Sustainable City Network

“Developing An Energy Master Plan For The Water/Wastewater Industry”

Thursday, November 3rd, 2011

carollo
Engineers...Working Wonders With Water®

Overview of Presentation

- The New “Energy Reality”
  - Internal drivers
  - External drivers
  - Learning from the past
- The “Integrated Energy Plan™” => a 5-Step Process
- What’s conventional, what’s new?
  - Concepts, technologies, institutional solutions
- Case studies:
  - San Jose/Santa Clara WPCP
  - CCCSD
- Summary

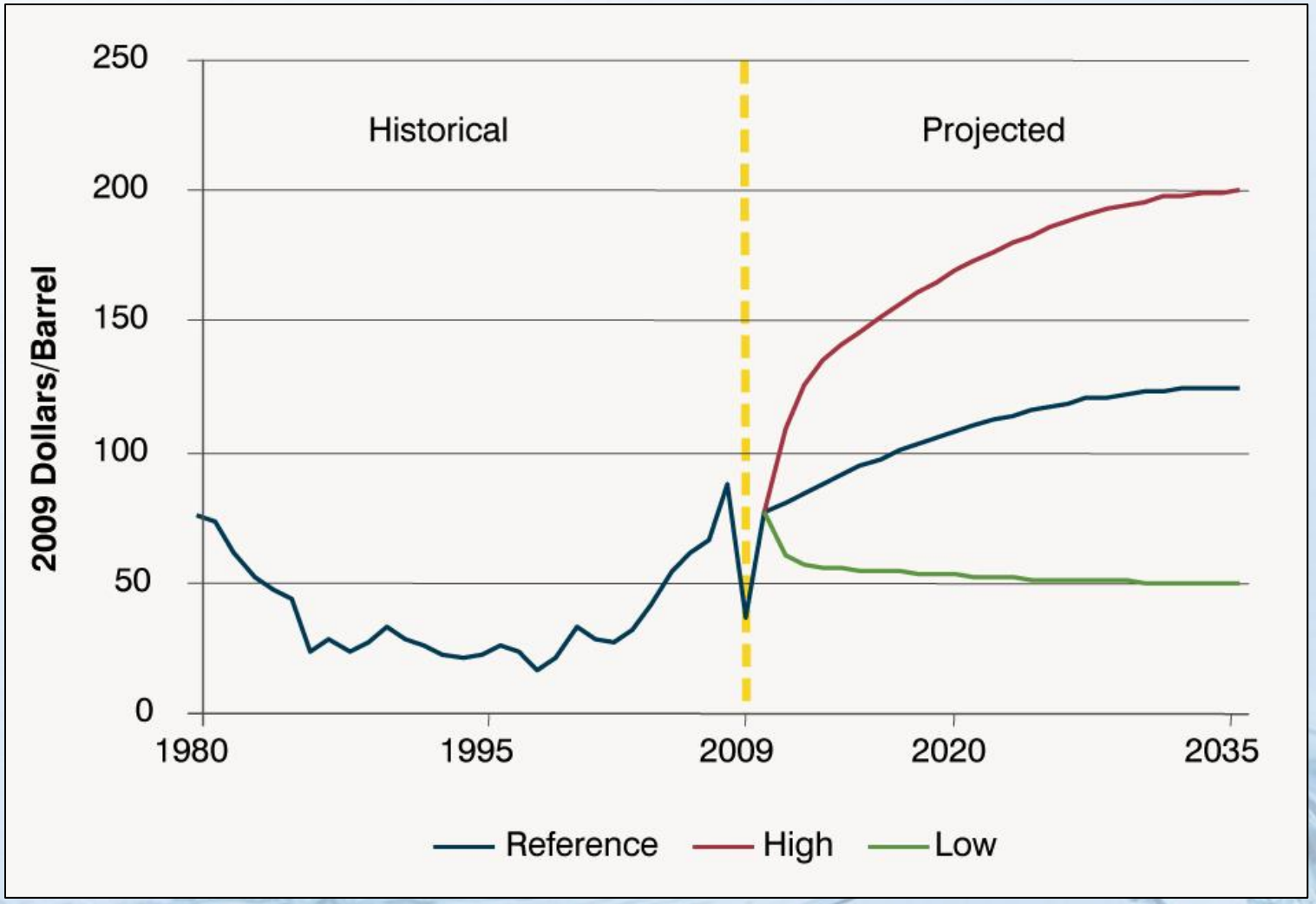
Internal Industry/Agency Drivers for a Renewed Focus on Energy

- Regulations
  - Increased level of treatment => more energy use
- Aging Infrastructure/Repair and Replacement
  - Asset Management and Life-cycle costing
- Expansion to accommodate planned growth
  - More capacity and associated energy requirements
- Management Efficiencies/Optimization
  - Push to “do more with less”

External Drivers for a Renewed Focus on Energy

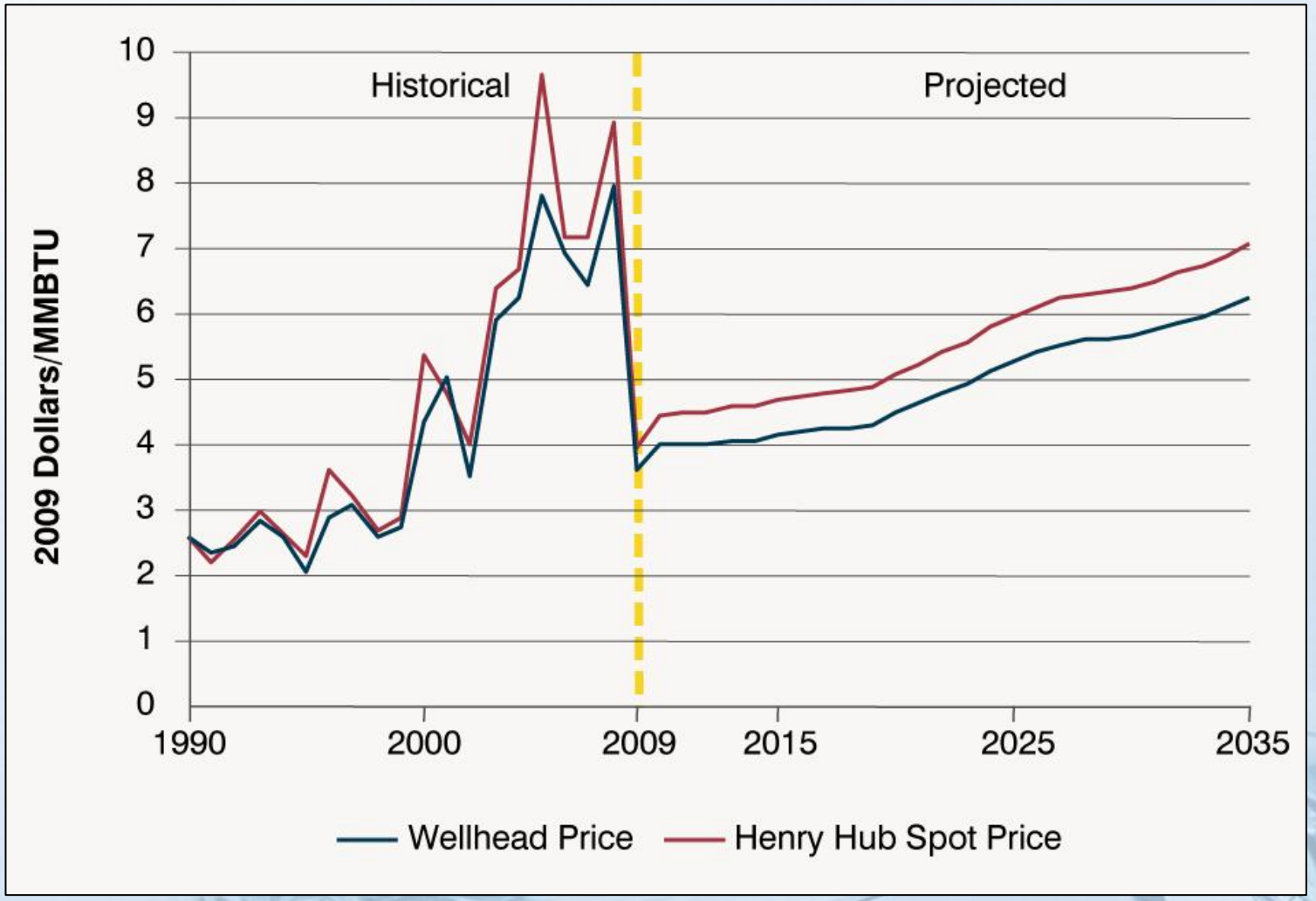
- Economic
  - Increasingly limited conventional energy resources (i.e., oil, natural gas, etc.)
  - Changes in financing options (e.g., P3 agreements)
- Environmental
  - Climate change concerns/GHGs
- Social
  - To “be green”

Oil Price Trends



Source: U.S. Energy Information Administration Energy Outlook 2011

Natural Gas Price Trends

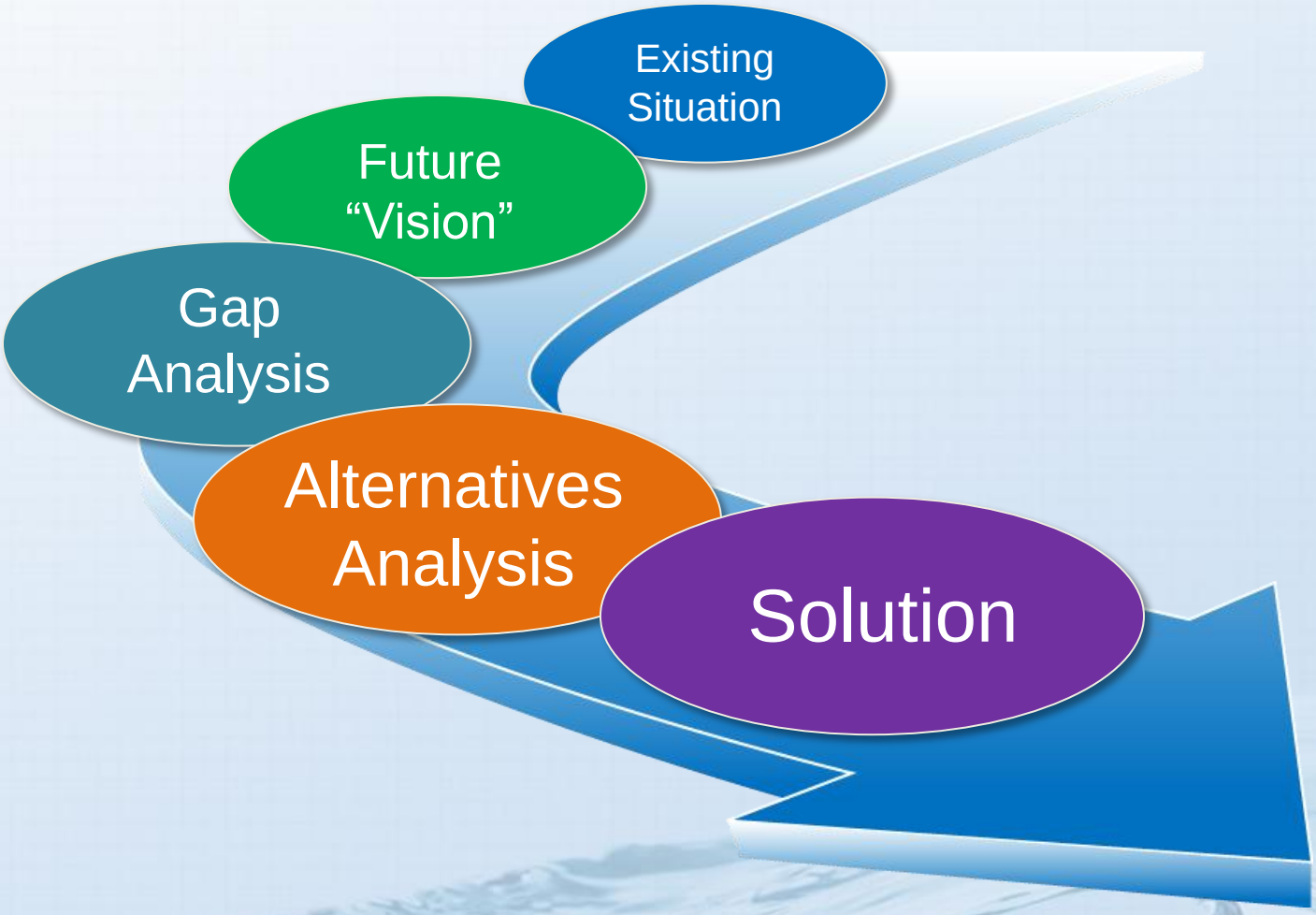


Source: U.S. Energy Information Administration Energy Outlook 2011

Fundamental Short-Comings in our Approaches in the Past…

- **Didn't Consider "Systems"** We didn't take into account the *interconnections* in our environment and our bodies
  - E.g., DDT was a great pesticide, but we didn't understand the consequence of a 'conservative' pollutant vs. "the solution to pollution is dilution"
- **Didn't Consider "Time"** We focused on the short-term, and not the *long-term that is required to fully realize the full consequences* of our actions
  - E.g., climate change due to lack of oceans to fully assimilate CO_2

The 5-Step Process for Developing an "Integrated Energy Plan™"

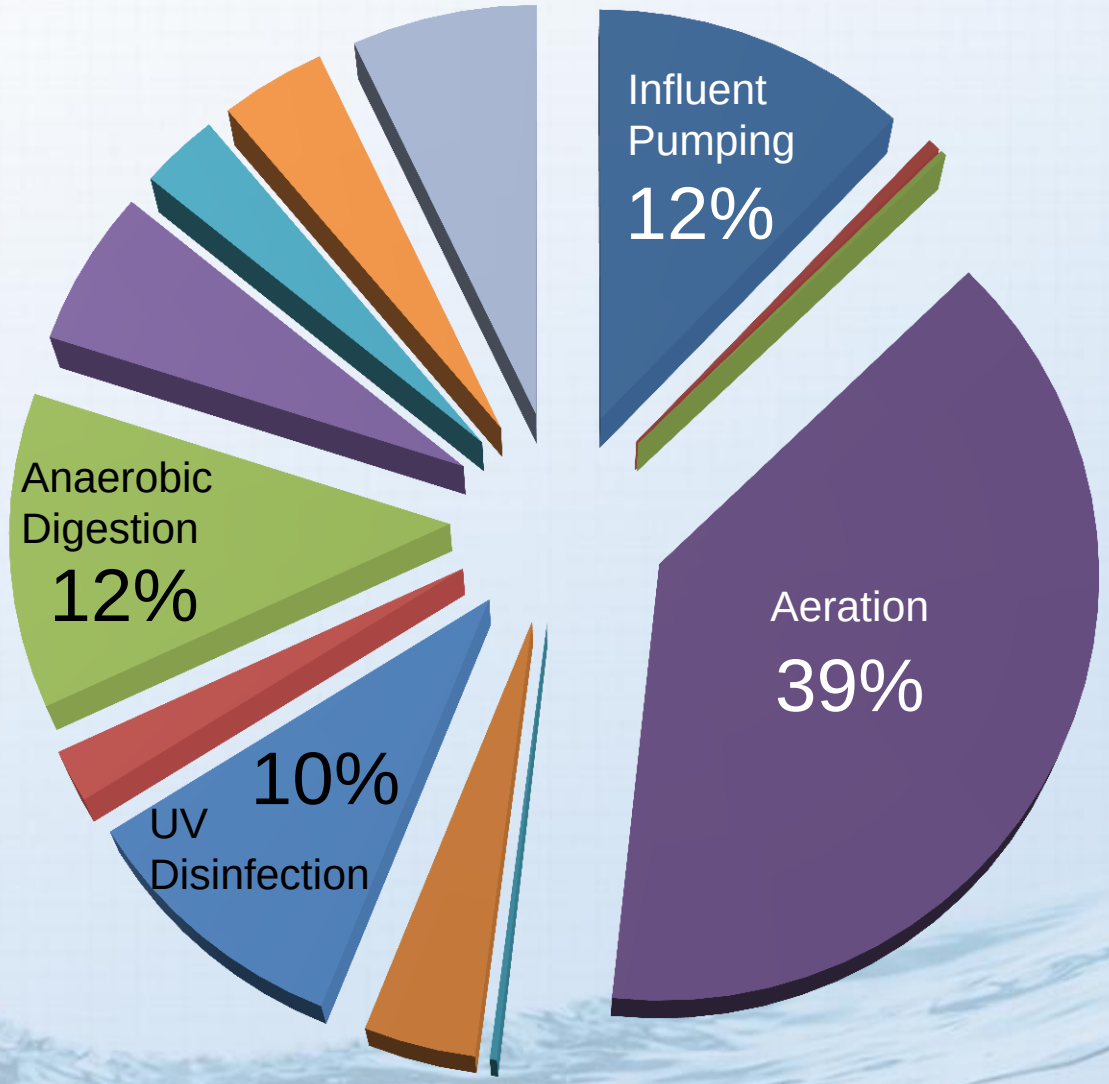


Step 1: Assess the Existing Situation

Step 1: Assess the Existing Situation (continued)

- Energy audit
  (i.e. field evaluation and data collection)
  - **Verify data**, i.e. compare actual daily operations/ practices with design data and plant capacities
  - Review **energy-intensive processes** (e.g., pump stations, process air blowers, centrifuges, etc.)
  - Identify areas where the **demand** can be controlled and reduced

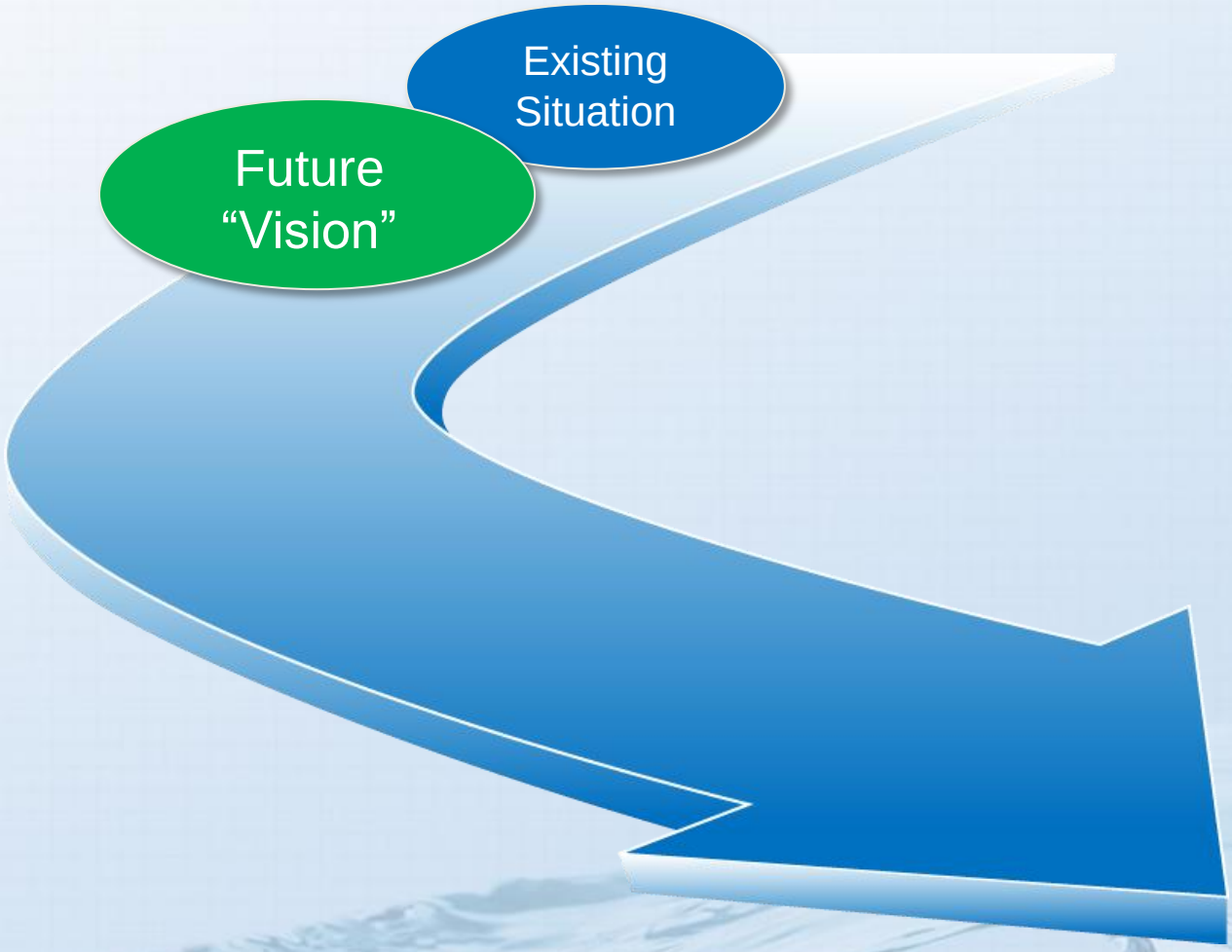
Typical Relative Energy Demand (WWTP)



- **Influent Pumping**
- Headworks
- Primary Sedimentation
- **Aeration**
- Secondary Sedimentation
- RAS Pumping
- **UV Disinfection**
- Thickening
- **Anaerobic Digestion**
- Dewatering
- Lighting
- HVAC
- Odor Control

Source: Whitlock, D., *et al* (2009)

Step 2: Identify the Future “Vision”

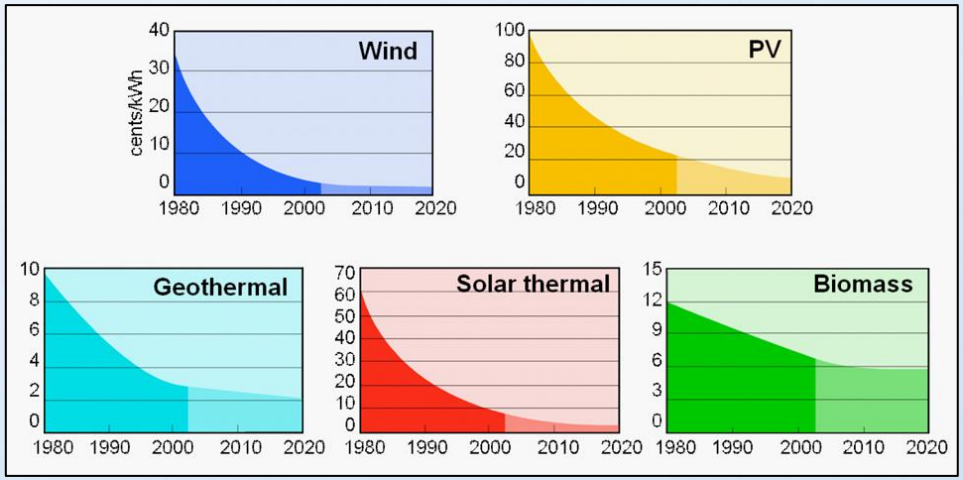


Step 2: Identify the Future "Vision" (continued)

- Set levels of service (LOS):
  - Standards:
    - NPDES permit requirements (EPA/local authority)
    - Public safety (State/Local Departments of Health)
    - Process requirements (e.g., aeration needs)
  - Conditions:
    - Critical/ upset conditions
    - Full plant operation conditions

Step 2: Identify the Future "Vision" (continued)

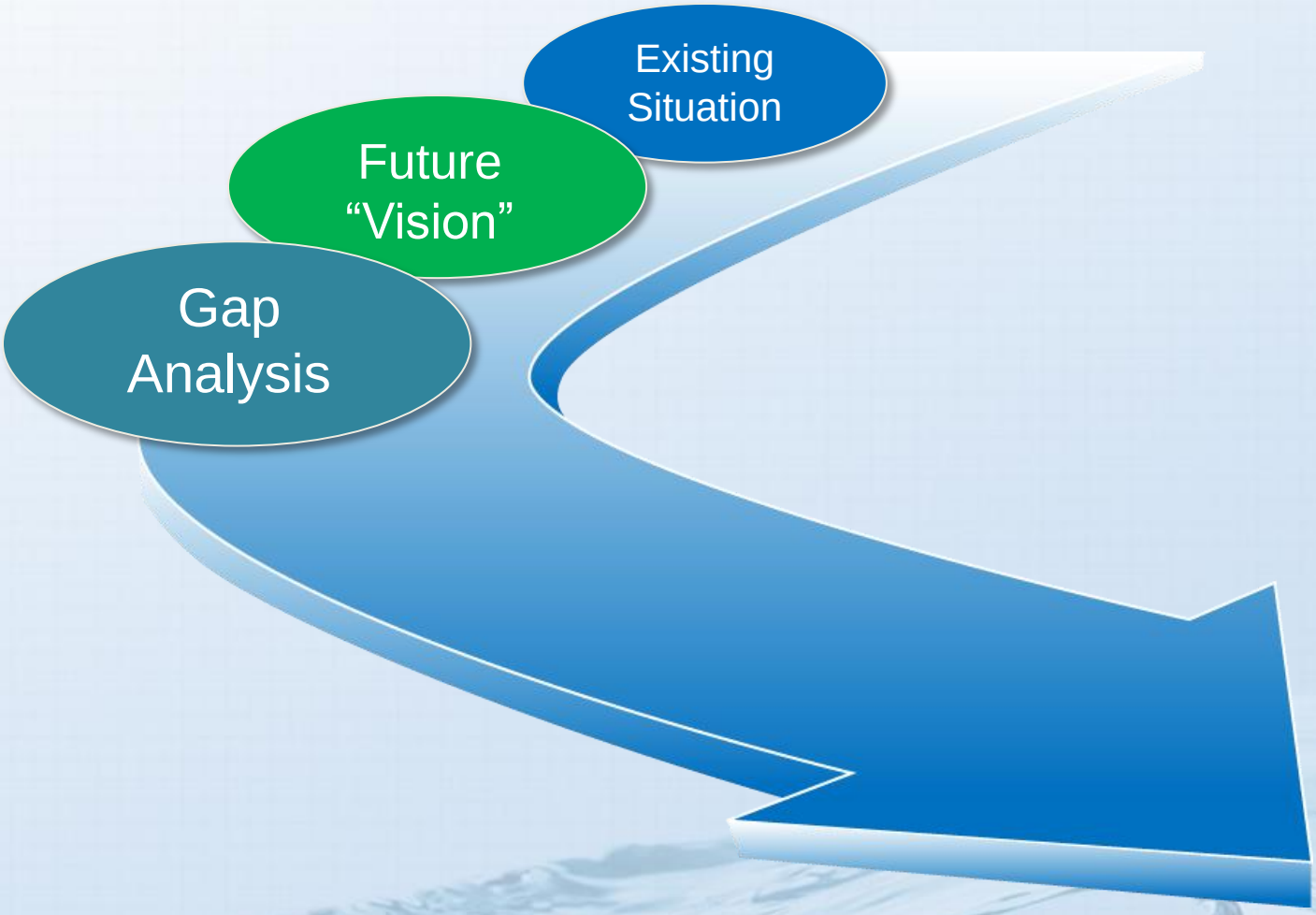
- "Energy Independence" (how to meet?)
  - Supply side options:
    - Add renewable ("green") energy to portfolio



Source: National Renewable Energy Laboratory Energy Analysis Office

    - Add "contract purchase"
  - Demand management options

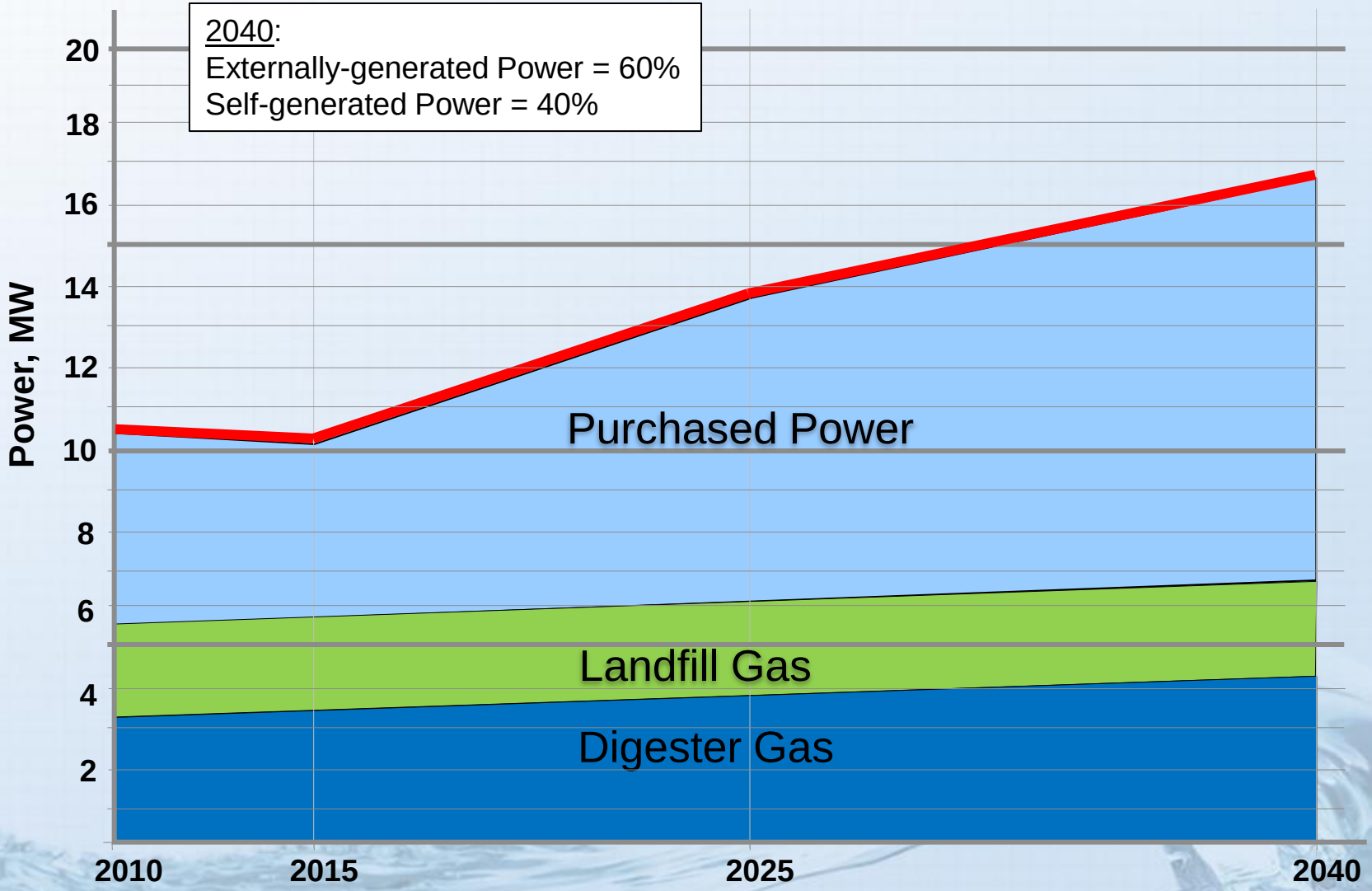
Step 3: Perform a “Gap Analysis”



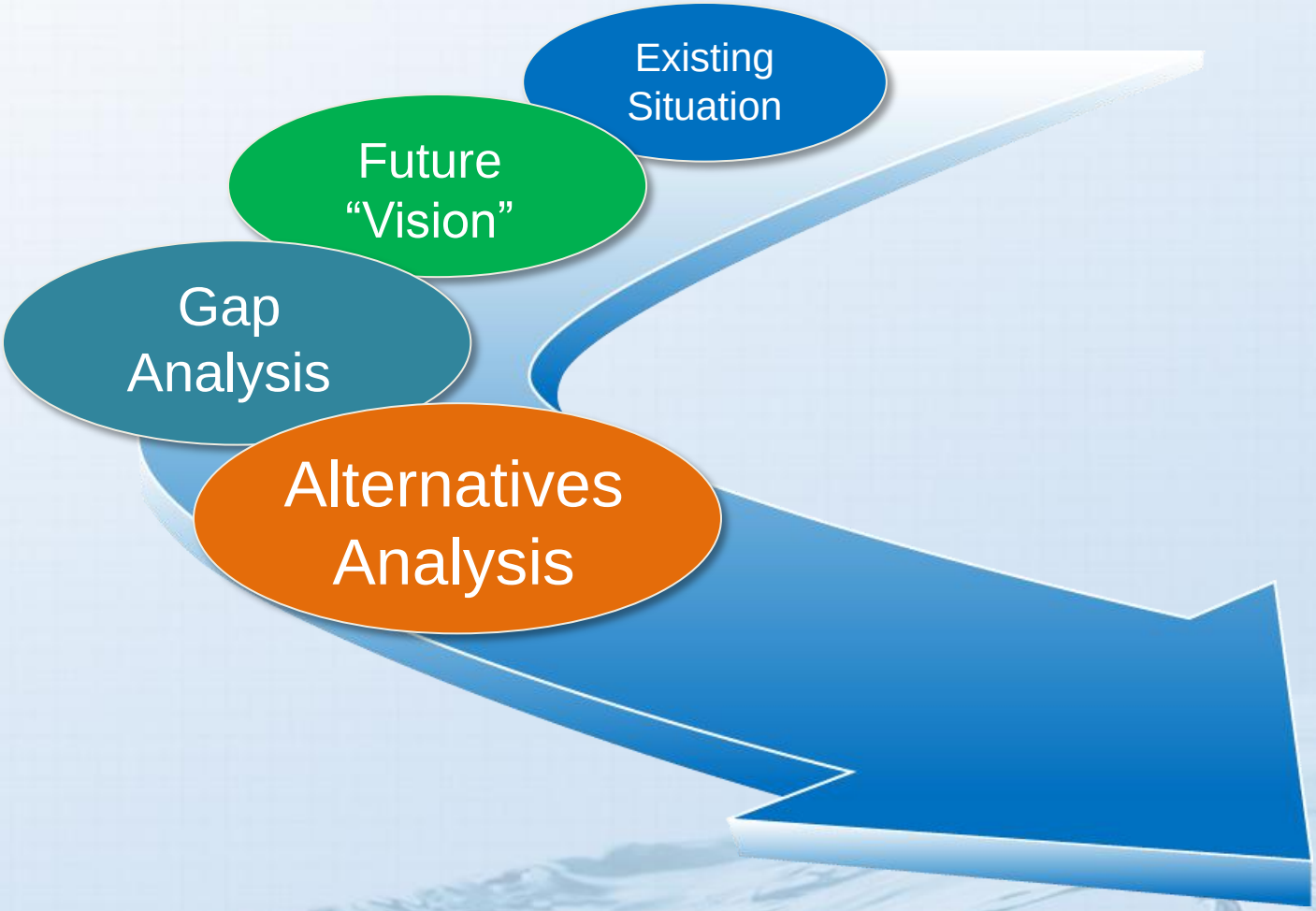
Step 3: Perform a "Gap Analysis" (continued)

- Defining the gap:
  - Total energy need vs. supply => additional energy?
  - Existing vs. desired reliability => additional reliability?
  - Dependent vs. independent energy user => okay?
- Considerations:
  - Estimate the future plant energy and reliability needs (influent flows and loads, possible future treatment requirements, etc.)
  - Compare with the *"current and future power generating portfolio"*
    - e.g. San Jose/Santa Clara WPCP

San Jose/Santa Clara WPCP *"current power generating portfolio"*

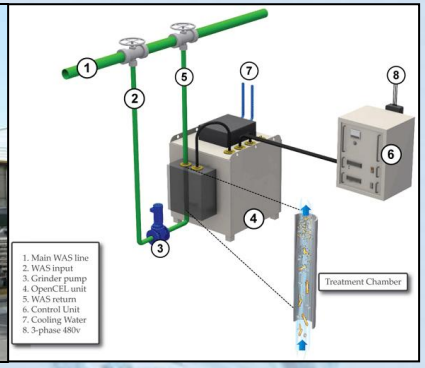


Step 4: Perform an Alternatives Analysis



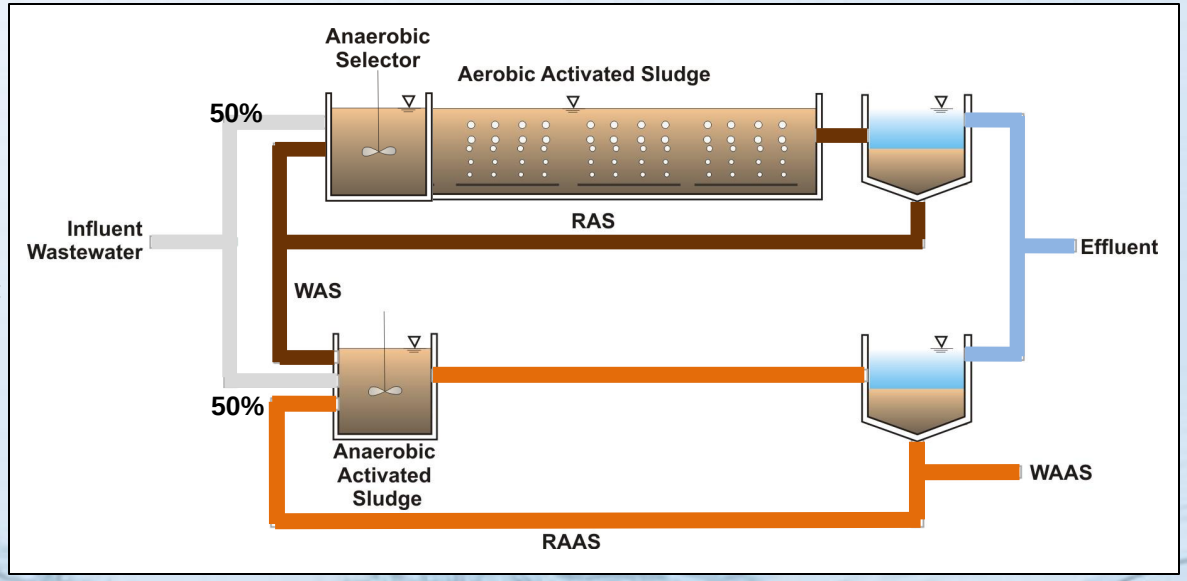
Step 4: Perform an Alternatives Analysis (continued)

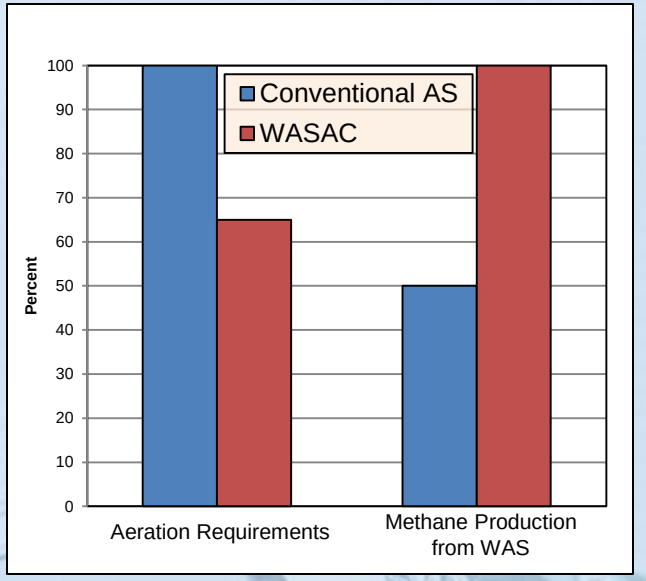
- Non-process efficiency improvements
  - Fuel cell
  - Mercury turbine
  - Pretreatment (e.g., CAMBI®, OpenCel®)
  - Turbo-type blowers



Step 4: Perform an Alternatives Analysis (continued)

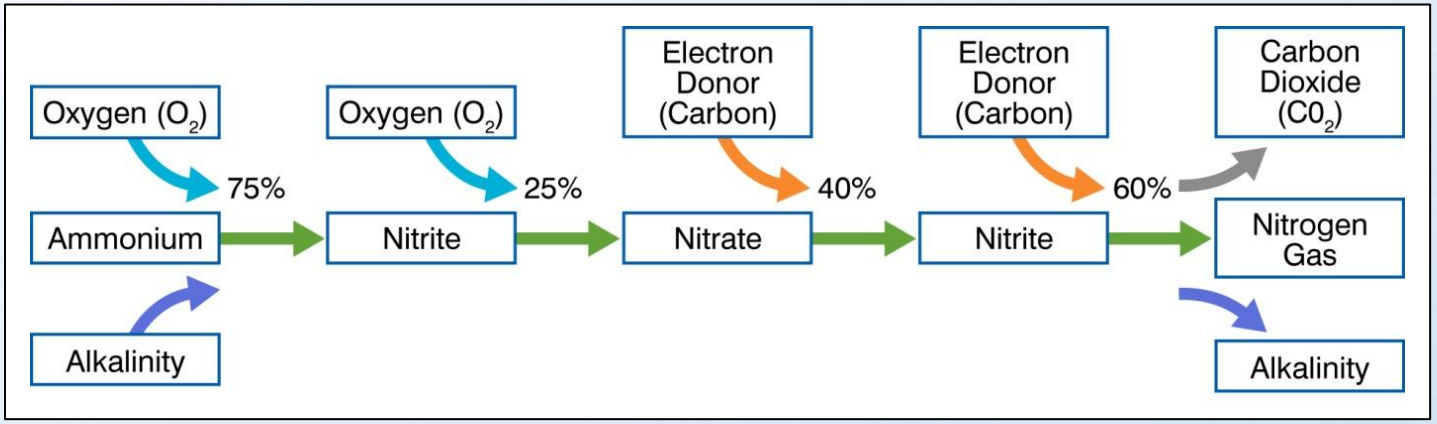
- Process modifications
  - Chemically enhanced primary treatment (CEPT)
  - WASAC®
  - Sidestream treatment (e.g., ANAMMOX®, DEMON®)



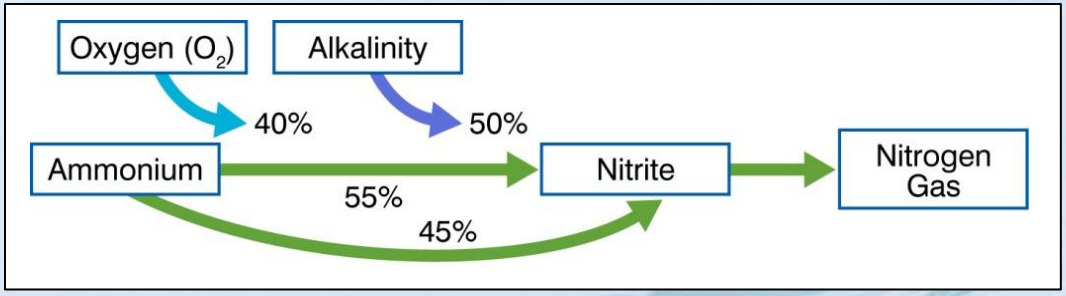


New Biological Nitrogen Removal Processes

Conventional Nitrification-Denitrification



ANAMMOX® Process

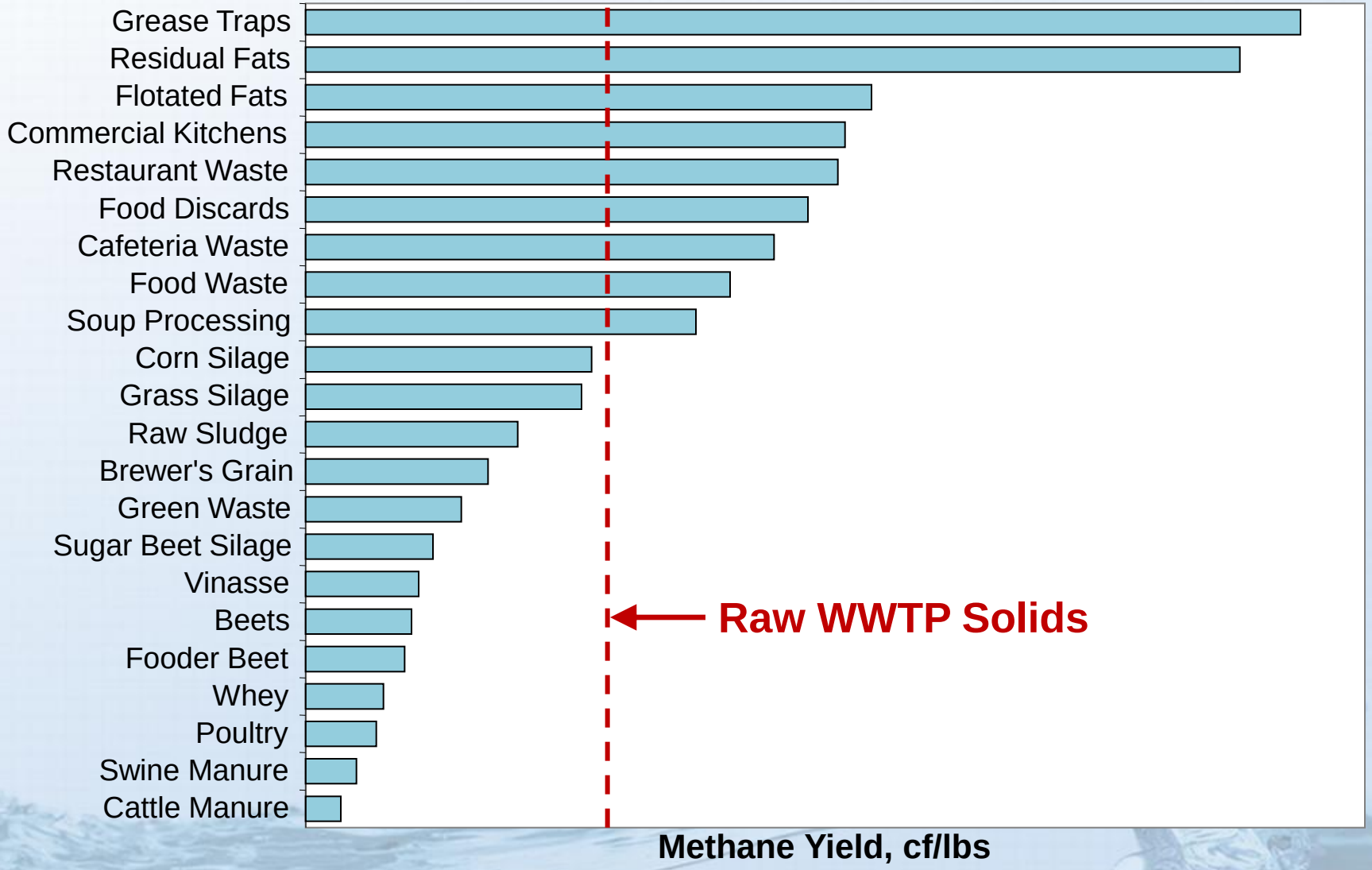



anammox reactor, KU Nijmegen

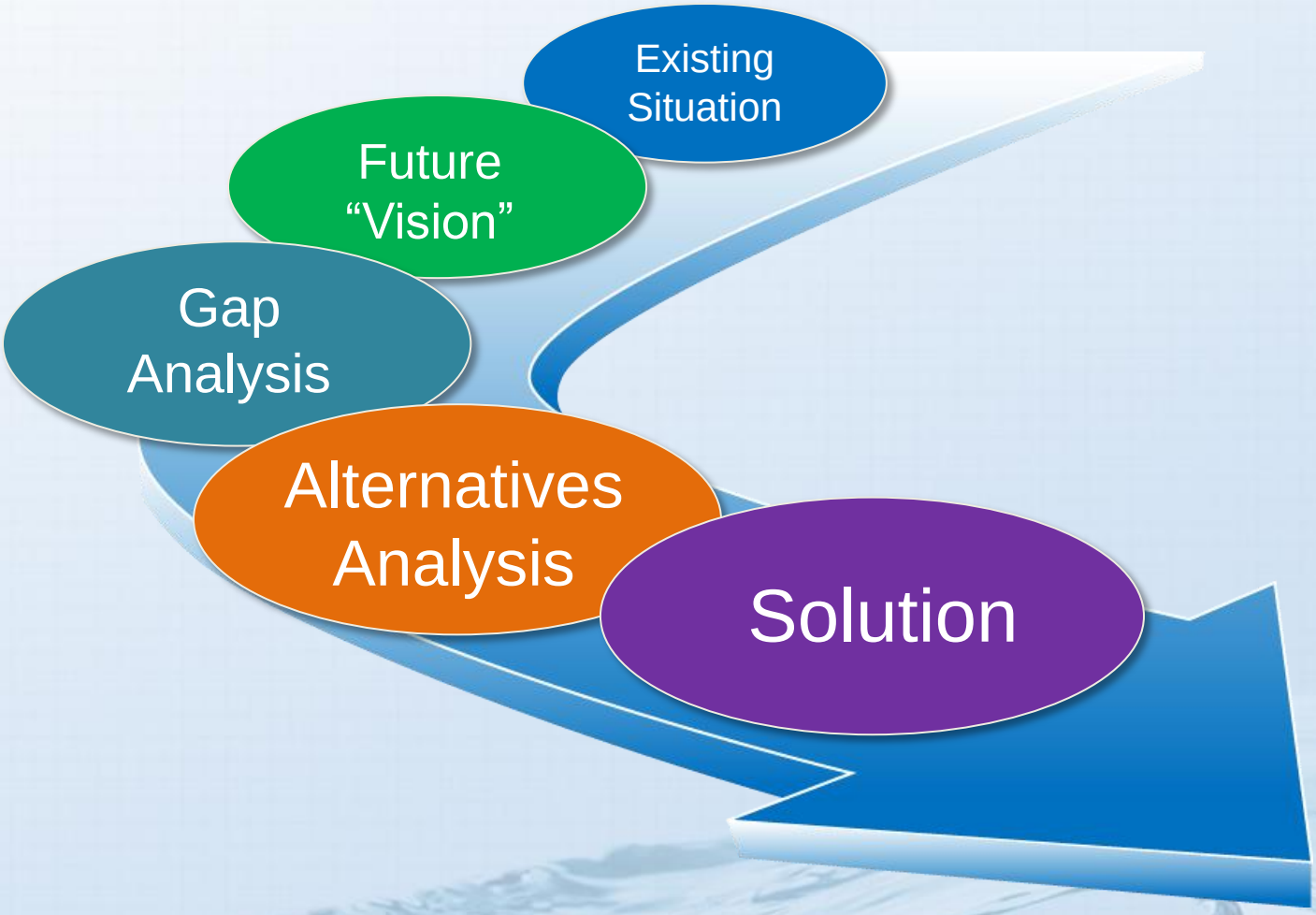
Step 4: Perform an Alternatives Analysis (continued)

- Renewable energy options
  - External feedstocks
  - Solar
  - Wind

Characterization of High Strength Wastes is Critical for the Estimation of Performance



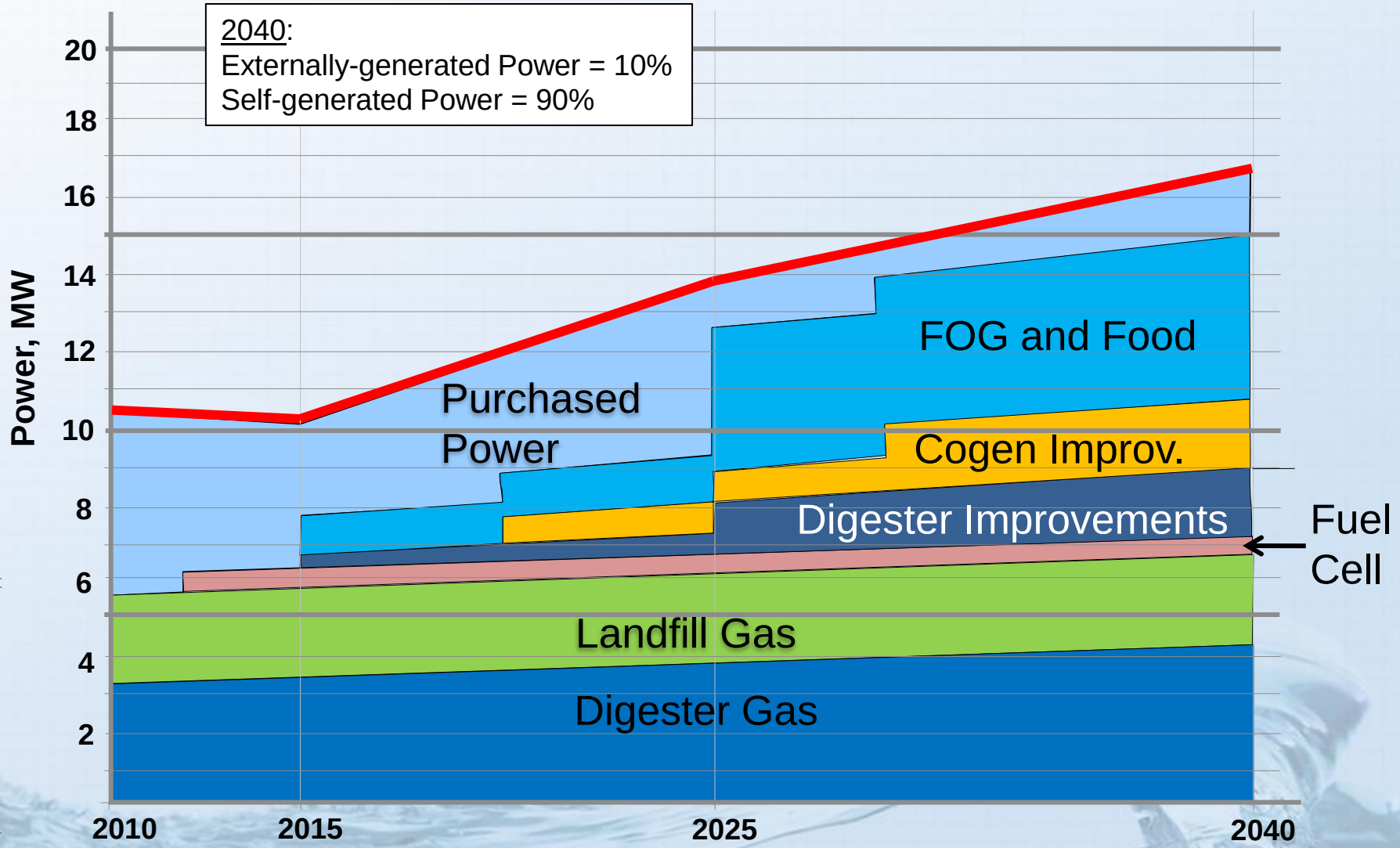
Step 5: Develop the Solution



Step 5: Develop the Solution
(continued)

- San Jose/Santa Clara WPCP phased implementation plan:
  - Continue with digestion and purchasing landfill gas
  - Install a 1.4 MW fuel cell
  - Perform digester improvements in two phases
  - Phased transition to higher-efficiency turbines
  - Develop a FOG (and food?) import program
  - Consider 1 to 7 MW solar power facilities

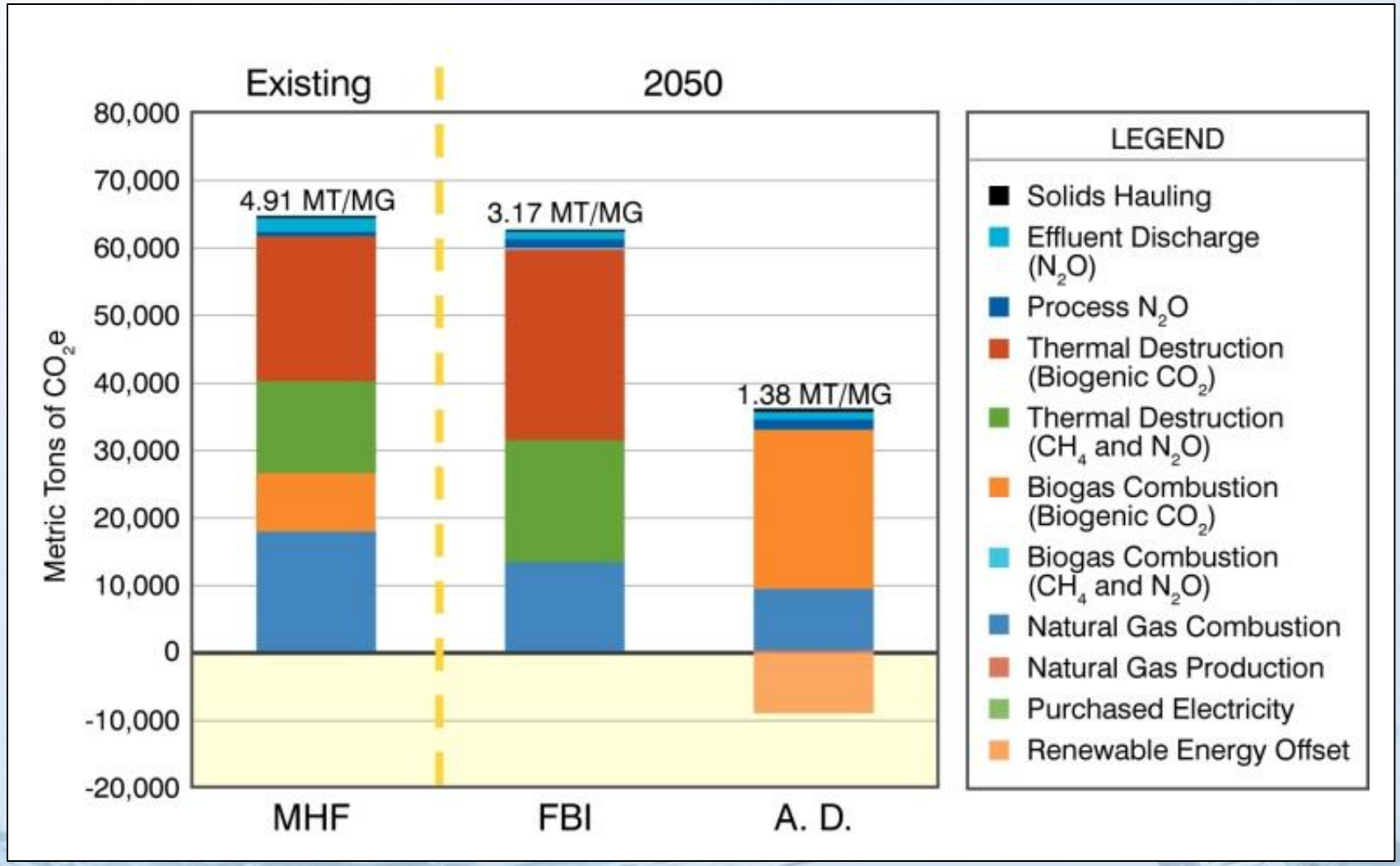
San Jose/Santa Clara WPCP *"future power generating portfolio"*



Step 5: Develop the Solution (continued)

- CCCSD *current* energy portfolio:
  - Natural gas turbine
  - Multiple-hearth furnaces using landfill gas as supplemental fuel
  - Purchased electric power (shortfall)
- GHG limitations:
  - Landfill gas no longer available
  - 25,000 MT/year emissions cap
- CCCSD *future* energy portfolio:
  - Replace gas turbine
  - Two alternatives (replace MHFs with fluidized-bed incinerators, or digestion with thermal pretreatment)

CCCSD Greenhouse Gas (GHG) Analysis



Summary

- There are both internal and external drivers creating the new “energy reality”
- We have presented a 5-step “*Integrated Energy Plan*™”
- Conventional and new elements of our 5-step plan:
  - Conventional => Energy balance and gap analysis
  - New => Concept of *“power generating portfolio”*

Questions?

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WASAC® Process Advantages

Secondary Treatment Quality

- Same effluent quality as conventional secondary
- Process configurations for nitrification/ denitrification

Reduces Capital Costs

- Reduces basin volume up to 45%
- Reduces blower needs up to 45%
- Investment Pay-Back in under 20 years

Reduces O&M costs

- Reduces aeration electrical use up to 45%
- Reduces maintenance of blowers and aeration system

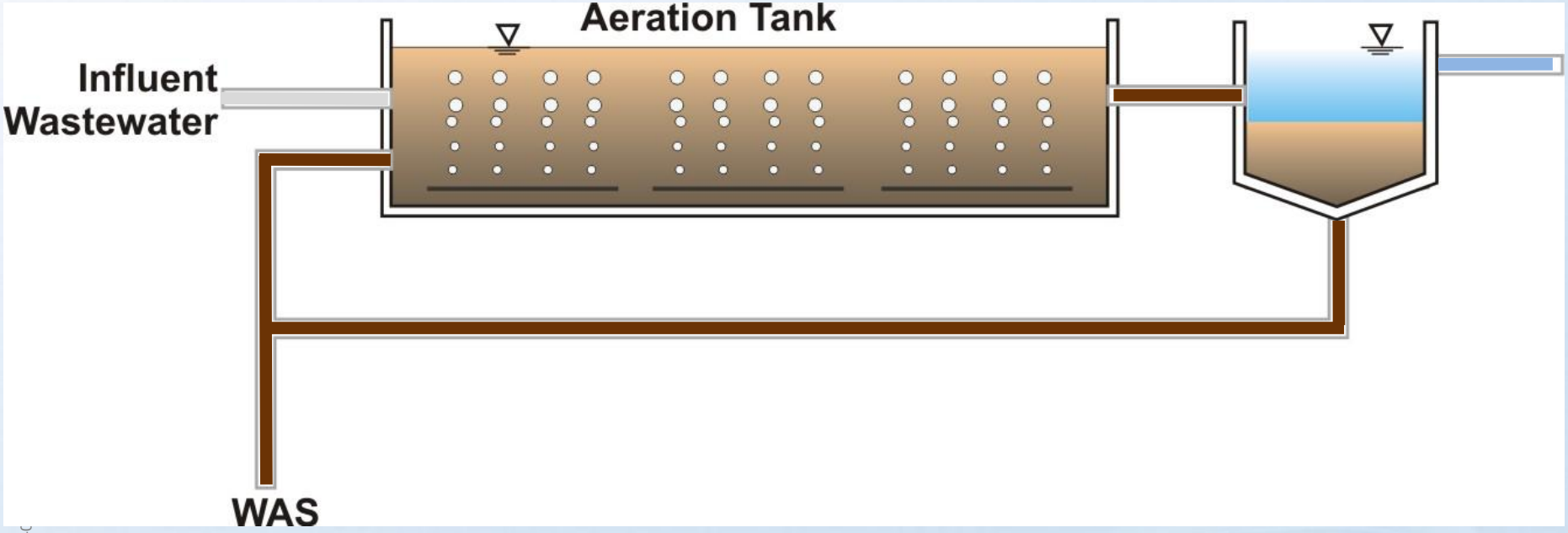
Increases Energy Production

- Doubles the methane production from WAS
- Results in reduction of purchased power up to 90%
- Potential for energy self-sufficient treatment

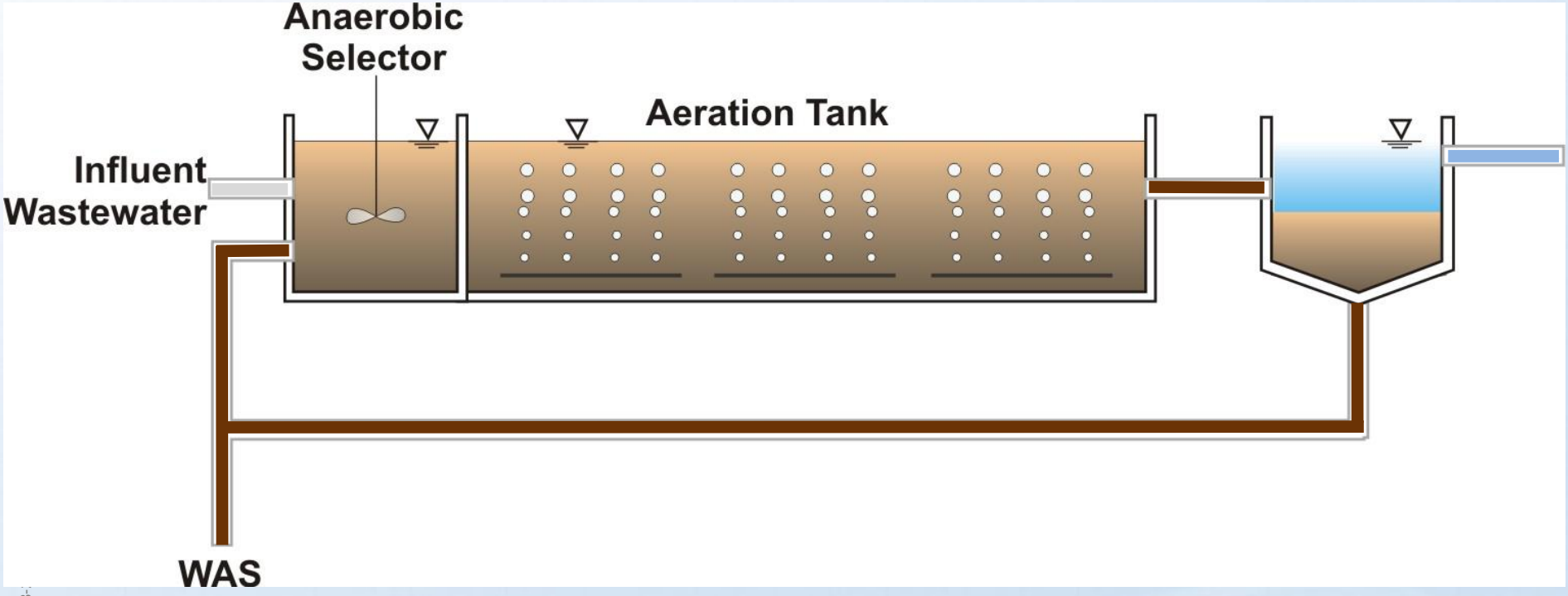
Small Carbon Foot Print

- Less energy required from the ‘grid’
- Less ‘carbon foot-print’ in construction
- Less release of GHG

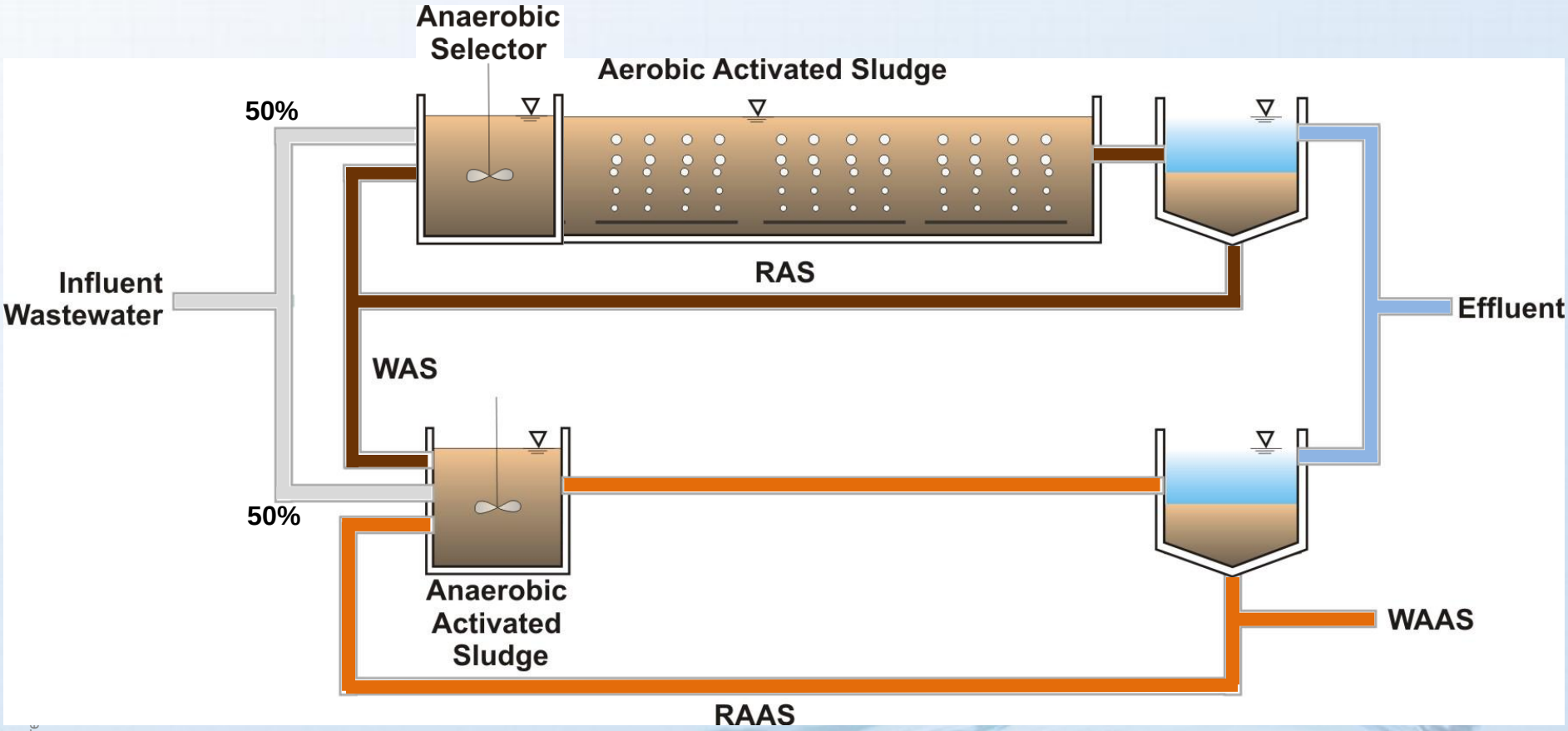
Conventional Activated Sludge Process



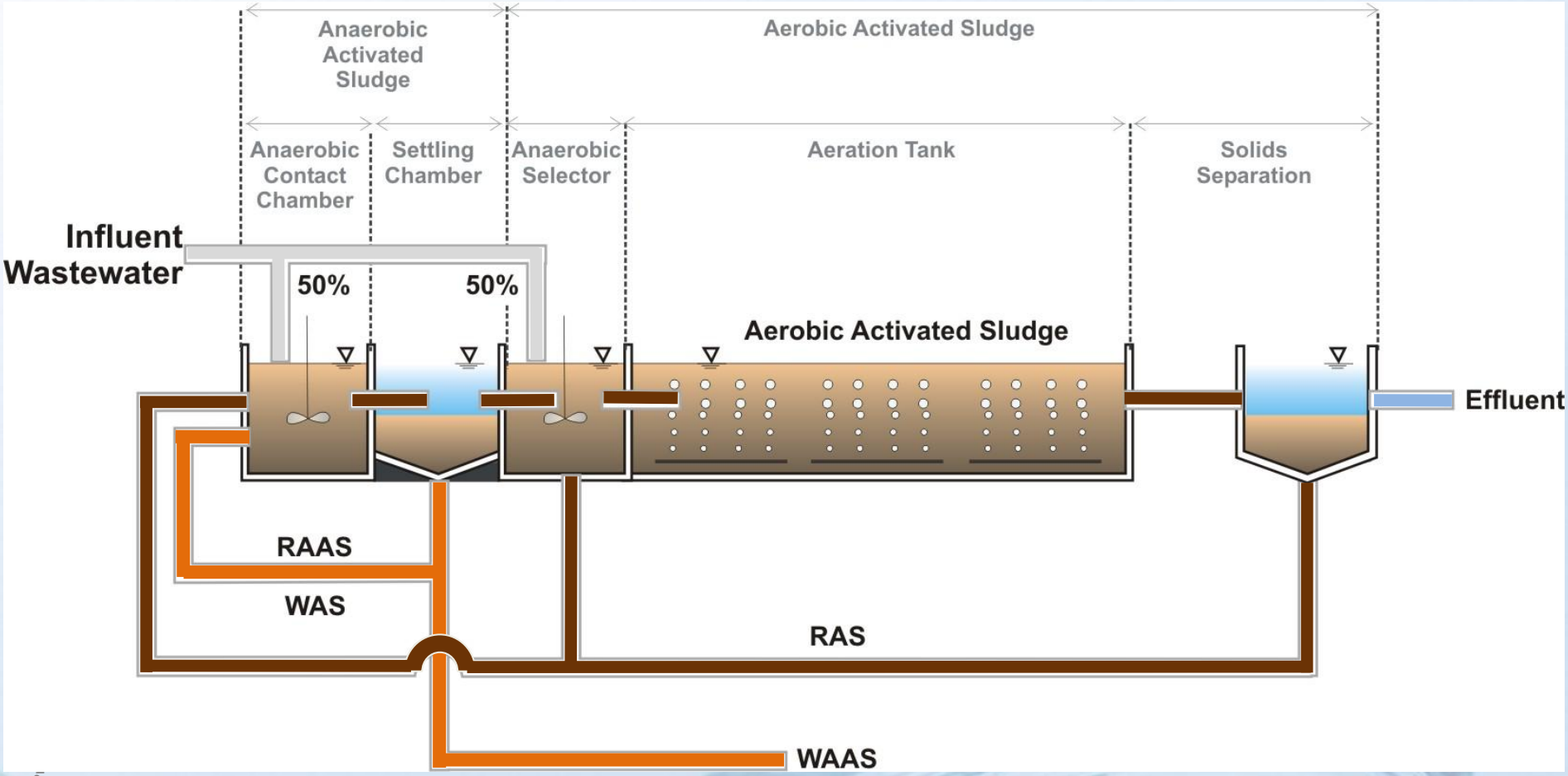
…with Anaerobic Selector for Phosphorus Accumulating Organisms (PAO)



Waste Activated Sludge Anaerobic Contactor (WASAC®) Configuration

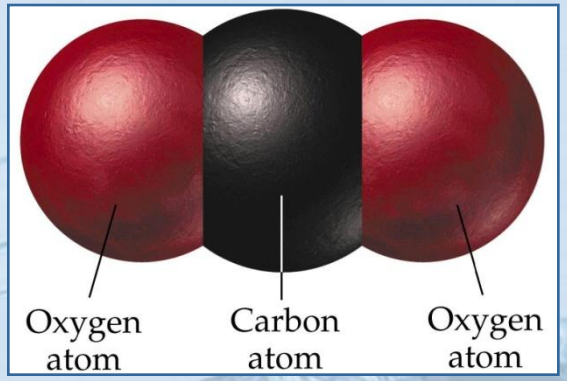


WASAC® Configured for Nitrification/ Denitrification

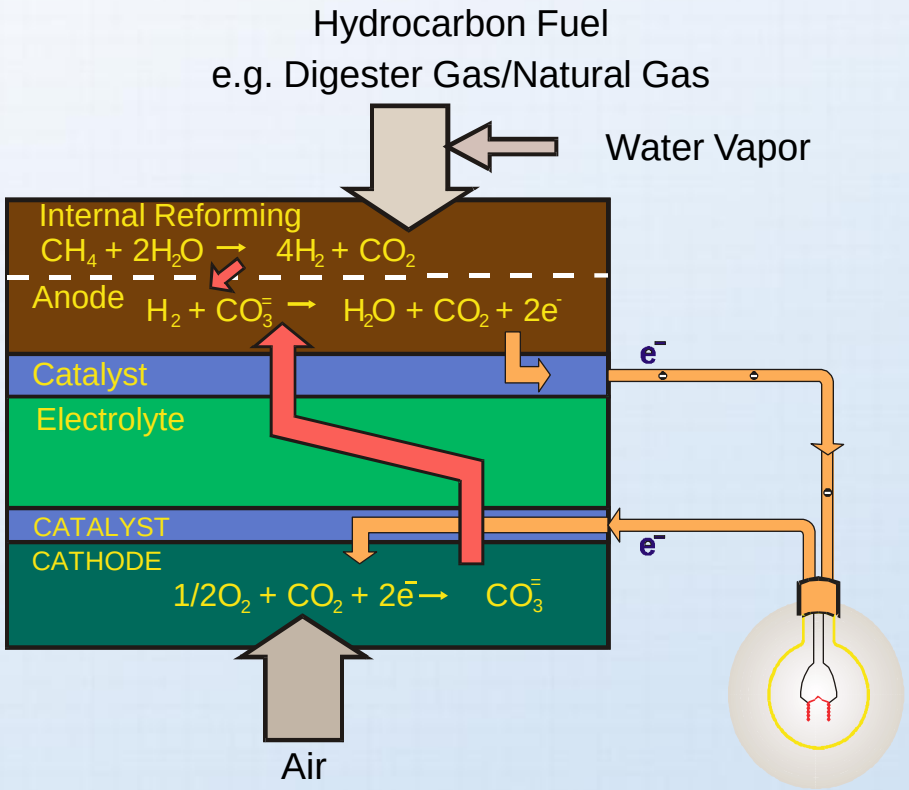


Fuel Cells – The Efficient, Sustainable Choice for Digester Gas Utilization

- Highest efficiency available for power generation equipment
  - Electrical efficiency 47%
  - Constant over 40-100% load
- Nearly 2x the reduction in plant carbon footprint over other cogeneration technologies
- Exempt from most, but not all, air permitting requirements. Some agencies have required permits; even though fuel cells easily comply.
- Approximately 1/3 the overall WWTP emissions of criteria pollutants:
  - NOx, CO, VOC, PM
  - Order of magnitude reduction



Technology – Fuel Cell Energy



- General Features
  - Uses commonly available materials
  - No noble metal catalyst
  - High temperature byproduct heat
- Internal Reforming
  - H_2 generated internally
  - High efficiency
  - Simple system
  - Negligible NO_x and CO
- Atmospheric Pressure Operation
  - Allows unattended operation
  - Highly reliable