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# Water-Energy Nexus of Water and Wastewater Services in Lebanon

**Lebanon Water Forum (LWF)**

**Wednesday, February 24th 2021**

# Water-Energy Nexus

- The interdependencies and tradeoffs between water and energy require an integrative approach to policy planning and resource management.
- There is a need to a supportive knowledge-base and an understanding of these interlinkages and systems.
- Lebanon lacks a comprehensive assessment of energy consumption and efficiency in water and wastewater service provision.
- Lebanon’s policy frameworks and coordination mechanisms in place do not facilitate the development of an integrated and efficient water-energy scheme, to alleviate pressures on both sectors.

# Project goals

- Examine the role of energy, particularly electricity, in Lebanon's water and wastewater service provision.
- Investigate the associated legal, social, environmental and economic aspects alongside with the existing legal, policy and institutional frameworks pertaining to the water, wastewater and energy sectors.
- Analyze the potential of and obstacles to mainstreaming energy efficiency, particularly renewable energy, in the water and wastewater sectors.
- Propose a national roadmap for improved energy efficiency in the water and wastewater sector.

# Energy Audit in Water and Wastewater sectors

# Energy Audit of Water and Wastewater Stations

| Establishment | Water stations audited | Wastewater stations audited | Electricity Bills Acquired |
|---|---|---|---|
| Bekaa | 5 | 7 | 2017 |
| Beirut and Mount Lebanon | 14 | 9 | 2016, 2017, 2018 (billed invoices) |
| North Lebanon Water | 8 | 3 | 2016, 2017, 2018 (unbilled invoices) |
| South Lebanon Water | 12 | 4 | 2018 |
| Total | 39 | 23 | |

** Identification of potential lands/rooftops suitable for solar PV implementation*

# Energy Audit in the Water Sector

***Benchmarking against best practices and analysis of trends***

**1**

**Energy Use Index (EUI): kWh/m³**

(to measure performance)

$$EUI = \frac{Total\ Energy\ Consumption\ (EDL + Diesel)}{Total\ Flow\ per\ day}$$

+

**Unitary Energy Cost UEC ($/KWh)**

(to measure cost)

$$UEC = \frac{Total\ Cost\ (EDL + Diesel)}{Total\ Flow\ per\ day}$$

- two types of EUI (kWh/m3) were identified until now with reference made to **case studies in Western Europe, USA, Australia, Canada & Jordan** (Further desktop review, consultations and analysis to be made to confirm findings):
  - **pump efficiency indicator to range between 0.3 – 0.65 KWh/m3.100m**

  and

  - **system efficiency indicator to range between 0.4-0.65 kWh/m3**

**2**

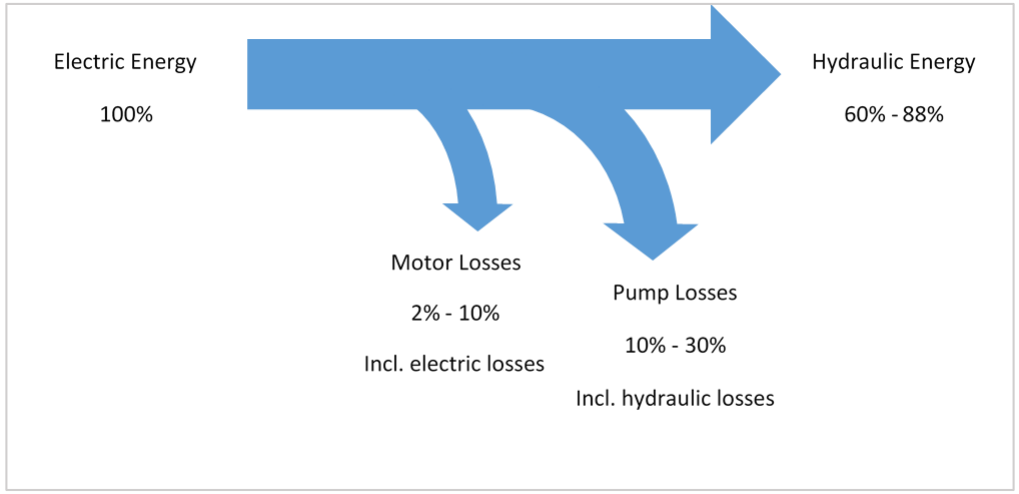
**Standardized Energy Consumption as a performance indicator + Normalization to 100m head**

Rough guidelines: 0.3-0.65 kWh/m3 per 100m

# In-depth Energy Audit

The aim of this exercise was to analyze the pumps' performance and assess the necessary power required at 85% motor efficiency and less, knowing the nameplate pumps' characteristics such as the flow, the total dynamic head in addition to the pump power (in kW) and using the following formula (ACWA/GIZ, 2015):

$$\eta = \frac{Hydraulic\ Energy\ (Output)}{Electric\ Energy\ (Input)} = \frac{Q \times H}{367 \times P_{El}} \times 100\%$$

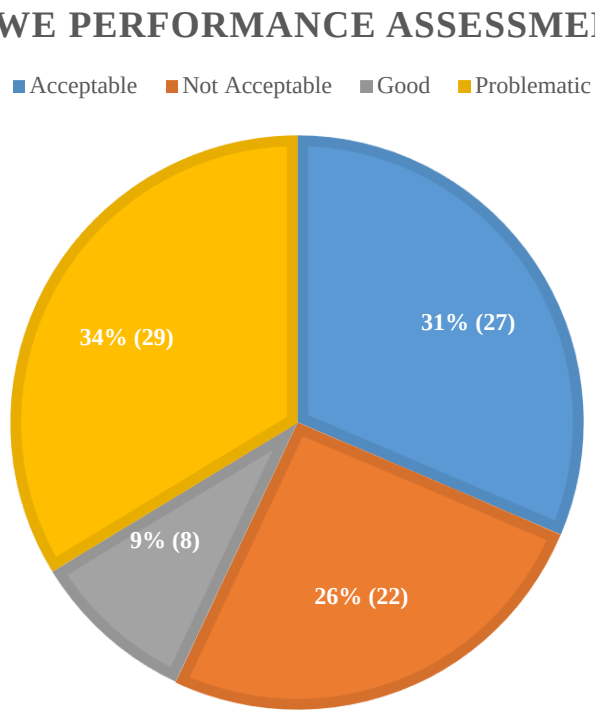


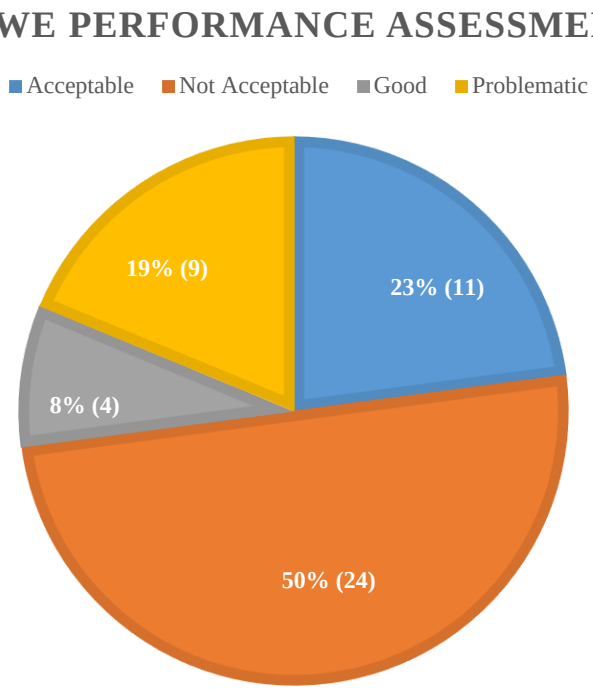

| Performance Indicator values | Performance Assessment |
|---|---|
| < 60% | Not Acceptable |
| 60 - 75% | Acceptable |
| 76 - 88% | Good |
| > 88% | Problematic |

# Methodology

| | kW (nameplate) | Static head (m) | TDH (m) | Flow (m3/s) | CALCULATED kW | | | | Δ kW | | | | Distributing to | Performance Indicator Formula (%) | Performance Assessment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 85% | 75% | 60% | 50% | 85% | 75% | 60% | 50% | | | |
| **Bahsas WTP** | | | | | | | | | | | | | | | |
| Hab Pumps (x6) | 37.3 | 20 | 23.0 | 0.13 | 36.9 | 41.8 | 52.2 | 62.7 | -0.01 | 0.1 | 0.40 | 0.7 | Network | 76% | Acceptable |
| Backwash Pumps (x2) | 37.3 | 12 | 13.8 | 0.23 | 40.3 | 45.7 | 57.1 | 68.5 | 0.08 | 0.2 | 0.53 | 0.8 | | 83% | Good |
| Qalamoun Pump | 74.6 | 40 | 46.0 | 0.07 | 38.3 | 43.5 | 54.3 | 65.2 | -0.49 | -0.4 | -0.27 | -0.1 | Network | 39% | Not Acceptable |
| Service Water Pumps (x3) | 5.6 | 5 | 5.8 | 0.01 | 0.4 | 0.5 | 0.6 | 0.8 | -0.92 | -0.9 | -0.89 | -0.9 | | 6% | Not Acceptable |
| Booster Pumps (x3+1 backup) | 44.8 | 27 | 31.1 | 0.12 | 48.4 | 54.8 | 68.6 | 82.3 | 0.08 | 0.2 | 0.53 | 0.8 | | 83% | Good |
| Backwash Pumps (x2) | 33.6 | 20 | 23.0 | 0.27 | 80.2 | 90.9 | 113.6 | 136.4 | 1.39 | 1.7 | 2.39 | 3.1 | | 183% | Problematic |
| Manar Pumps (x5) | 11.9 | 20 | 23.0 | 0.17 | 49.2 | 55.7 | 69.6 | 83.6 | 3.15 | 3.7 | 4.88 | 6.1 | Off-site reservoir | 317% | Problematic |
| Manar Pumps | 11.9 | 20 | 23.0 | 0.07 | 20.6 | 23.4 | 29.2 | 35.1 | 0.74 | 1.0 | 1.47 | 2.0 | Off-site reservoir | 133% | Problematic |
| | | | | | | | | | | | | | | | |
| **Jisr** | | | | | | | | | | | | | | | |
| Jisr 1 | 298.3 | 130 | 149.5 | 0.07 | 133.1 | 150.9 | 188.6 | 226.3 | -0.55 | -0.5 | -0.37 | -0.2 | Off-site reservoir | 34% | Not Acceptable |
| Jisr 2 | 298.3 | 130 | 149.5 | 0.08 | 154.4 | 175.0 | 218.8 | 262.5 | -0.48 | -0.4 | -0.27 | -0.1 | Off-site reservoir | 40% | Not Acceptable |
| | | | | | | | | | | | | | | | |
| **Qobbeh** | | | | | | | | | | | | | | | |
| Qobbeh Reservoir | 33.6 | 120 | 138.0 | 0.01 | 19.7 | 22.3 | 27.9 | 33.4 | -0.41 | -0.3 | -0.17 | 0.0 | | 45% | Not Acceptable |
| Maytam Old Well | 52.2 | 150 | 172.5 | 0.02 | 44.2 | 50.1 | 62.7 | 75.2 | -0.15 | 0.0 | 0.20 | 0.4 | | 65% | Acceptable |
| Mouhajjarin (Hariri) Reservoir well | 18.6 | 20 | 23.0 | 0.02 | 5.9 | 6.7 | 8.4 | 10.0 | -0.68 | -0.6 | -0.55 | -0.5 | Off-site reservoir | 24% | Not Acceptable |
| Mouhajjarin (Hariri) Reservoir pump | 37.3 | 200 | 230.0 | 0.02 | 49.2 | 55.7 | 69.6 | 83.6 | 0.32 | 0.5 | 0.87 | 1.2 | Off-site reservoir | 101% | Problematic |
| | | | | | | | | | | | | | | | |
| **Ayrounieh** | | | | | | | | | | | | | | | |
| Fouwar Pump 1 | 5.2 | 2.42 | 2.8 | 0.01 | 0.4 | 0.4 | 0.6 | 0.7 | -0.92 | -0.9 | -0.89 | -0.9 | | 6% | Not Acceptable |
| fouwar Pump 2 | 5.2 | 2.42 | 2.8 | 0.02 | 0.5 | 0.6 | 0.8 | 0.9 | -0.90 | -0.9 | -0.85 | -0.8 | | 8% | Not Acceptable |

# Water Analysis: In-Depth Energy Audit For Water Stations

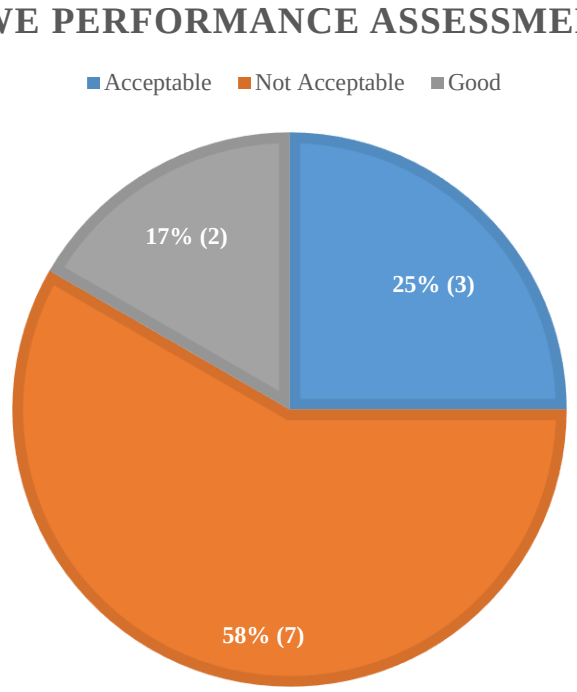


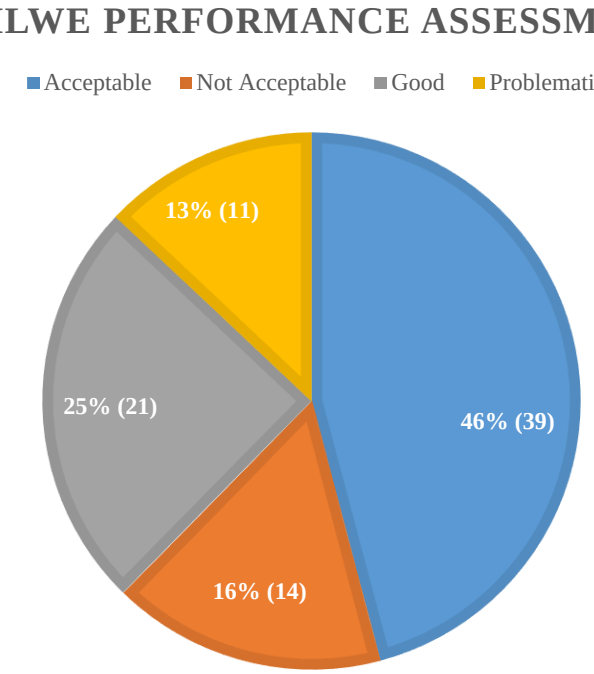




*SLWE data analysis has revealed that around 40% of the pumps fall in the good and/or acceptable ranges while the remaining **60%** are either not acceptable (26% or 22 pumps), i.e. performing below the 60% performance limit, or problematic (34% or 29 pumps), i.e. exceeding the 88% performance limit.*

*Around **70%** of NLWE's pumping systems are not performing well, where 50% (24 pumps) of the stations have a performance assessment below 60%, and 19% (9 pumps) are identified as problematic. Those are located in Bahsas, Qobbeh, Jradeh, Chekka and El Oyoun pumping stations.*

# Water Analysis: In-Depth Energy Audit For Water Stations




*BWE reflects the highest percentage (**58%**) among all establishments for unacceptable pumping systems showing a performance assessment below 60% for a total of seven pumps, five located at the Loussi station and two pumps at the Chamsine station. The remaining two pumps in the latter show a problematic performance assessment.*

*BMLWE performance assessment shows that 46% of the available pumping systems (39 pumps) are within the acceptable 60-75% range, in addition to around 25% (21 pumps) which are in a good condition. Both clusters of pumps result in around 70% of the pumps which have acceptable performance assessment, leaving the remaining **30%** between unacceptable and problematic ranges.*

# Key Takeaways

- No direct correlation between the stations with high electricity bills and their respective pumps' performance.
- High energy cost is not always caused by an inadequate pump performance. This was reached through an analysis of the pumps of the audited pumping stations with respect to their performance.

# WASTEWATER ENERGY AUDIT

# Energy Consumption in WWTPs: Data Collection and KPIs

| Establishment | District | WWTP | Degree of utilization (%) | EDL (kWh/day) | EDL cutoff hour | DG (kWh/day) | Total Energy Consumption (kWh/day) | KPI | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | kWh/m3 | kWh/PE/y | kWh/(Kg.BOD.removed) | kWh/(Kg.COD.removed) |
| SLWE | Saida | Sineek | 86.15 | 3416.667 | 12 | 1072.5 | 4489.167 | 0.080 | 5.014 | - | - |
| | Nabatiyeh | Nabatiyeh | 55.00 | 0.000 | 24 | 4359.1 | 4359.100 | 0.793 | 44.196 | 2.037 | 1.032 |
| | Bent Jbeil | Tebnine | 29.69 | 1558.500 | 0 | 73.359 | 1631.859 | 1.718 | 82.726 | 3.813 | 1.994 |
| | Tyre | Tyre | - | - | - | - | - | - | - | - | - |
| NLWE | Tripoli | Tripoli | 39.95 | 4078.481 | 0 | 26.58 | 4105.061 | 0.076 | 6.873 | 0.315 | 0.148 |
| | Batroun | Chekka | 147.30 | 3245.908 | 0 | 91.09 | 1739.681 | 0.679 | 17.638 | 1.296 | 0.645 |
| | Batroun | Selaata | 62.32 | 1079.681 | 12 | 660 | 3337.001 | 1.658 | 76.125 | 3.174 | 1.597 |
| BMLWE | Aley | Kfar Katra | 27.27 | 190.398 | 12 | 0 | 190.398 | 1.269 | 69.495 | 3.273 | 2.111 |
| | Chouf | Mokhtara | 77.78 | 218.532 | 13 | 89.1 | 307.632 | 0.879 | 48.123 | 2.246 | 1.177 |
| | Chouf | Jbaa | 36.67 | 142.076 | 4 | 53.342 | 195.418 | 1.777 | 97.265 | 4.517 | 2.352 |
| | Chouf | Mrosti | 30.00 | 134.025 | 4 | 108.357 | 242.382 | 2.693 | 147.449 | 7.044 | 3.865 |
| | Chouf | Baadaran | 20.00 | | 12 | 97.643 | 97.643 | 1.953 | 106.919 | 5.128 | 2.603 |
| | Chouf | Khraibeh | 22.22 | 168.408 | 12 | 27.1233 | 195.532 | 1.955 | 107.054 | 4.967 | 2.634 |
| | Chouf | Maaser El Chouf | 22.22 | 186.354 | 12 | 131.5479 | 317.901 | 3.179 | 174.051 | 8.095 | 4.355 |
| | Baabda | Ghadir | 38.13 | 5074.816 | 0 | 66.452 | 5141.268 | 0.075 | 4.101 | #VALUE! | 0.778 |
| | Baabda | Hammana | 100.00 | 178.767 | 12 | 151.23 | 329.997 | 0.330 | 24.090 | 0.862 | 0.448 |
| BWE | Zahleh | Zahleh | 50.94 | 8082.919 | 0 | 123.64 | 8206.559 | 0.432 | 17.657 | 0.945 | 0.486 |
| | Baalback-Hermel | Iaat-2016 | 111.42 | 2662.025 | 6 | 1080.09 | 3742.115 | 0.336 | 13.730 | 0.668 | 0.364 |
| | Baalback-Hermel | Iaat-2017 | 111.42 | 2279.075 | 6 | 1080.09 | 3359.165 | 0.301 | 12.325 | 0.600 | 0.327 |
| | Baalback-Hermel | Iaat-2018 | 111.42 | 2737.871 | 6 | 1080.09 | 3817.961 | 0.343 | 14.008 | 0.681 | 0.371 |
| | Baalback-Hermel | Yammouneh | - | - | - | - | - | - | - | - | - |
| | Western Beqaa | Jeb Jannine-2016 | 65.00 | 5287.726 | 2 | 779.0211 | 6066.747 | 0.933 | 38.155 | 1.802 | 0.913 |
| | Western Beqaa | Jeb Jannine-2017 | 65.00 | 4426.949 | 2 | 779.0211 | 5205.970 | 0.801 | 32.742 | 1.547 | 0.784 |
| | Western Beqaa | Jeb Jannine-2018 | 65.00 | 4890.664 | 2 | 779.0211 | 5669.686 | 0.872 | 35.658 | 1.684 | 0.853 |
| | Western Beqaa | Saghbine-2016 | 57.69 | 64.275 | 2 | 10.989 | 75.264 | 0.251 | 10.256 | 0.476 | 0.243 |
| | Western Beqaa | Saghbine-2017 | 57.69 | 420.815 | 2 | 10.989 | 431.804 | 1.439 | 58.840 | 2.734 | 1.396 |
| | Western Beqaa | Saghbine-2018 | 57.69 | 492.139 | 2 | 10.989 | 503.128 | 1.677 | 68.560 | 3.185 | 1.627 |
| | Zahleh | Ablah | 60.00 | 939.335 | 0 | 0 | 939.335 | 0.783 | 32.000 | 1.532 | 0.770 |
| | Zahleh | Ferzol | 150.00 | Not provided by the Minicipality despite several communications and requests | | | | 0.000 | 0.000 | - | - |

# Wastewater Analysis - Benchmarking

| Size class | PE range | Number of plants | Plant name |
|---|---|---|---|
| SC1 | <1,000 | 2 | Jbaa, Mrosti |
| SC2 | 1,000-5,000 | 3 | Mokhtara, Kfar Atra, Saghbine |
| SC3 | 5,001-10,000 | 2 | Tebnine, Hammana |
| SC4 | 10,001 - 100,000 | 7 | Nabatiyeh, Iaat, Jeb Jannine, Ablah, Ferzol, Chekka, Selaata |
| SC5 | >100,000 | 3 | Saynik, Tripoli, Zahle |

| Station | Type | PE serviced | Size clas | kWh/PE/y | Guide value | Target value | DU (%) | COD removed (Kg/year) | COD Removal % | kWh/(Kg.COD.removed) |
|---|---|---|---|---|---|---|---|---|---|---|
| Mrosti | AS - trickling filter | 600 | SC1 | 147.45 | 67 | 49 | 30 | 22891.26 | 87.11 | 3.86 |
| Hammana | Activated sludge | 5,000 | SC2 | 24.089 | 40 | 24 | 100 | 268640.00 | 92.00 | 0.45 |
| Ghadir | Primary | 457,587 | SC5 | 4.1 | | | 38.1 | 2413470.20 | 12.04 | 0.78 |
| Jbaa | AS - trickling filter | 733 | SC1 | 97.26 | 67 | 49 | 36.7 | 30329.66 | 94.47 | 2.35 |
| Kfarkatra | Extended aeration | 1000 | SC2 | 69.5 | 45 | 28 | 27.3 | 32914.79 | 75.15 | 2.11 |
| Maasser | AS - trickling filter | 667 | SC1 | 174.05 | 67 | 49 | 22.2 | 26646.39 | 91.25 | 4.35 |
| Baadaran | Extended aeration | 333 | SC1 | 106.91 | 70 | 38 | 20 | 13694.03 | 93.79 | 2.60 |
| Khreibeh | AS - trickling filter | 667 | SC1 | 107.05 | 67 | 49 | 22.2 | 27098.96 | 92.80 | 2.63 |
| Mokhtara | AS - trickling filter | 2,333 | SC2 | 48.1 | 39 | 32 | 77.8 | 95433.06 | 93.39 | 1.18 |
| Tebnin | Extended aeration | 7,200 | SC3 | 82.7 | 38 | 23 | 29.7 | 298636.36 | 94.70 | 1.99 |
| Nabatiye | Extended aeration | 36,000 | SC4 | 44.19 | 34 | 20 | 55 | 1542464.38 | 97.82 | 1.03 |
| Saynik | Primary | 326,789 | SC5 | 7.63 | - | - | 86.1 | #VALUE! | - | - |
| Zahle | Extended aeration | 169,643 | SC5 | 17.6 | 30 | 20 | 50.9 | 6169390.24 | 93.90 | 0.49 |
| Iaat | Extended aeration | 99,482 | SC4 | 12.523 | 34 | 20 | 111.4 | 3754710.07 | 86.17 | 0.37 |
| Saghbine | Activated sludge | 1,902 | SC2 | 4.44 | 40 | 24 | 57.7 | 112877.69 | 96.21 | 1.63 |
| Jeb Jannine | Activated sludge | 41,027 | SC4 | 47.25 | 30 | 18 | 65 | 2424830.57 | 95.39 | 0.85 |
| Ablah | AS - trickling filter | 10,714 | SC4 | 32 | 30 | 18 | 60 | 445260.08 | 94.88 | 0.77 |
| Ferzol | AS - trickling filter | 13,393 | SC4 | TBC | 30 | 18 | 150 | #VALUE! | #VALUE! | - |
| Tripoli | Primary | 357,143 | SC5 | 6.8 | | | 39.9 | 10116015.90 | 47.97 | 0.15 |
| Chekka | Activated sludge | 17,857 | SC4 | 17.6 | 30 | 18 | 147.3 | 985156.14 | 98.29 | 0.64 |
| Selaata | Activated sludge | 16,071 | SC4 | 76.1 | 30 | 18 | 62.3 | 762743.66 | 96.89 | 1.60 |

| < value | Within value (+/- 10%) | > value |
|---|---|---|

- **Primary indicator** adopted: kWh/PE/year.
- kWh/kgCODrem indicator can be used for internal cross-checking.
- Guide and target values are taken from the literature, according to size class and treatment type.
- **Secondary indicator**: Degree of Utilization (DU)

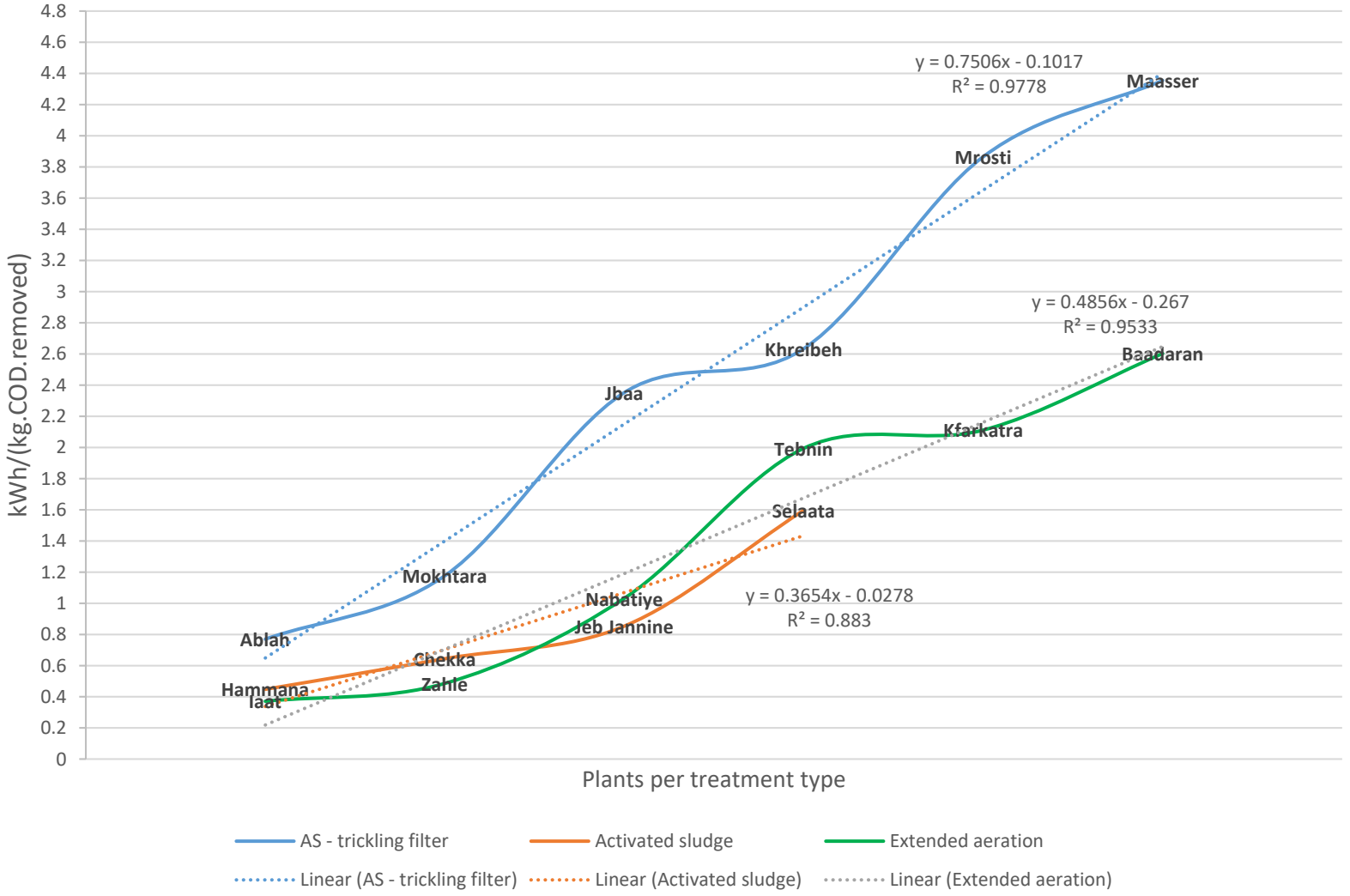
# Wastewater Energy Audit Analysis

| Station | Type | PE serviced | Size class | kWh/PE/y |
|---|---|---|---|---|
| Baadaran | Extended aeration | 333 | SC1 | 106.91 |
| Mrosti | AS - trickling filter | 600 | SC1 | 147.45 |
| Maasser | AS - trickling filter | 667 | SC1 | 174.05 |
| Khreibeh | AS - trickling filter | 667 | SC1 | 107.05 |
| Jbaa | AS - trickling filter | 733 | SC1 | 97.26 |
| Kfar Atra | Extended aeration | 1000 | SC2 | 69.5 |
| Saghbine | Activated sludge | 1,902 | SC2 | 4.44 |
| Mokhtara | AS - trickling filter | 2,333 | SC2 | 48.1 |
| Hammana | Activated sludge | 6,667 | SC3 | TBC |
| Tebnin | Extended aeration | 7,200 | SC3 | 82.7 |
| Ablah | AS - trickling filter | 10,714 | SC4 | 32 |
| Ferzol | AS - trickling filter | 13,393 | SC4 | TBC |
| Selaata | Activated sludge | 16,071 | SC4 | 76.1 |
| Chekka | Activated sludge | 17,857 | SC4 | 17.6 |
| Nabatiye | Extended aeration | 36,000 | SC4 | 44.19 |
| Jeb Jannine | Activated sludge | 41,027 | SC4 | 47.25 |
| Iaat | Extended aeration | 99,482 | SC4 | 12.52333333 |
| Zahle | Extended aeration | 169,643 | SC5 | 17.6 |

*classification of kWh/PE/year according to size class*

| < value | Within value (+/- 10%) | > value |
|---|---|---|

# Wastewater Energy Audit Analysis




- *Plants that carry out Conventional Activated Sludge and Extended Aeration processes show the lowest energy consumption reaching up to 1.6 kWh/kg.COD.removed for the first (Selaata plant) and around 2.6 kWh/kg.COD.removed for the second (Baadaran plant).*

- *Activated Sludge with Trickling Filters systems are characterized by the highest energy consumption, being almost two times higher and reaching up to 4.4 kWh/kg.COD.removed.*

# Wastewater Energy Audit Analysis

| Station | Type | PE serviced | Size class | kWh/PE/y |
|---|---|---|---|---|
| Baadaran | Extended aeration | 333 | SC1 | 106.91 |
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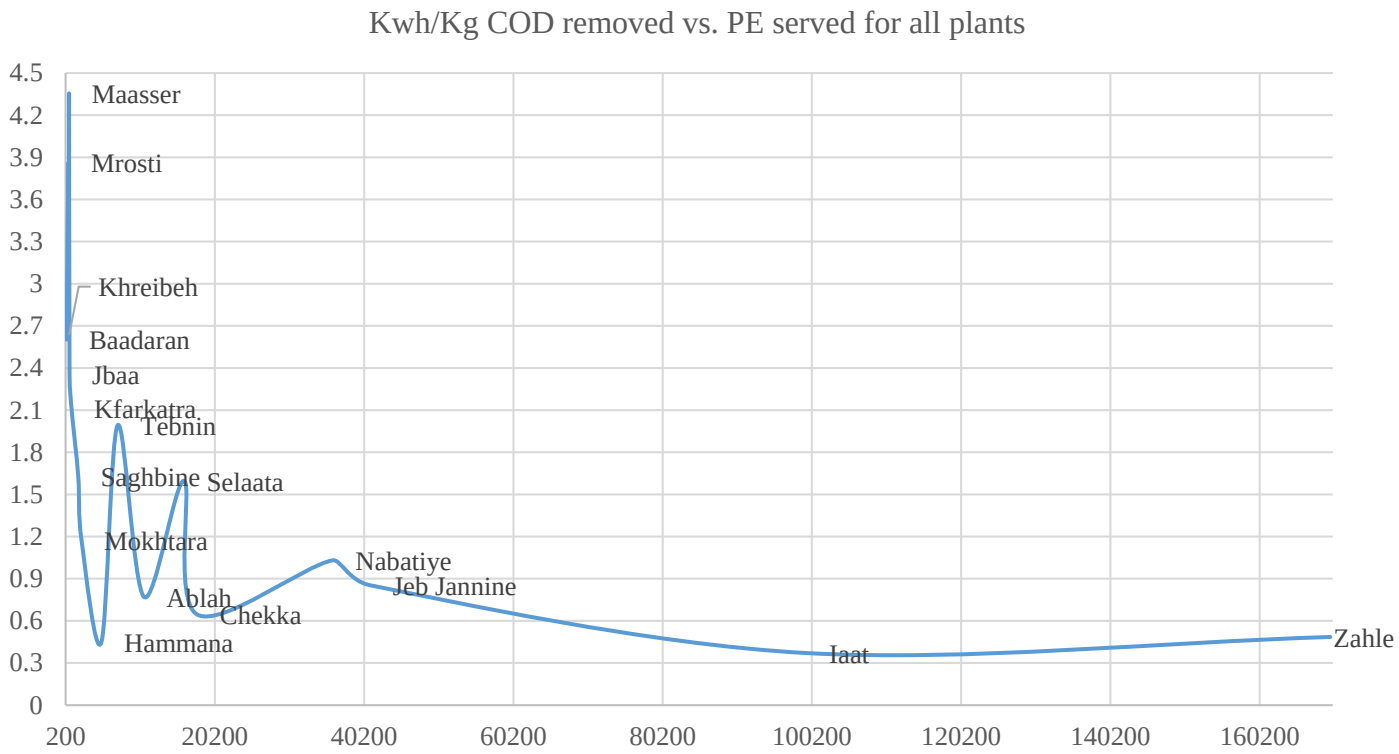
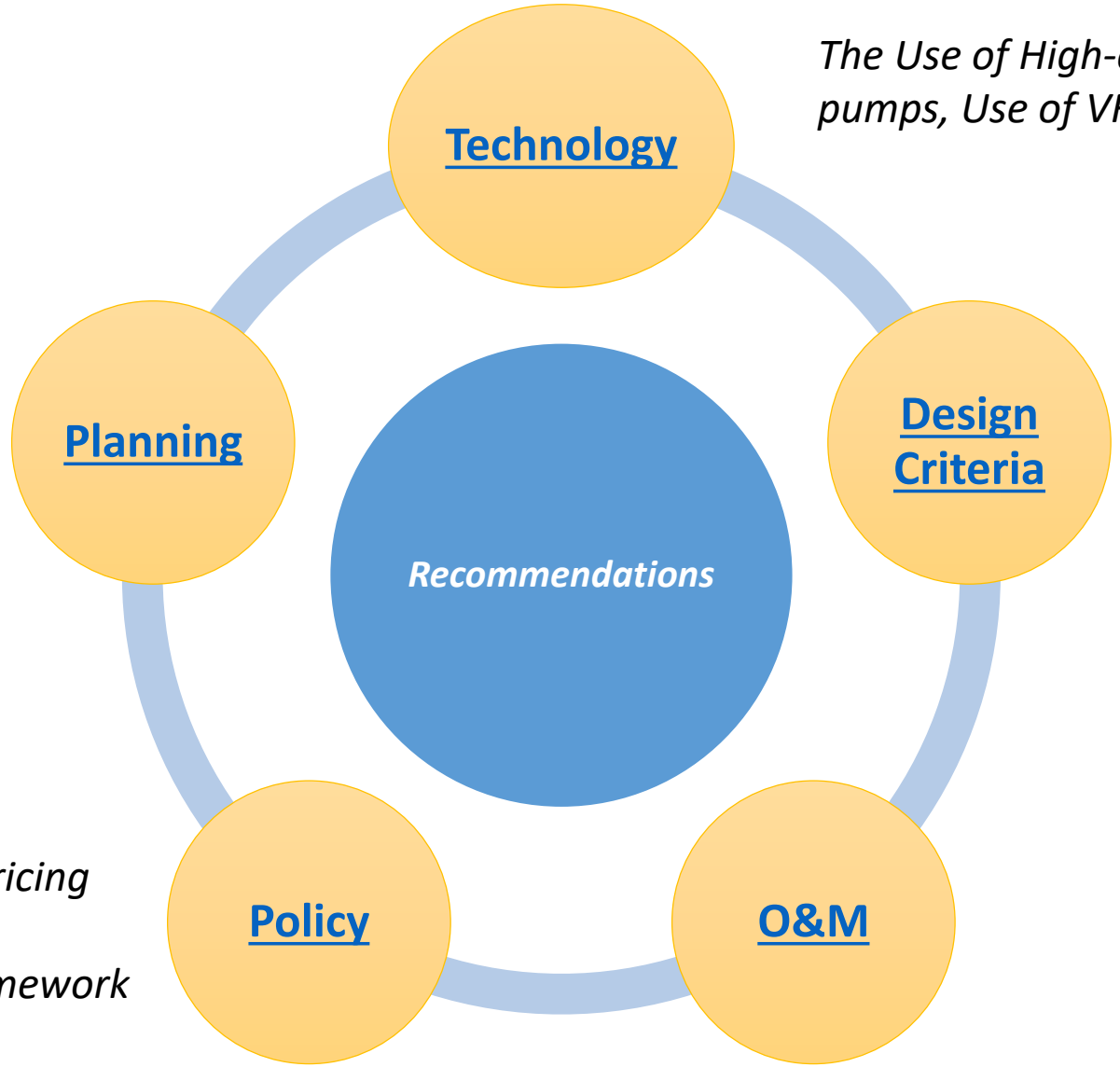
| Hammana | Activated sludge | 5,000 | SC2 | 24.089 |
| Tebnin | Extended aeration | 7,200 | SC3 | 82.7 |
| Ablah | AS - trickling filter | 10,714 | SC4 | 32 |
| Ferzol | AS - trickling filter | 13,393 | SC4 | TBC |
| Selaata | Activated sludge | 16,071 | SC4 | 76.1 |
| Chekka | Activated sludge | 17,857 | SC4 | 17.6 |
| Nabatiye | Extended aeration | 36,000 | SC4 | 44.19 |
| Jeb Jannine | Activated sludge | 41,027 | SC4 | 47.25 |
| Iaat | Extended aeration | 99,482 | SC4 | 12.5233333 |
| Zahle | Extended aeration | 169,643 | SC5 | 17.6 |



# Key Takeaways

- Design aspects of the plants lie behind energy inefficiency which have led to high energy costs.
- Out of the 16 audited secondary treatment facilities, 14 operate below capacity, reflecting a tendency for over-sized plant design with treatment capacity greater than what is needed (accounting for future increased loads due to population load should not be used as an excuse for such oversizing).
- Smaller plants are more energy intensive than larger ones. As the population served increases, energy consumption decreases with high energy consumption being attributed to plants serving the lowest number of people.
- This finding highlights the importance of cost sustainability in O&M in terms of energy in the proper design and sizing of future and planned WWTPs.

# Water Sector Recommendations




*The Use of High-efficiency electrical motors & pumps, Use of VFDs when there is Variable P and Q*

** Duty Point and pump selection;*
** Design of Water Networks;*

** ToRs should define a set of energy efficiency standards;*

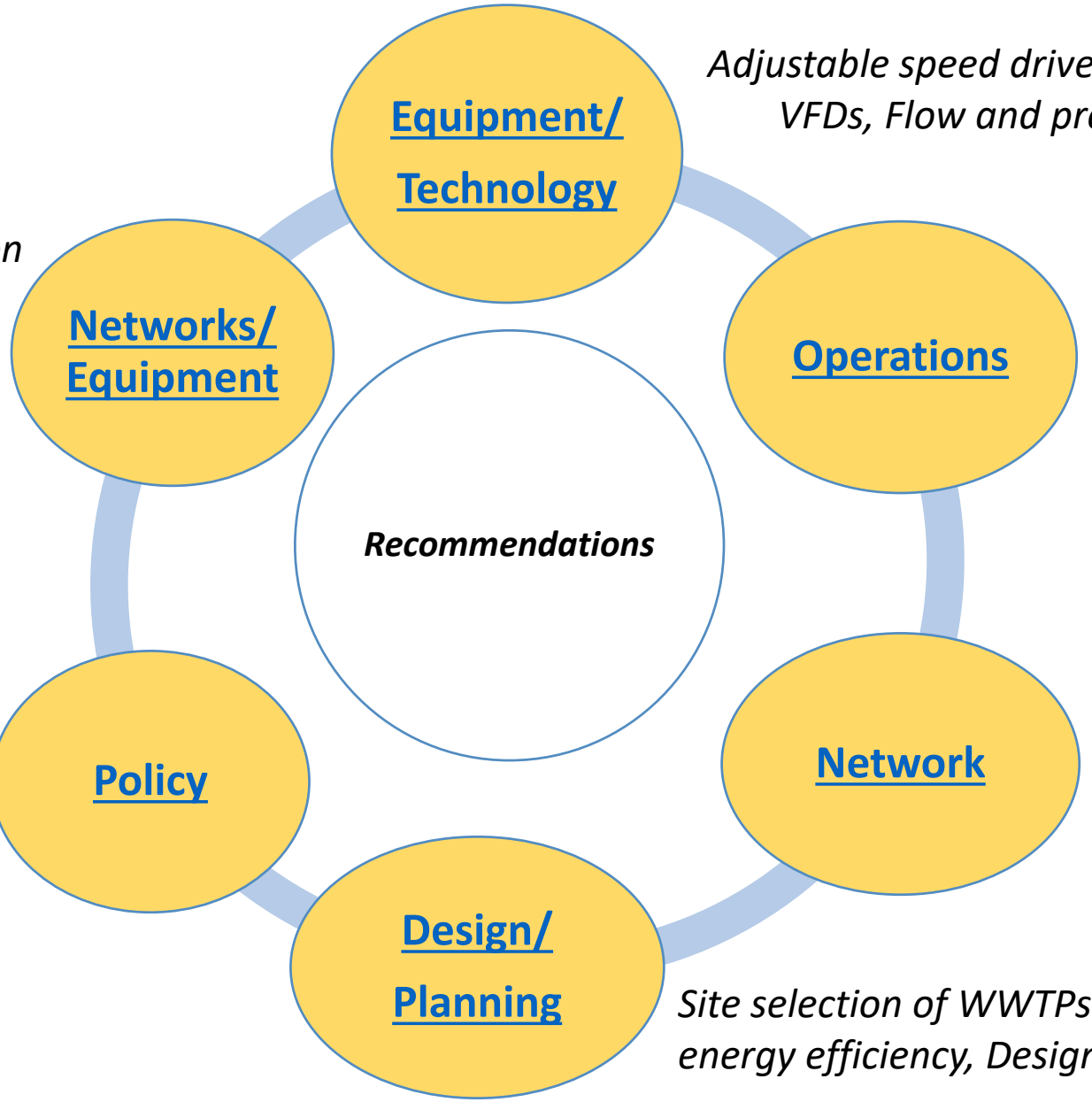
** Specifications should be homogenized in one central monitoring system.*

** Develop an appropriate pricing strategy;*
** Establish a regulatory framework for RE implementation.*

dar

*A set of good practices in O&M of pumping*

# Wastewater Sector Recommendations




*Adjustable speed drives on pumps and blowers, DO Sensors, VFDs, Flow and pressure monitoring equipment, etc.*

*Odor Control ventilation, Heating and cooling control, Perform audits of all installed electrical equipment, address Leaks and malfunctions, etc.*

*Separate the two systems – stormwater drainage networks and sewage networks.*

*Site selection of WWTPs should prioritize energy efficiency, Design of new WWTPs, etc.*

*Set appropriate tariffs for wastewater collection and treatment, O&M protocols, etc.*

*Industrial and medical waste treatment, installation of VFDs and EE equipment, etc.*

# Renewable Energy Potential and Market Assessment

# RE Market assessment Aims

- Zooming-in on the status of water/wastewater services in the RE legal framework
- Overview of existing and planned RE projects in water/wastewater services
- Market perspective: Interviews conducted with 3 solar PV contractors in Lebanon
- Assessing the RE potential in water and wastewater stations: case studies

# Renewable Energy Potential from field observations

*Preliminary review of land availability revealed the existence of substantial potential to incorporate solar PV*

***Zgharta***

***Tripoli***

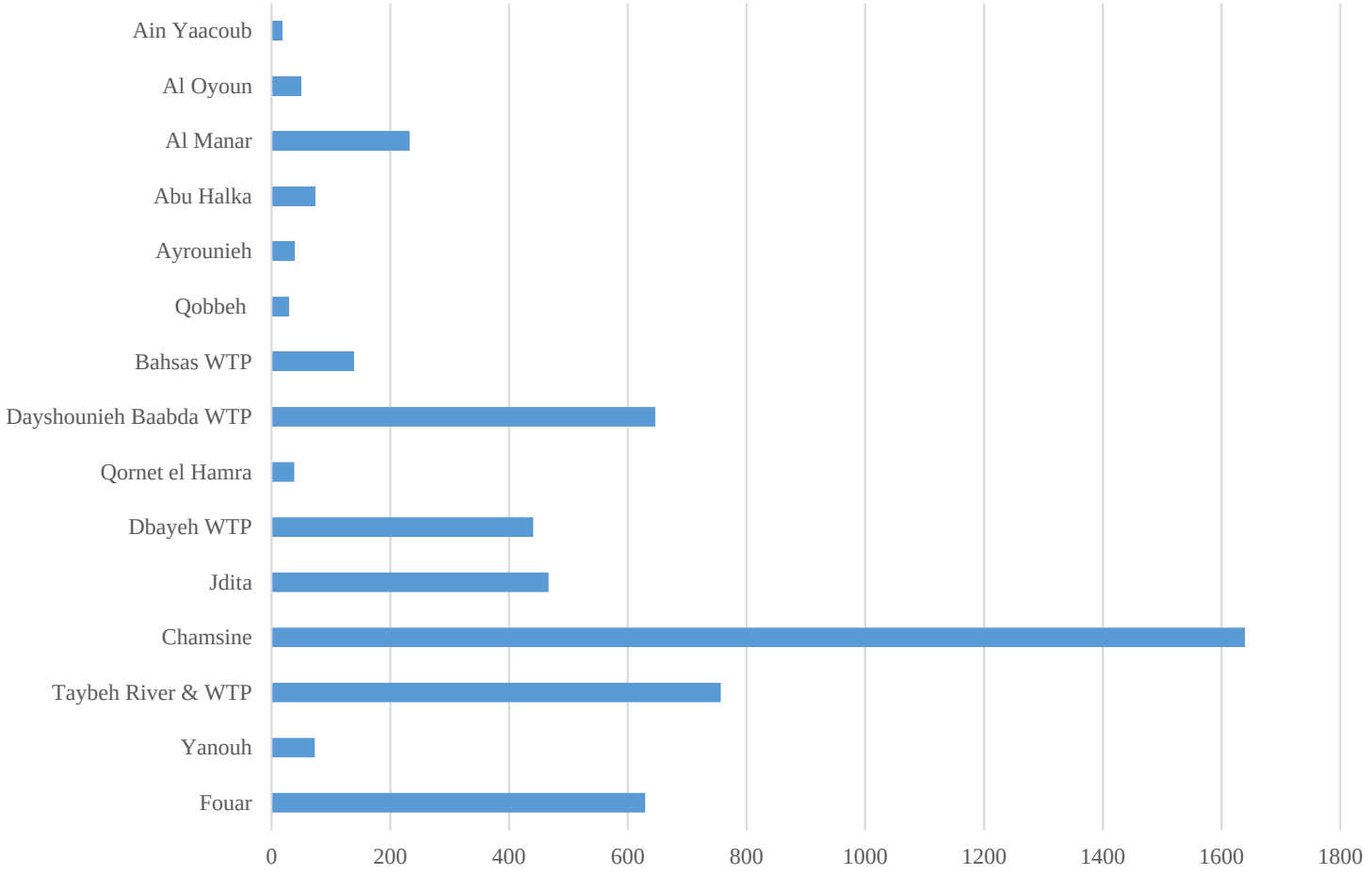
***Baabda (Daychouniyeh)***

# Renewable Energy Market Assessment
## *Approach*

***Economic Modelling***

| Parameter | Value | Description |
|---|---|---|
| **Discount Rate** | Variable | The current discount rate is estimated at 8% based on the latest market trends in 2018, taking into consideration Lebanon's economic status and credit rate ranking (this discount rate could increase due to the current economic crisis since October 2019).<br><br>A subsidized discount rate of 2% is considered for a scenario where the economy is stable and in continuous growth |
| **EDL's tariff** | Variable | 9.3 c/kWh<br><br>22 c/kWh (post cost-recovery i.e. when subsidies are lifted) |
| **Capital cost (USD/kWp)** | Variable | Estimated at 800USD/kWp based on interviews with local solar PV companies |
| **Specific yield** | 1500 kWh/kWp | |
| **Area required per 1kWp** | 8$m^2$ | Estimated based on interviews with the private sector. |
| **System lifetime** | 25 Years | |

# Renewable Energy Market Assessment
## *Assessment of Market Potential*




*Recommended solar PV capacity without storage in water facilities (kWp)*

*An economic modeling of solar PV potential was performed for the following facilities:*

- *<u>South:</u> Fouar, Yanouh, Taybeh River and WTP*
- *<u>Beirut Mount Lebanon:</u> Dbayeh WTP, Qornet el Hamra and Dayshouniet Baabda WTP*
- *<u>Bekaa:</u> Chamsine and Jdita*
- *<u>North:</u> Bahsas WTP, Qobbeh, Ayrouniyeh, Abu Halka, Al Manar, Al Oyoun, Ain Yaacoub*

# Renewable Energy Market Assessment
## *Assessment of Market Potential*

**Economic Modeling :**

- **Water**: stations in the South (Fouar, Yanouh, Taybeh) and the Bekaa (Chamsine, Jdita)

- **Wastewater**: Iaat WWTP

- ***Recommended solar PV capacity (without storage)***
- ***Annual savings***
- ***Payback periods***
- ***LCOE***

| Station | Region | Total consumption (kWh) | Total area approximation (m2) | Potential Solar PV Capacity (kWp) | Estimated kWh produced from solar PV | Solar PV potential with storage (% of utility consumption ) | Solar PV potential without storage (% of utility consumption ) | Recommended Solar PV capacity (kWp) |
|---|---|---|---|---|---|---|---|---|
| Fouar | South | 3496271.4 | 10497 | 1050 | 1574550 | 45 | 27 | 629 |
| Yanouh | South | 405171.43 | 8558 | 856 | 1283700 | 317 | 27 | 73 |
| Taybeh River & WTP | South | 12609392.8 | 7735 | 774 | 1160250 | 9 | 9 | 757 |
| Chamsine | Bekaa | 9107792.857 | 3142602 | 314260 | 471390300 | 5176 | 27 | 1639 |
| Jdita | Bekaa | 2592292.857 | 295893 | 29589 | 44383950 | 1712 | 27 | 467 |
| Iaat | Bekaa | 1,399,938.24 | 35600 | 3560 | 5340000 | 381 | 27 | 252 |

| Station | Recommended Solar PV capacity (kWp) | Upront Capital Cost | Annual Savings (@ 9.3 cents/kWh tariff / 8% discount rate) | Annual Savings (@ 22 cents /kWh tariff /8% discount rate) | Annual Savings (@ 9.3 cents/kWh tariff /2% discount rate) | Annual Savings (@ 22 cents /kWh tariff / 2% discount rate) |
|---|---|---|---|---|---|---|
| Fouar | 629 | 503200 | 30500 | 149462 | 52041 | 171003 |
| Yanouh | 73 | 58400 | 3540 | 17346 | 6040 | 19846 |
| Taybeh River & WTP | 757 | 605600 | 36707 | 179877 | 62631 | 205802 |
| Chamsine | 1639 | 1311200 | 79475 | 389456 | 135605 | 445586 |
| Jdita | 467 | 373600 | 22645 | 110968 | 38638 | 126961 |
| Iaat | 252 | 201600 | 12219 | 59880 | 20850 | 68510 |

# Renewable Energy Market Assessment
## *WWTP CASES STUDIES*

### Tripoli WWTP

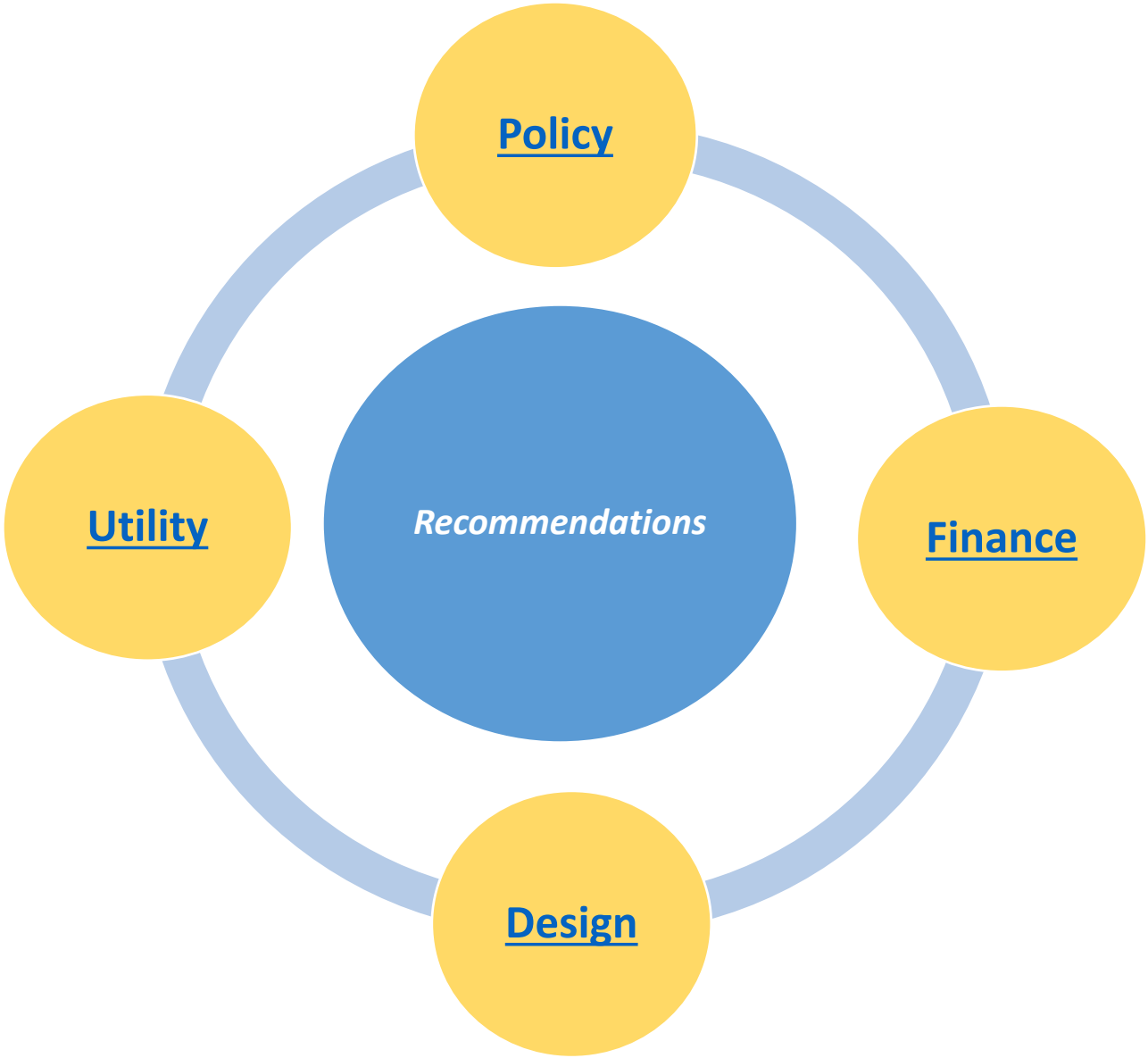

- Area 1 (A1): 12,000 $m^2$
- Area 2 (A2): 5,000 $m^2$
- Rooftop 1 (R1): 700 $m^2$
- Rooftop 2 (R2): 500 $m^2$

### Iaat WWTP

*Iaat wastewater treatment plant has 35,000 m2 of available total land and 600 m2 of rooftop space. The plant relies on a 500 kVA diesel generator to make up for the six hours of daily electricity outages.*

*Without storage, around 2,500 m2 were used from the available lands to generate around 252 kWp equivalent to 27% of the utility consumption.*

# Recommendations and The Way Forward



# Renewable Energy Market Assessment

## Policy

| | |
|---|---|
| Medium - long term | Develop a policy for RE integration in all water and wastewater facilities at the national level as part of a Water Sector Strategy. |
| | Increase synchronization between EDL and the facilities acting as decentralized producers generating solar PV surplus. |
| | Eliminate EDL subsidies and increasing the electricity tariff. |
| Immediate | Advocate for power wheeling agreements |
| | Prioritize adequate implementation of multi-site net-metering by addressing technical challenges such as the grid's instability. |
| | Monitor and report yearly GHG emissions to set mitigation action plans. |

# Renewable Energy Market Assessment

## Finance

**Medium - long term**

- Enhance RE affordability further by exempting RE components from import and other taxes to reduce the initial cost of financing.
- Assess the possibility to revise the reallocation of international loans and funds.
- Rethink the relationship between EDL and the water establishments.

# Renewable Energy Market Assessment

## Design

### Medium - long term

- Assess the techno-economic feasibility of hydro-storage solutions in facilities

### Immediate

- Mainstream the deployment of solar PV in the design of water and wastewater facilities, whenever applicable

# Renewable Energy Market Assessment

## Utility

Medium - long term

seek Public Private Partnerships for solar PV installation and maintenance.

Immediate

Regularly monitor energy consumption and efficiency through scheduled energy and financial audits.

# THANK YOU

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