Other
Energy Storage Devices

Water, Compressed Air, Ice, Thermal,
Rotating, Flow Batteries, Hydrogen, etc.

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Location: Fort Worth, TX

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Bio:

Background: Power Electronics Engineer
Majored in : System Integration & Controls in Power Architectures
Personal Interest: Sustainable Water & Energy supply

Worked @: Tectrol, Saft, Alcatel, AEG, Xogen, Exicom, Hyxos
Positions: design engineer, Manager, CTO, Senior Advisor, COO

Energy Storage background: Saft, Alcatel, AEG, Exicom
Water Treatment background: Xogen (electrolysis)

Current Status: Co-founder and CTO of Hyxos Innovations

Theme:

There are many devices that store energy besides capacitors and batteries.

Some store energy in an intermediate form, then convert it back to electric power.

Most store energy non-electrically for later use so that the electric power demand is better matched to supply.

Although not a classical energy storage mechanism, they can provide controls that synchronize loads to the peaks and sags of the Grid and can perform an equivalent function for regulation services / peak shaving / load shifting at a much lower cost.

The other players:

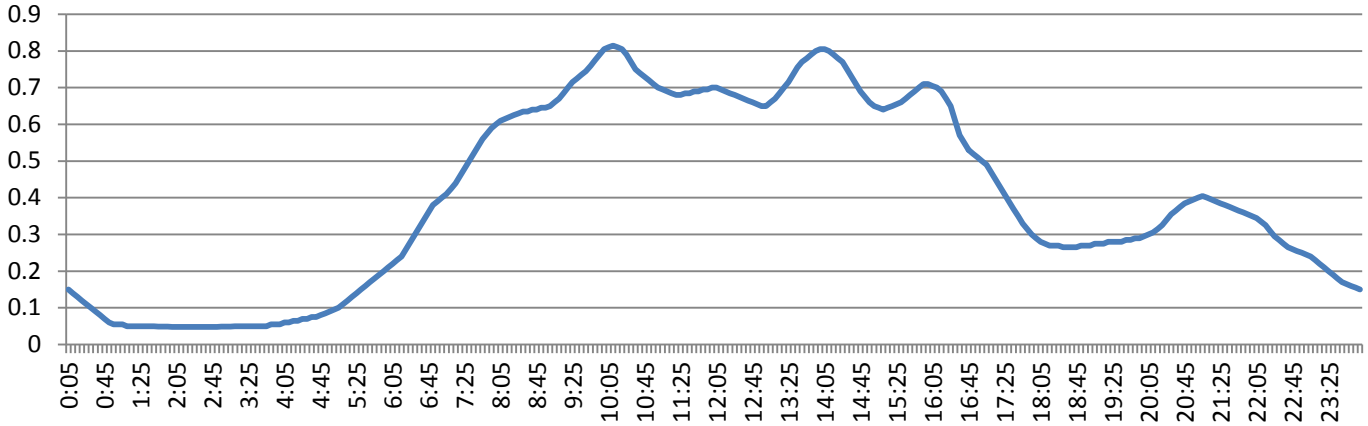
Thermal Storage: heat can be stored in
- solids like salt, phase changing materials
- liquids like water, coolant material

Pressure Storage: pressurized storage can be found in many places
- natural gas, air in caves, balloons
- hydrogen for fuel cells
- LNG for transportation

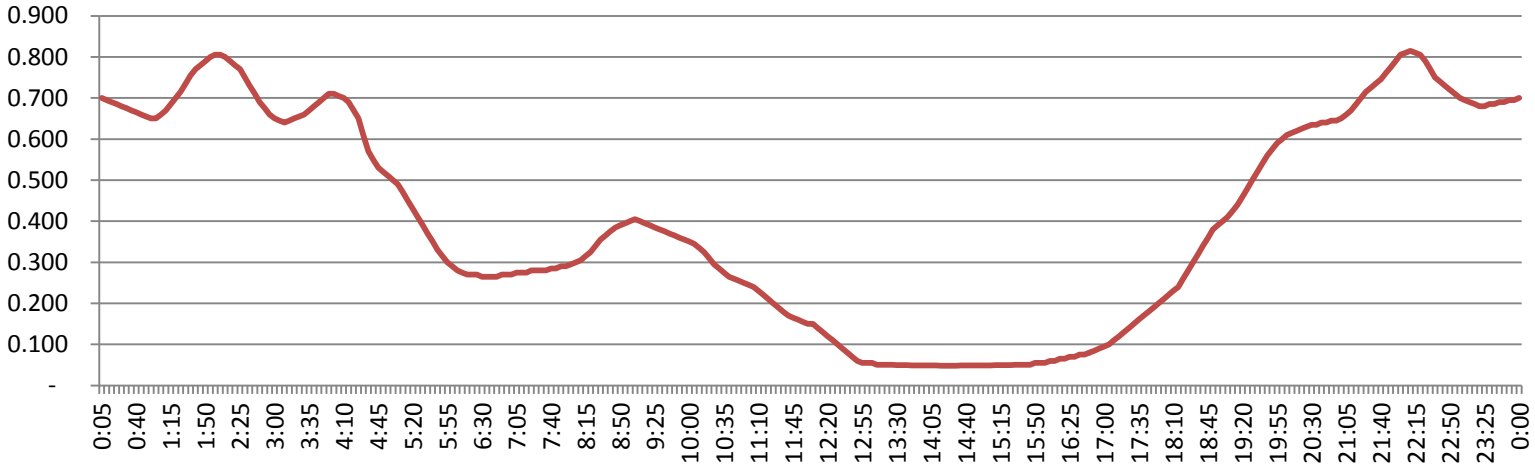
Phase changing Storage: water to ice, water to steam, solids to liquid

Mechanical Energy Storage: flywheel, pumped hydro

Typical Load Curve



Time shift by 12 hrs. = Load shifting ➔ STORAGE DEVICE



Municipal Water Usage (Circa 2010)

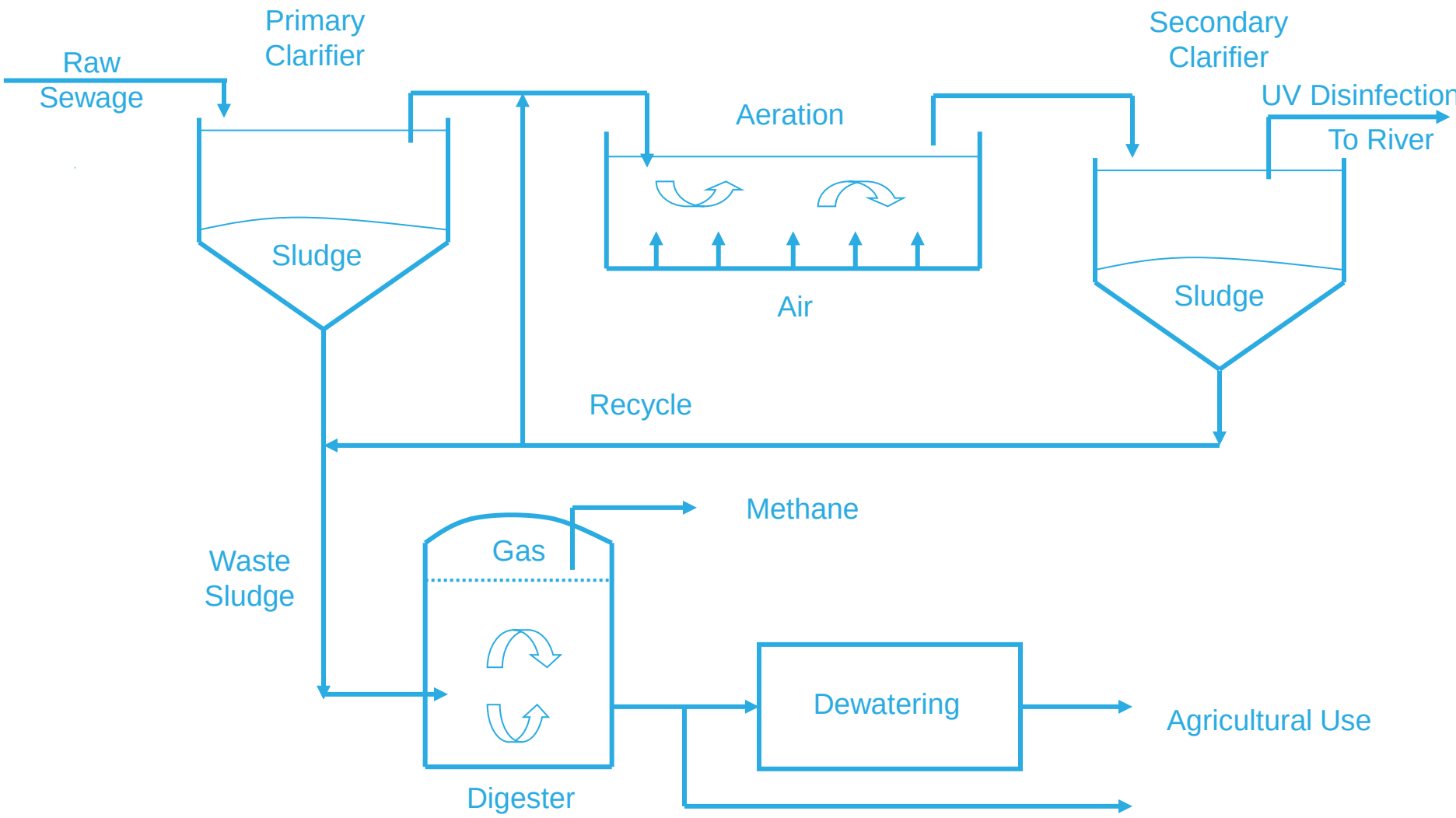
- Example Cities: Singapore, Dallas (DFW+Arlington), Toronto (GTA): approx. 4-6M people

  - 8 - 10 Billion Litres of water pumped per day
  - 14 - 22 pumping stations-each approx. 550-850 Million litres/day capacity
  - Approx. 200kWh per million litres is used or 1.8GWh / day

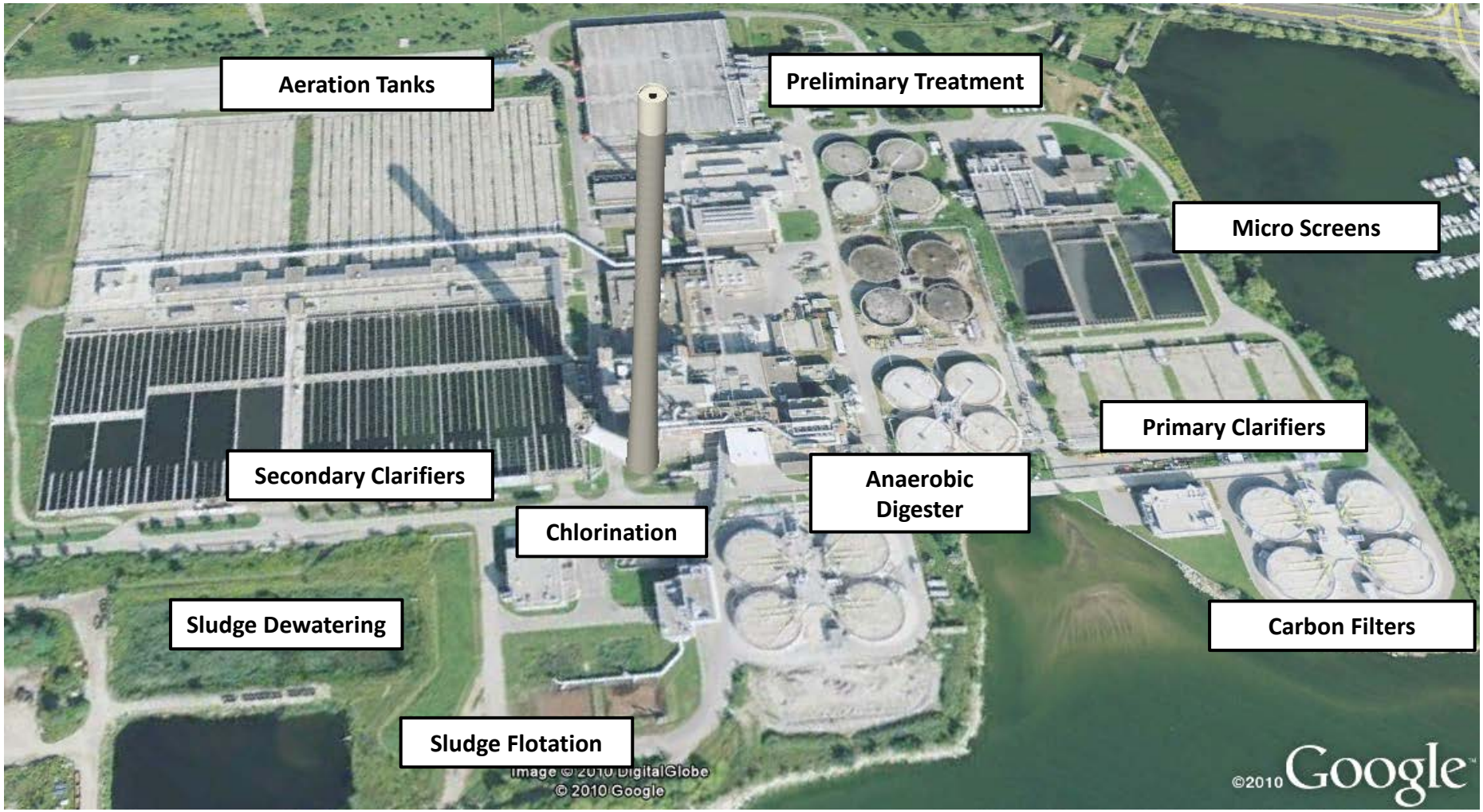
  - 10 – 14 reservoirs
  - 5,000-6,000 km (3000 – 3600 miles) of pipeline infrastructure
  - 4 – 6 waste water treatment & re-use facilities, w. 1.0 Billion Litres/day processed and 2.5 – 3 Billion Litres/day capacity
  - Each water treatment facility uses 3 - 6 MWh per day per Million Litres or
  - Between 3 - 6GWh / day of total electricity used

  - Average daily power usage for the water process per city is: 7.8 GWh
  - At $0.10/kWh this is $780k / day, with 365 days full operation per year

Conventional Biological Treatment



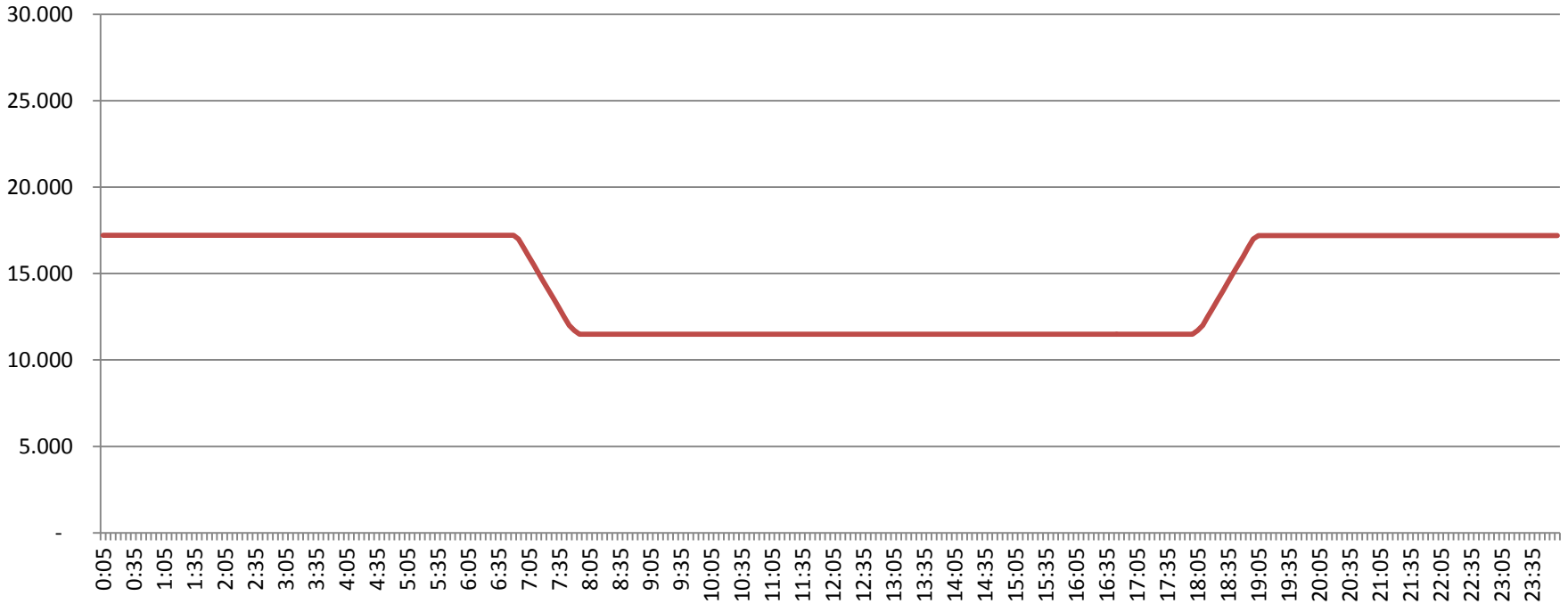
Conventional WWT – 820,000m^3 capacity (Ashbridges Bay – built in 1912, 4.1Mft^2)



- Waste water storage capacity = 7 days
- 1 + 1 system redundancy
- Operational Life = 40 yrs.
- Multiple MV grid fed

Typical Municipal WWT Load Curve

- Daily average usage is: 344.40MWh; at a cost of $23,780; or 7cents/kWh
- Annualized costs: $8.68M



Technologies Available

- Conventional Biological Treatment ➔ 6 – 8 hrs. per batch

- Electrolysis Treatment ➔ 1 – 3 hrs. per batch
- UV Treatment ➔ 1 – 3 hrs. per batch
- Ozone Treatment ➔ 1 – 3 hrs. per batch

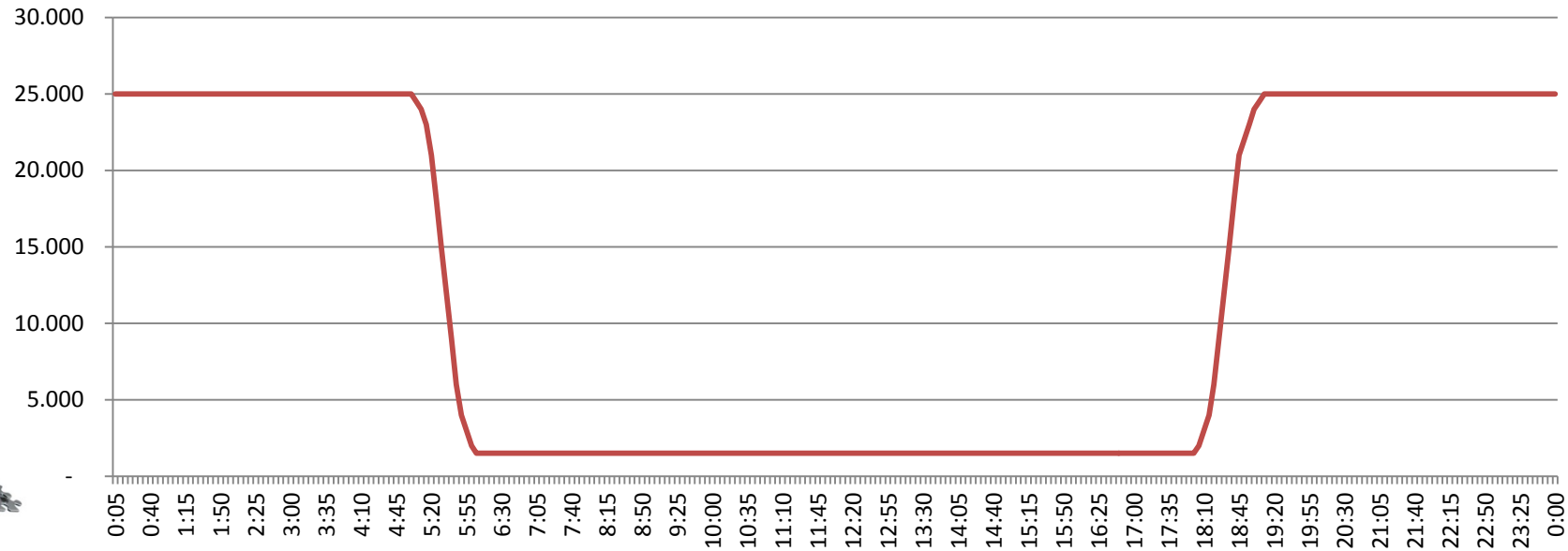
KEY here is not what technology to select!

➔ the opportunity of reducing treatment time, yields a bi-product of being able to shift the treatment load

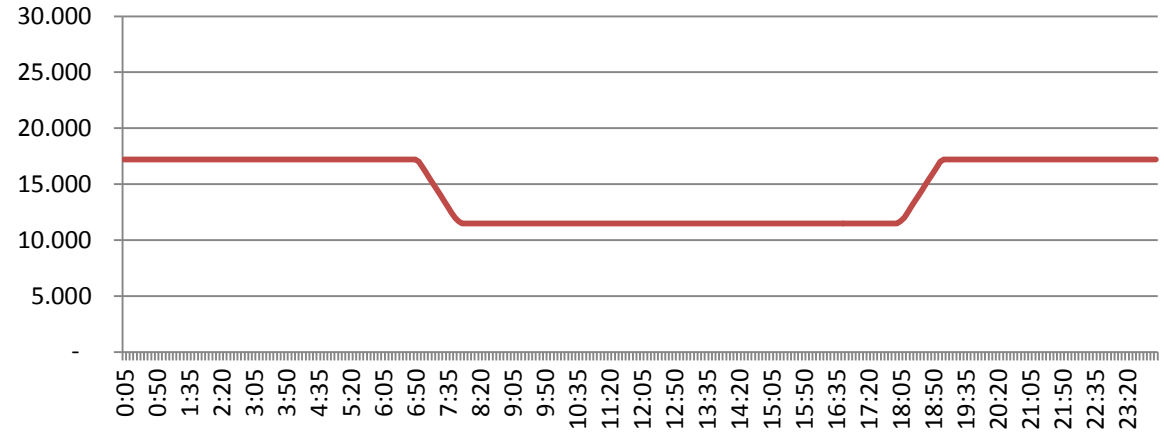
New Load Profile

- Aeration + Digesters ≈ 55% of the load
- Pumps for filtration and Dewatering ≈ 30% of the load
- Admin, office, security etc. ≈ 15% of the load

- Variable: 85% or in this case 120MWh during critical peak time (6am – 6pm)
  - Aeration + Digesters
  - Pumps for filtration and Dewatering



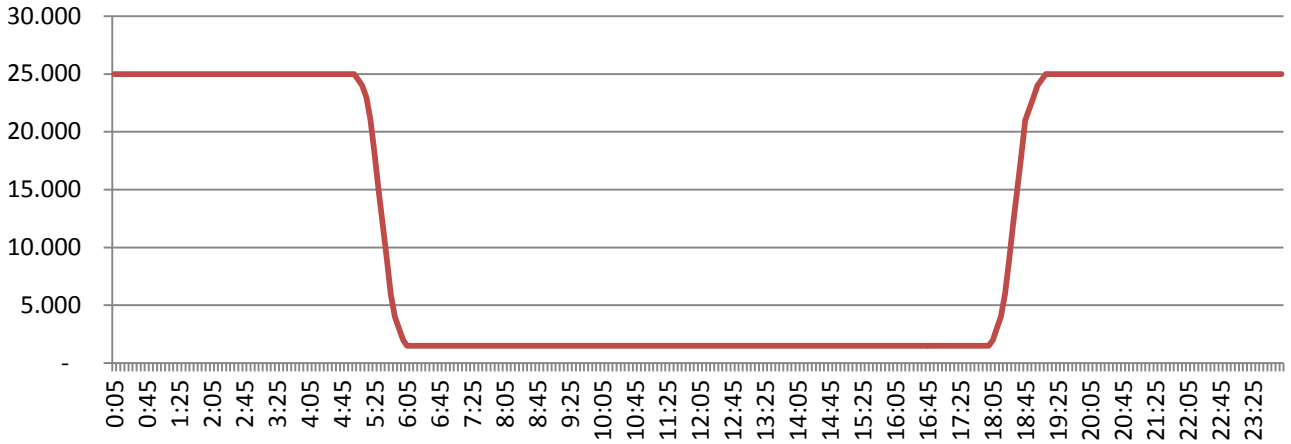
Load Curves



Time shift by 12 hrs. = Load shift 120MWh / day = save $3.5M / yr. on TOU

CAPEX ≈ $100M ➔ less then 3 cents/kWh

Note: example uses electrolysis process, 2011 COGS, interest, TOU etc.

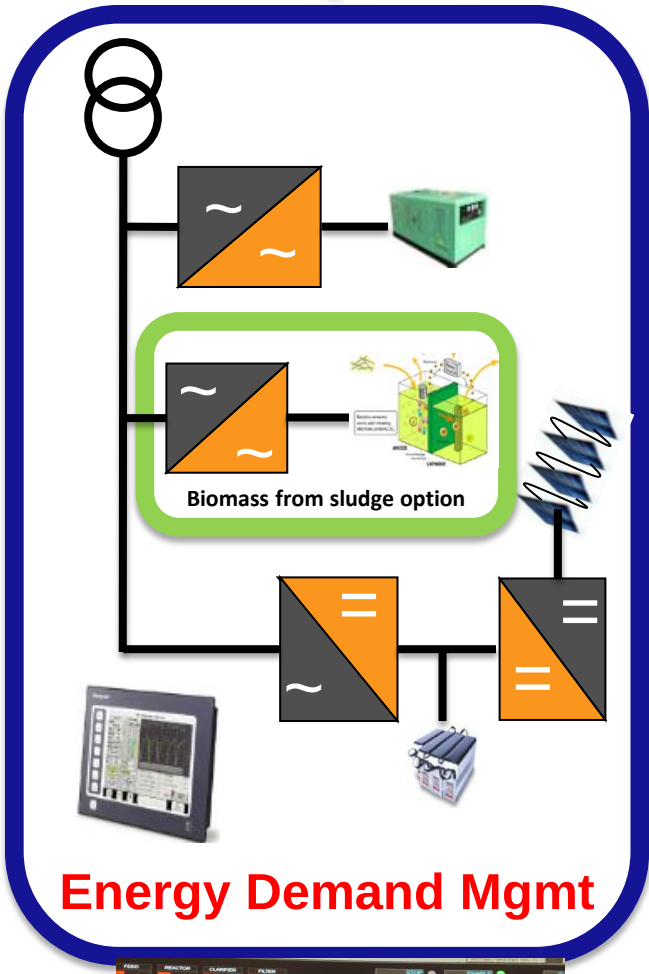


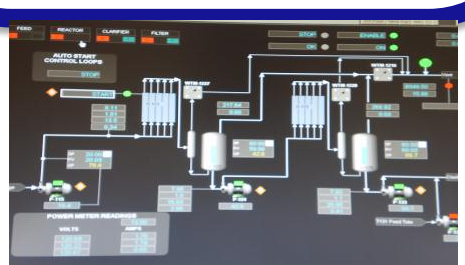
Sustainable 35m³ / hr., 50kW WWT demo µGrid

- Solar PV size is 45% of the load or 450kWh
- **Process Gas handling using CHP ≈ 30% of the load**
- Biomass from sludge (BOD/COD > 75%) ➔ 25% of the load
- EDM controls the various sources and loading to match WWT flow

- Enabling technology ➔ < 1hr. Treatment time
- Key design criteria:
  - Input buffer tank sized for 3 days to cover cloudy days
  - Battery to handle 15 min. intermittence only

- Benefit for local utility:
  - Load shifting, V, f and pf correction (from PV inverter)






Q & A