Triple Net Zero Impact of Future Communities

WATER, ENERGY, WASTE AND RESOURCES

Vladimir Novotny PhD, PE, BCEE

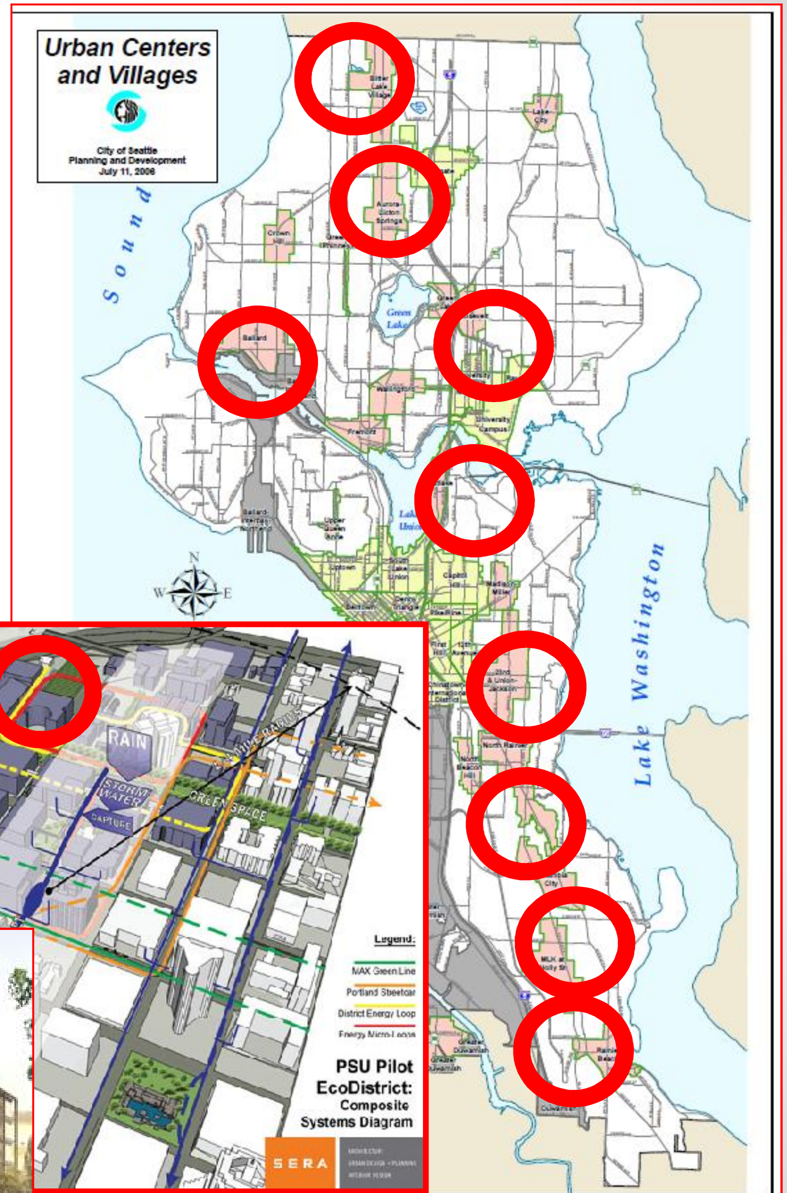
Global Energy Outlook Conference
Madison, WI October 29,2014

Triple net zero goals for Future Communities

- *Zero waste water*
  - Water conservation
  - Zero pollution
  - Resources recovery
- *Net zero or better GHG Emissions*
  - Renewable energy production (solar, hydropower and wind)
  - Passive energy conservation
  - Energy recovery from used water and geothermal sources by heat pump or exchange, and from organic solids as methane and/or hydrogen and electricity
- *Zero solid waste to landfills*
  - Recovering energy in a form of syngas or hydrogen and electricity from organic solids
  - Producing valuable products such as biofuel, biochar with slow release nutrients, paper, building and other materials.
  - Recycling glass, metals, paper, etc.

Three levels of implementation

- <u>Buildings</u>
  - Energy efficient, solar panels, water savings
- <u>Neighborhood (cluster) water management</u>
  - Low Impact Drainage (LID)
  - Water reclamation and reuse
  - Heat Recovery
- <u>Region Integrated Resources Recovery Facility - IRRF</u>
  - Water
  - Energy
  - Nutrients
  - Biosolids & biofuel



Source Steve Moddemeyer

Realistic net zero carbon homes

Affordable CarbonLight home in UK

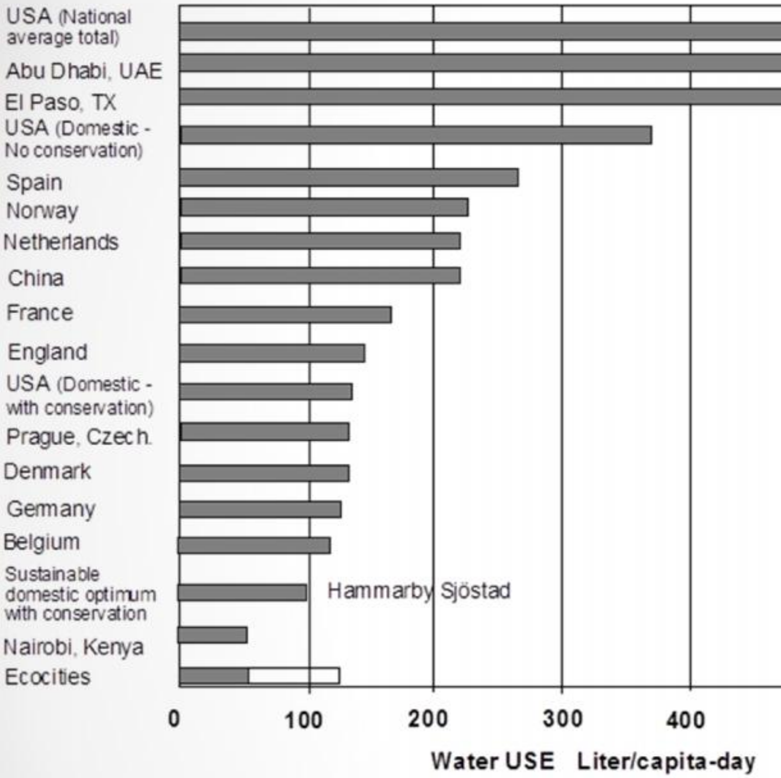
Z House Apartments Seattle

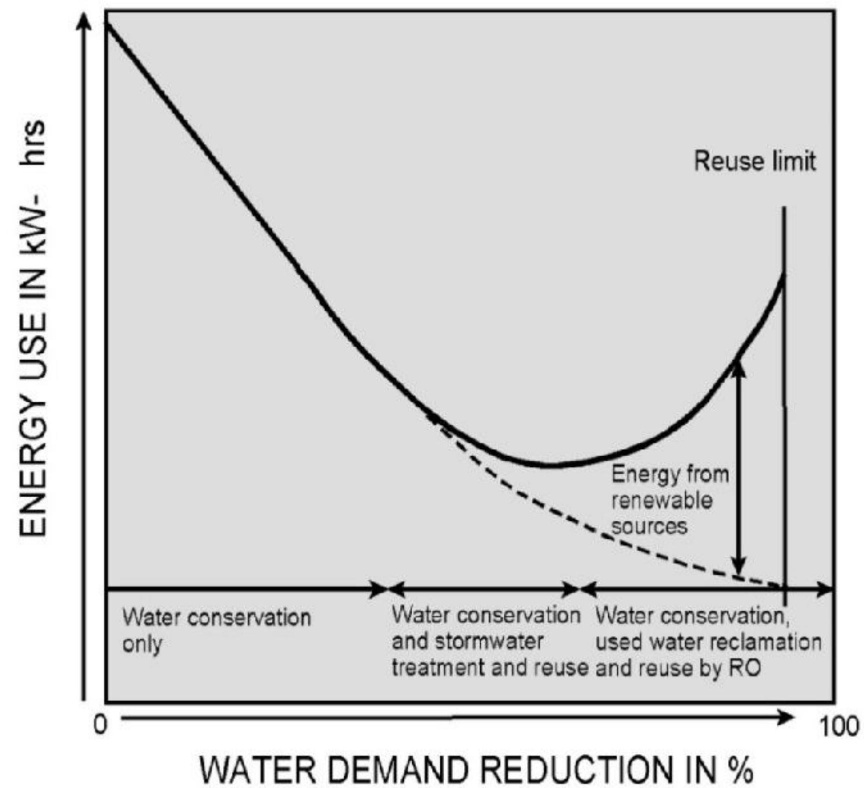
Other features of the sustainable house:

- Passive energy conservation
- Dual piping for water supply
  - Potable
  - Nonpotable
- Used water separation
  - Black water
  - Gray water
- Solid waste separation into biodegradable and recyclable
- Xeriscape landscaping

Water Energy Nexus

Effects of Water Conservation



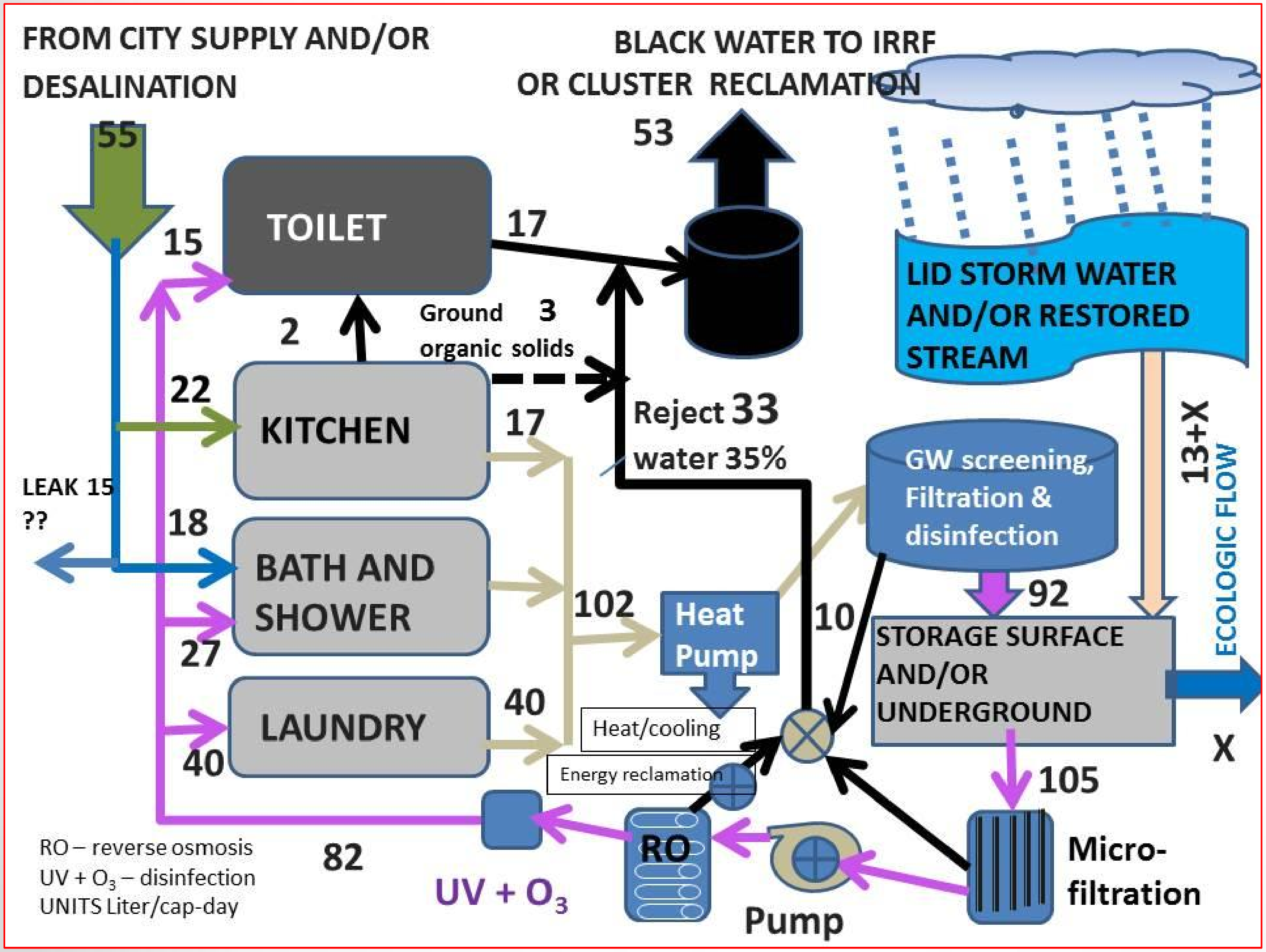


Energy delivered from the grid

1 kW-hr = 0.69 kg of CO_2 emitted

1 m^3 conserved ≈ 1.4 kg CO_2 emissions reduced

Water Loop in the Cluster

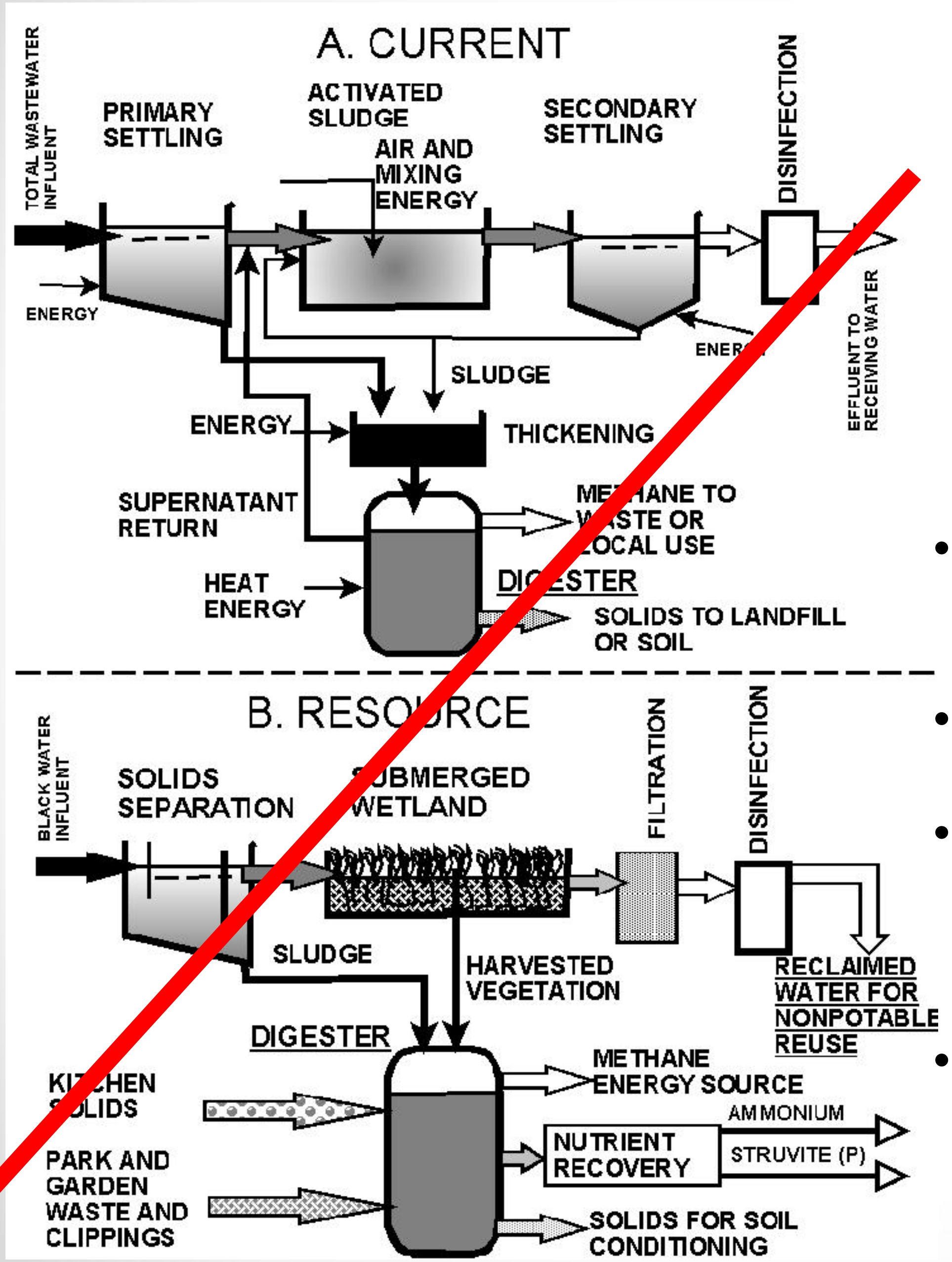


<u>Separation into black and gray water flows</u>

Water demand flows based on AWWA-RF study for a house with water conservation

The gray water loop needs storm water from storage on dry days

BUILDING IRRF



Traditional energy demanding and a simple more sustainable water reclamation system

- **The A process requires an lot of energy**
- **Most of organic C is emitted as CO_2**
- **If wetland is employed (B) methane is emitted which is 25x more potent GHG than CO_2**
- **Energy recovery from methane is small; covers only a fraction of the energy used by the treatment plant**

There is not enough energy in used water

- The traditional aerated water reclamation systems use far more energy than that contained in organics in used water and sludge
- The energy needed to treat, transfer and deliver water to the city users may be significant, varies around 1 -2 kW-hr/m^3 (~ 1 kW-h/cap-day)
- Household water heating requires significantly more energy (> 1.40 kW-h/cap-day) than that contained in used water organic content (0.14 kW-hr/cap-day).
- By switching to anaerobic treatment and co digestion of organic solids (food and yard organic waste) and including solar energy in the heating cycle, the water system could become a net producer of energy

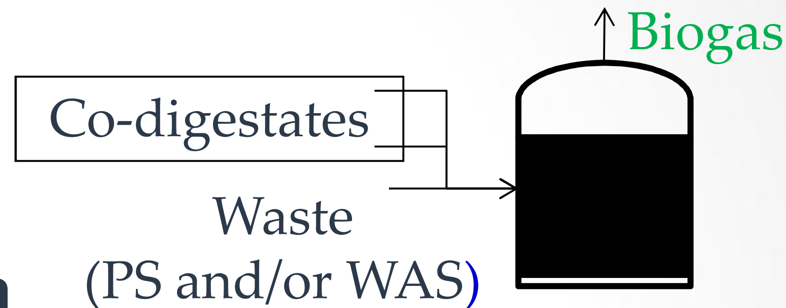
ADDITIONAL ENERGY SOURCES ARE NEEDED

Integrated
Resources
Recovery

…

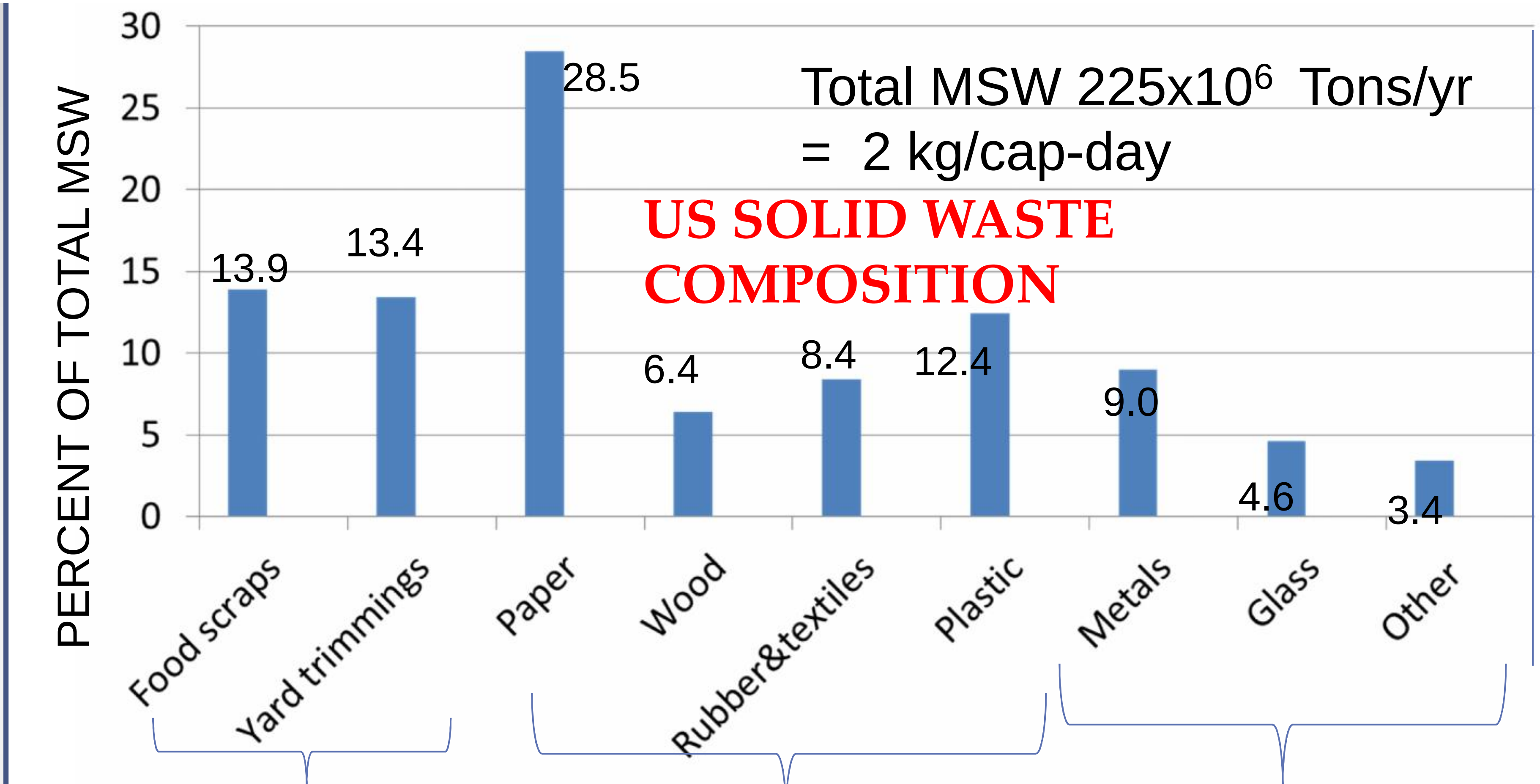
CODIGESTION

- Typical biodegradable solid (food and yard) recoverable waste production in the US is about 0.5 kg/cap-day that can be codigested with the sludge
- Nutrients in the effluent and CO_2 from IRRF can be used for growing algae for more energy
- Codigestates: Food waste, organic deicing fluids, yard waste, oil and hydraulic fluids, meat production waste, yeast, algae and many others



PS-Primary Sludge
WAS-Waste Activated Sludge

- Solar and wind energy can be implemented in IRRF and in clusters to provide more energy for heating the reactors and buildings and (in the future) to enhance fermentation and steam methane/carbon monoxide reforming to hydrogen



To: co-digestion, Include also manure, glycols & other biodegradable wastes

To: pyrolysis or gasification or recycle

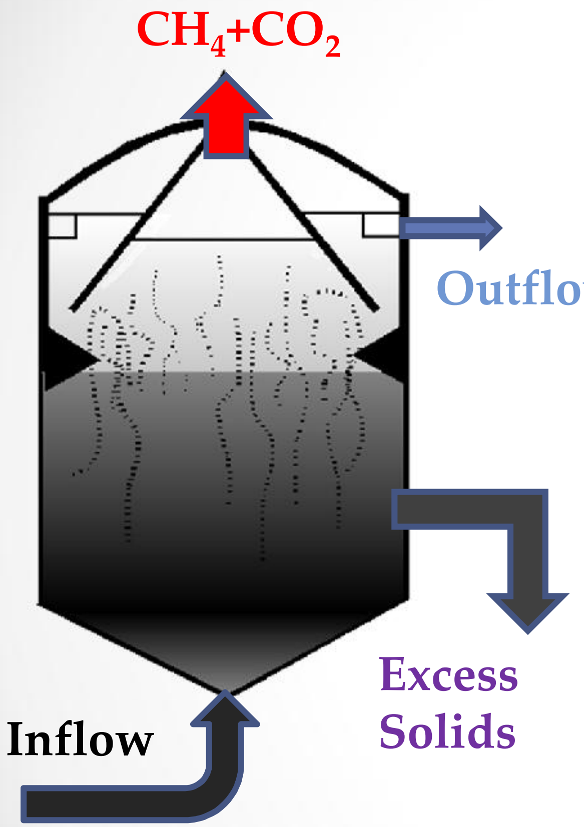
To: recycle

MSW-municipal solid waste

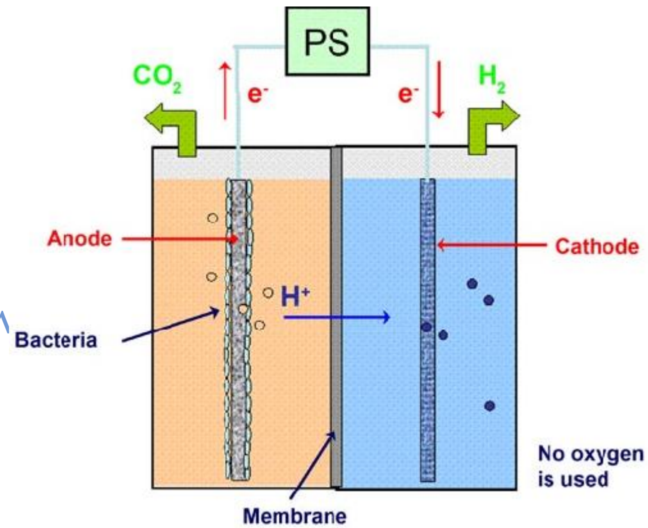
INTEGRATING SOLID WASTE INTO TOTAL RESOURCE RECOVERY

US EPA : wwwepa.gov/osw/nonhaz/municipal/pubs/msw_2010_rev_factsheet.pdf

Enabling technologies for 21century IRRF



UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR (UASBR)



Bioelectrochemically Assisted Microbial Reactor (BEAMR)

Converts organic biomass directly into hydrogen by adding small electricity to the reactor (from Liu, Grot and Logan, 2005)

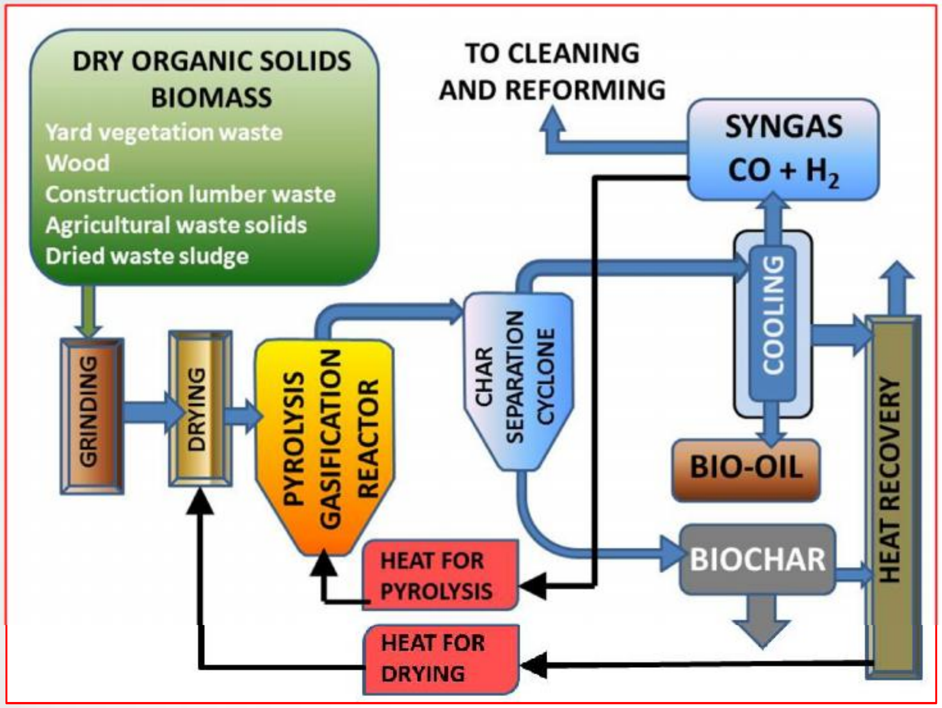
95 % energy recovery from produced acetate

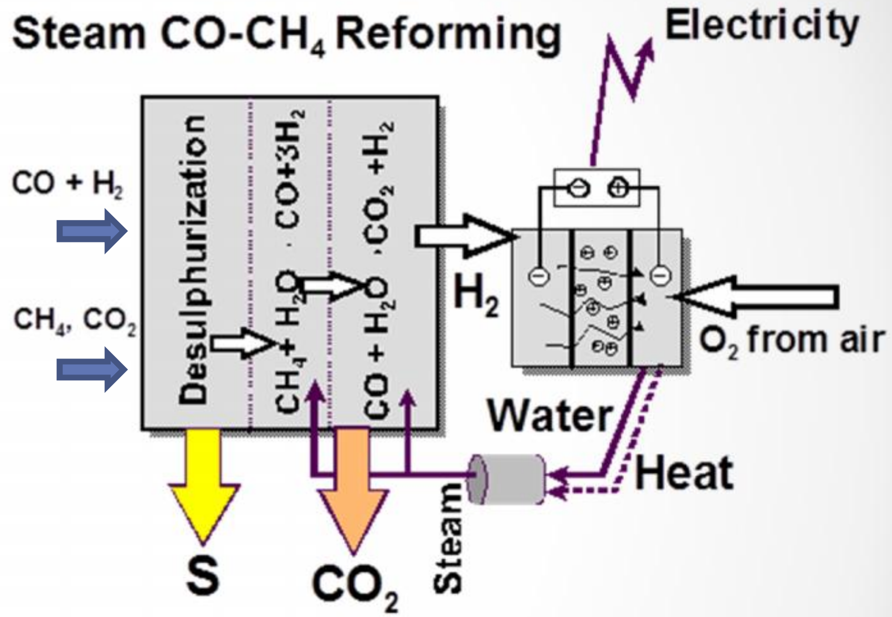
HEAT PUMP

MEMBRANE REACTOR

Enabling technologies for 21century IRRF cont.

BLUE TOWER

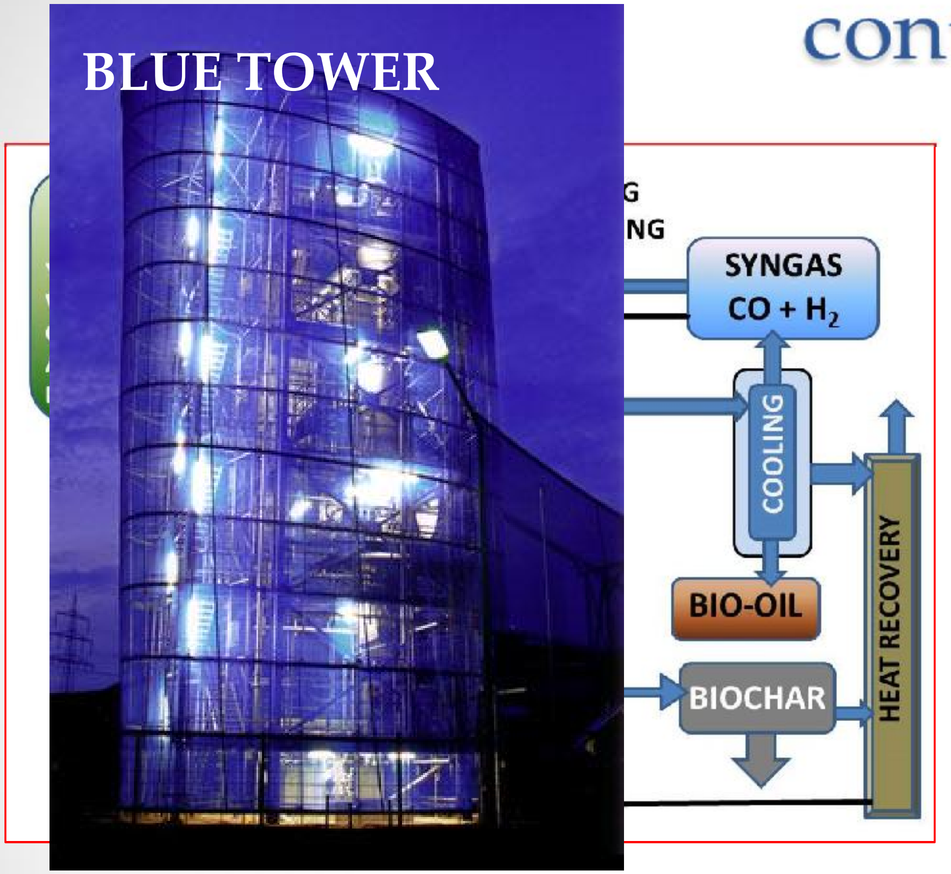




Pyrolysis-gasification

Hydrogen fuel cell

Enabling technologies for 21century IRRF cont.



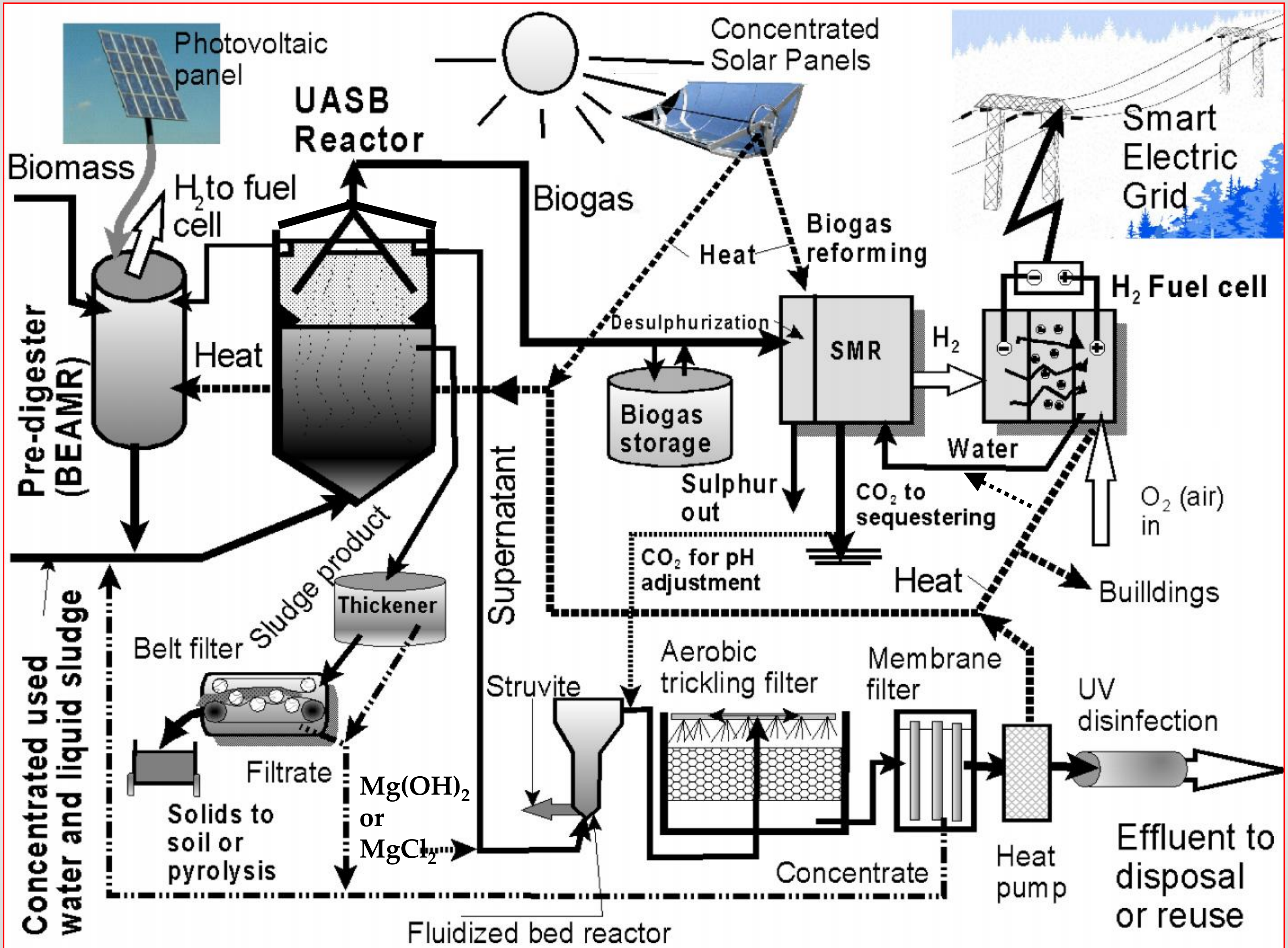
Pyrolysis-gasification

Hydrogen fuel cell

Developing Integrated Resource Recovery Facility

INPUT

A. Energy from Concentrated Used Water Recovered by Anaerobic Treatment
B. Energy from Co-digestion of Sludge and Other High Concentration Liquid (glycol) and Solid Organic Waste (manure, food solids, algae)
C. Energy from Gasification/Pyrolysis of Organic Solids (waste wood, wood chips, cardboard, dried sludge, tires, etc.)
D. Heat Recovery from Effluent and Biogas Conversion to Energy
E. Nutrient Recovery
F. Clean Water



EARLY VARIANT OF IRRF

Conclusions

- US has one of the highest per capita carbon footprint
  - Low density urban centers
  - High automobile use
  - Great reliance on fossil fuel (primarily coal) power production
- Adopting the three zeroes future city guidelines is increasing significantly recovery and energy production from renewable carbon free sources
  - Water conservation is effective
  - More efficient appliances and heating (e.g., heat pumps)
  - Biogas conversion to electricity and/or hydrogen with carbon sequestering is effective
  - Large inclusion of solar and wind power and passive energy conservation
  - Heat recovery from used water
  - Energy from solid waste and, potentially, from algae
- Other Resources (N& P) can be recovered
- The goal of three net zero footprints is achievable by 2030 even in the US

REFERENCES

- Novotny. V. et al. (2010) *Water Centric Sustainable Communities*, J. Wiley, Hoboken, NJ
- Novotny, V. (2013) Water energy nexus: retrofitting urban areas to achieve zero pollution; *Building Research & Information, 41:5,589-604*

Vnovotny@AquanovaLLC.com