastrophic causing major issues to the area, such as the agriculture (leach of toxins into the soil) and has been nicknamed (1) "the triangle of death" as the hazardous/toxic waste has increased the cancer rate significantly the past decade, and, (2) "the land of fire" due to burning waste piles. The Italian senate has passed a bill in 2014 to address the issue, but the problem has become so big that to date, there have been very limited effects from the legislation, and concurrently it will cost the Italian government millions of dollars to resolve the issue. The issue has alarmed the OECD and the EU/EC regulatory agencies and has warned to penalize the Italian state with fines if the issue is not contained. It has been recently reported that attempts are being made to ship the waste to Germany and other Scandinavian countries in order to properly dispose with minimal consequences.

Albania does not need to "reinvent the wheel", it simply needs to duplicate and implement previously functioning models that have been rigorously studied and proposed by the EU/EC for waste management. However, it should not fall in the "pitfall" of "comparisons" and expect the same results as other countries. From trial and error, it should reconfigure its own model that tailors best the needs for MSW and recycling in Albania. Moreover, these recycling industries at time of need should support private WtF industry where pyrolysis plants can be used to produce fossil fuels that could control cost, support, and stimulate the industrial and manufacture industry

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10 NOTES

(1) The typical preferred proprieties of pyrolysis oil are based on octane index, density, flash point, sulfur content, and kinematic viscosity. Detailed, scientific explanation in regard to Pyrolysis has been well accounted by Kunwar et al. (2015), Wongkhorsub (2015), Kaustubh (2014), Yadav et al. (2011).
(2) For example: Titan Cementing in Albania uses a small WtE reactor to recycle its own plant waste to power the plants furnaces.

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12 APPENDIX

Table AI: Standard testing for fossil fuels (ASTM, 2015).

Test	Method	Unit
Density @15 ºC	ASTM D 1298/99	g/mL
API gravity @60 ºF	ASTM D 1298/99	-
Flash point	ASTM D 93/08	ºC
Kinematic viscosity @40 ºC	ASTM D 445/06	mm2/s
Appearance	Visual	-
Conradson carbon residue	ASTM D 189/06	wt.%
Asphaltine content	IP 143	wt.%
Ash content	ASTM D 482/07	wt.%
Pour point	ASTM D 97/08	ºC
Calculated carbon aromatic index	ISO 8217	-
Sulfur content	ASTM D 4297/08a	wt.%
Water by distillation	ASTM D 95/05	vol.%
Calorific value	ASTM D 240/07	cal/g
Distillation (at 760 mm Hg) IBP 5% Recovery - 90% Recovery FBP	ASTM D 86/08b	ºC ºC ºC ºC ºC

Table AII: Typical properties of wood-derived (organic, biomass) pyrolysis oil vs. plastic (non-organic) pyrolysis oil.

Property	Wood-derived pyrolysis oil	Plastic-derived pyrolysis oil
Density (g/mL)	1.2	0.81
API Gravity	-	42
Flash Point (ºC)	-	<40
Asphaltine Content (wt.%)	-	< 0.01
Pour Point (ºC)	-	12
Sulfur Content (%mass)	-	0.013 7
Calorific Value (cal/g)		10 293
C (wt.%) H (wt.%) N (wt.%) O (balance)	46 7 <0.01 47	- - - -
Water Content (wt.%)	25	5
Ash Content (wt.%)	0.02	< 0.003
Solids Content (wt.%)	0.04	-
LHV (MJ/kg) LHV (MJ/l)	16 19	- -
pH	2.9	N/A
Kinematic Viscosity (cSt)	13	1.47 (mm²/s)

Note: Notice the high density compared to regular fossil fuels (Btg-btl, 2017 and Pyrocrat, 2016).

Table AIII: Standards and specifications for various grades of bio-oils (biomass). Source- ASTM.

Properties	Light (~ASTM #2)	Light–Med. (~ASTM #4)	Medium (~PORL 100)	Heavy (~CAN #6)
Density (g/mL)	See ASTM	See ASTM	See ASTM	See ASTM
Kinematic Viscosity (cSt)	1.9–3.4 (FO) 1.9–4.1(D, GT) @ 40 °C	5.5–24 @ 40 °C	17–100 @ 50 °C	100–638 @ 50 °C
Ash Content (wt.%)	0.05 (FO) 0.01 (GT)	0.05 (FO) 0.01 (D)	0.10 (FO)	0.10 (FO)
Water Cont. (wt.%), max	32	32	32	32
LHV (MJ/L min), wet oil	18	18	18	-
Phase stability @ 20 °C after 8 hr @ 90 °C	Single	Single	Single	Single
Flash point (°C)	52	55	60	60
C (wt.%)	-	-	-	-
H (wt.%)	-	-	-	-
O (wt.%)	-	-	-	-
S (wt.%)	max	max	0.2 max	0.4 max
N (wt.%)	max	max	0.3 max	0.4 max
K+Na (ppm)	0.5 (GT)	-	-	-

Note: Phase separation occurs when water content is higher than 30%–45%, which is higher with pyrolysis oil being derived from biomass in comparison to oil derived from plastics and rubber (ASTM).

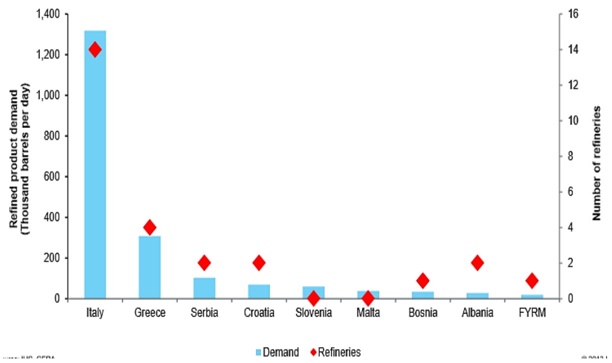

Figure A1: Refined Product demand in southern Europe. Source- IHS CERA consulting report, 2013.

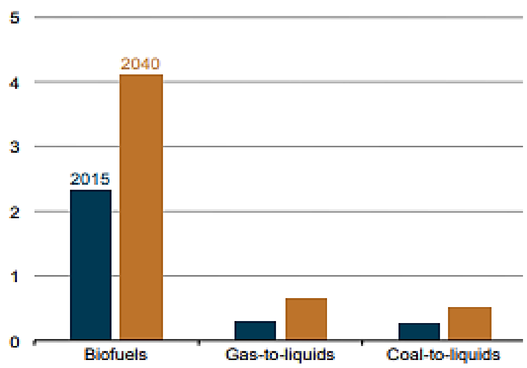

Figure A2: World production on non-petroleum liquids by million bbls/day for 2015 and 2040 forecast. EIA report, 2016.