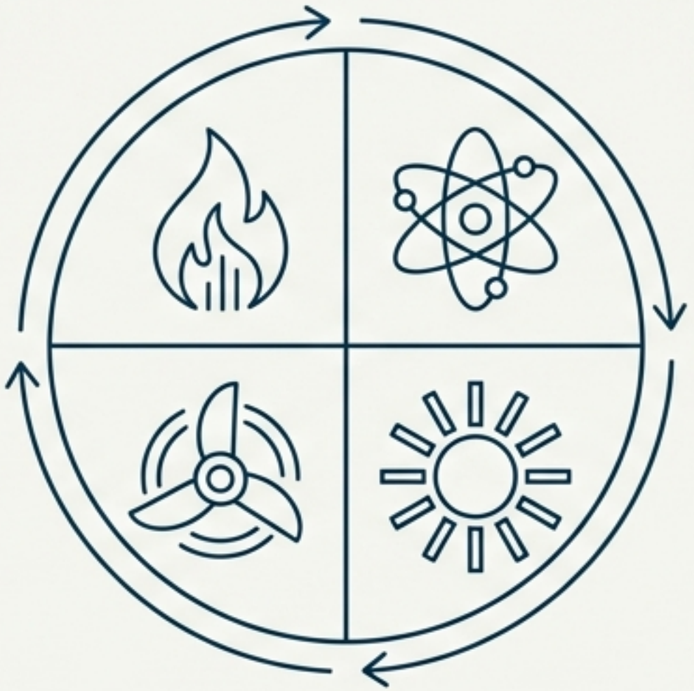


Energy Generation & Recovery from Water Infrastructure

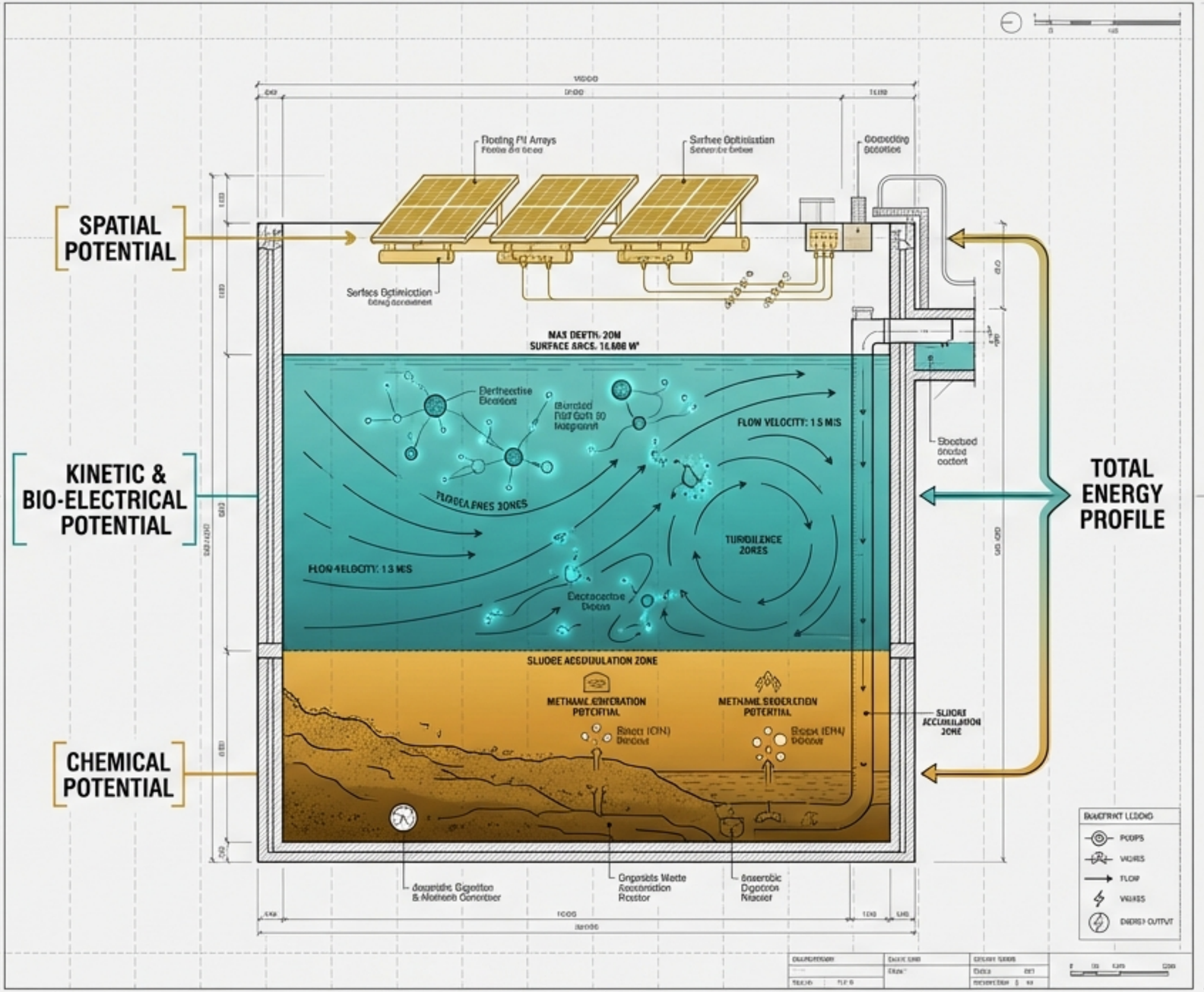
Transforming Passive Treatment Systems into Active Power Sources

Water infrastructure has historically been an energy consumer. By unlocking the latent energy in chemical, biological, spatial, and kinetic layers, we can shift the paradigm from waste treatment to resource recovery.

THE HIDDEN BATTERY: UNLOCKING LATENT ENERGY

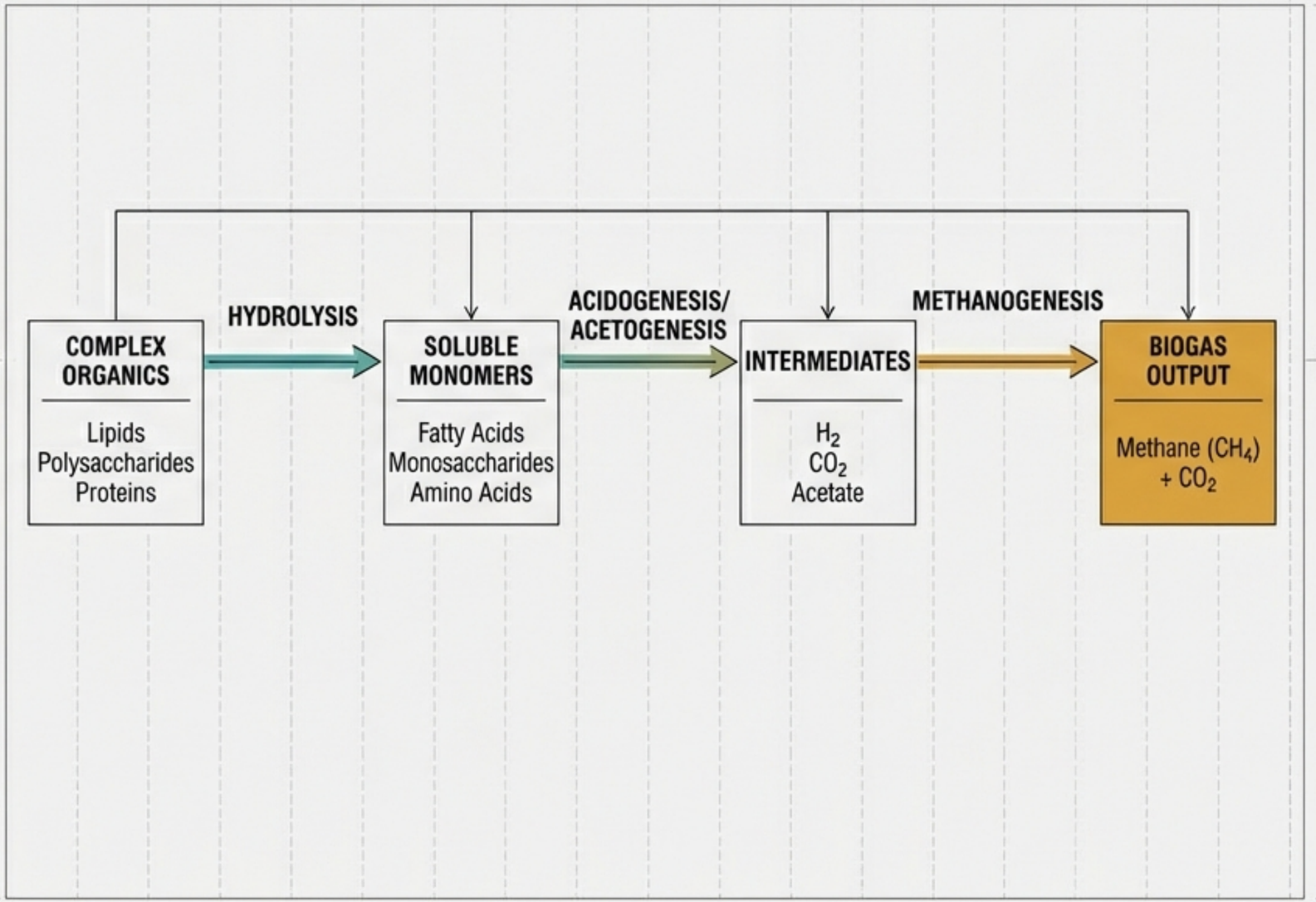
Three distinct layers of harvestable potential within existing infrastructure.

Optimization requires moving beyond a linear treatment model to a circular recovery model, utilizing every asset from the bacteria in the sludge to the current in the outfall.



ANAEROBIC DIGESTION: HARNESSING THE BIOLOGY OF DECAY

Nature's Engine: The 'Eternal Flame' in Yanartas, Turkey, fueled by natural subsurface methane.



OPTIMIZING THE DIGESTER ENVIRONMENT

Strict control of biological variables is required for maximum yield.

Solids Retention Time

Hydraulic Retention Time

pH Level

Alkalinity

Temperature

Parameter	Mesophilic (Standard)	Thermophilic (High Performance)
Temperature Range	85°F – 100°F	122°F – 135°F
Control Difficulty	Moderate/Stable	High/Sensitive
Treatment Speed	Standard	Fast
Methane Yield	Baseline	High

THE TRIPLE BOTTOM LINE

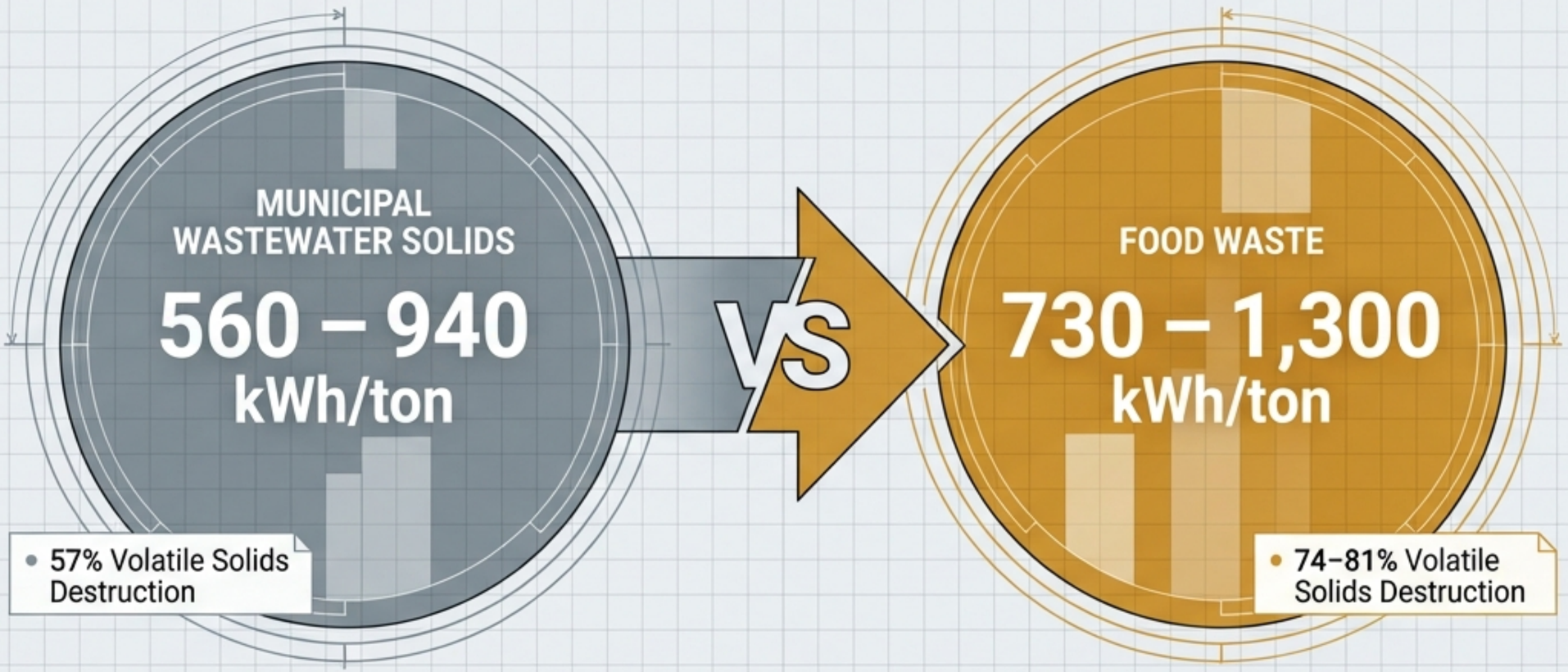
Revenue: Power generation or grid sales.

Climate: Capturing methane (20x more potent GHG than CO2).

Byproduct: Class A Biosolids/Fertilizer production.

HIGH-OCTANE FUEL: THE CASE FOR FOOD WASTE CO-DIGESTION

Food waste offers significantly higher organic content and degradable fatty acids compared to standard municipal sludge.

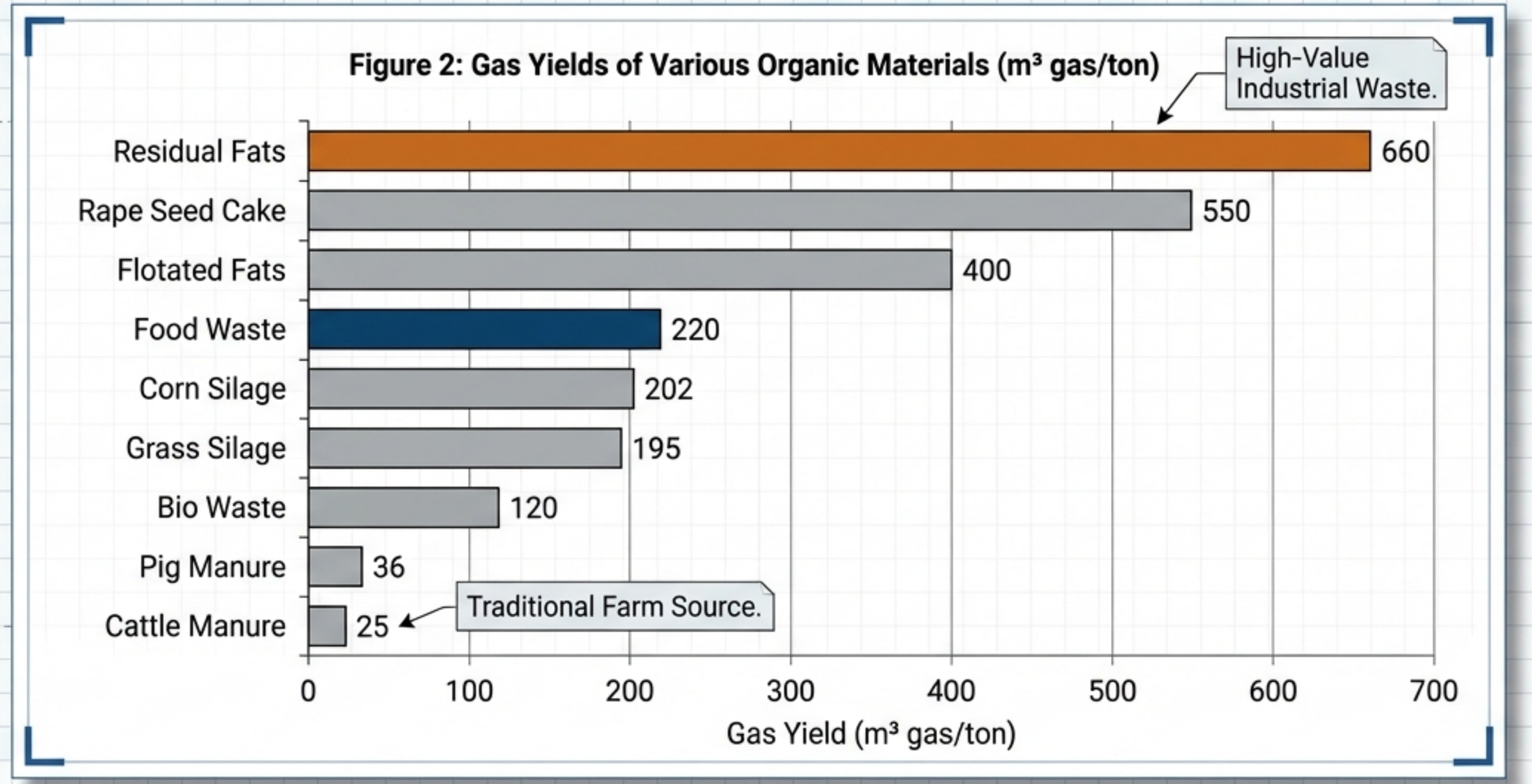


KEY INSIGHT

Efficiency Gain: Gas potential is fully achieved in 3 weeks via digestion, compared to 30 years of slow release in a landfill.

COMPARATIVE GAS YIELDS BY SUBSTRATE

Not all waste is created equal. **Fats** and **oils** represent the **highest energy density.**



Courtesy of M-Con Bio and Farmatic biotech energy ag

NAVIGATING OPERATIONAL CONSTRAINTS

High energy yield requires high operational sophistication.

CHEMICAL HURDLES

High H2S content in food waste necessitates robust scrubbers to prevent equipment corrosion and engine damage.

PHYSICAL HURDLES

High density of food waste requires specialized pumps and macerators. Dilution water is often needed to facilitate flow.

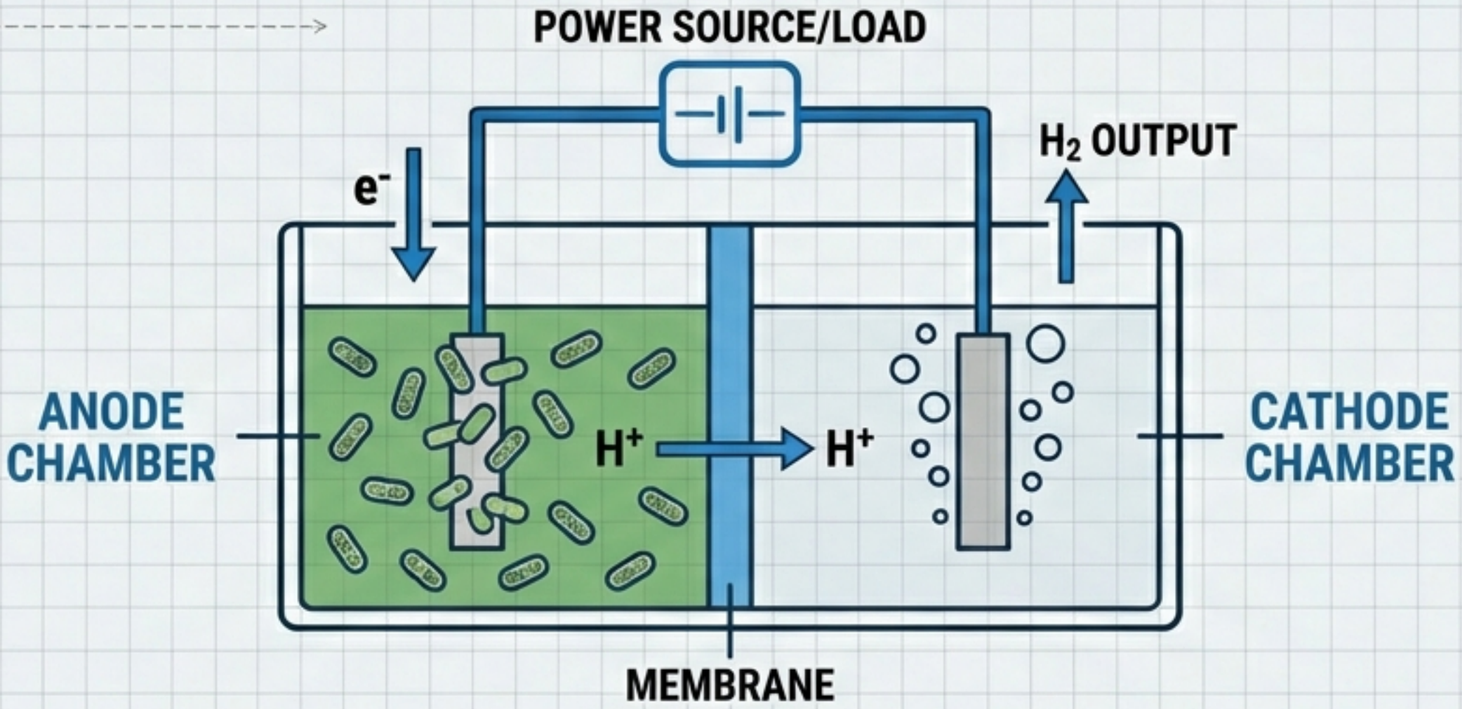
LOGISTICAL HURDLES

Siting is complex as these are classified as 'tipping facilities." Management of liquid digestate disposal remains a critical bottleneck.

Courtesy of M-Con Bio and Farmatic biotech energy ag

MICROBIAL FUEL CELLS: DIRECT ELECTRICITY FROM BIOLOGY

Replacing the combustion engine with bacterial metabolism.



$$C_{12}H_{22}O_{11} + 13H_2O \rightarrow 12CO_2 + 48H^+ + 48e^-$$

Organic Matter + Water → Carbon Dioxide + Protons + Electrons.

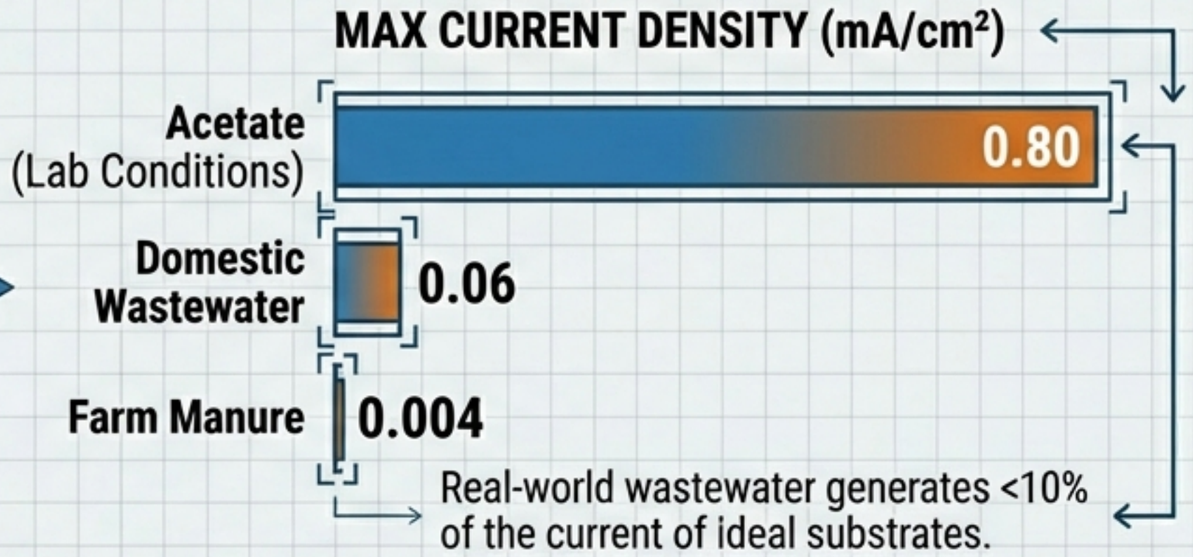
Courtesy of M-Con Bio and Farmatic biotech energy ag

MFC APPLICATION: A TREATMENT TOOL, NOT A POWER PLANT

While the science is sound, current density limits the technology to efficiency roles rather than bulk generation.

Promise vs. Reality

THEORETICAL POTENTIAL



STRATEGIC PIVOT

The Value Proposition: Use MFCs for cost-effective COD removal and desalination, reducing the energy load of aerobic treatment rather than acting as a primary generator.

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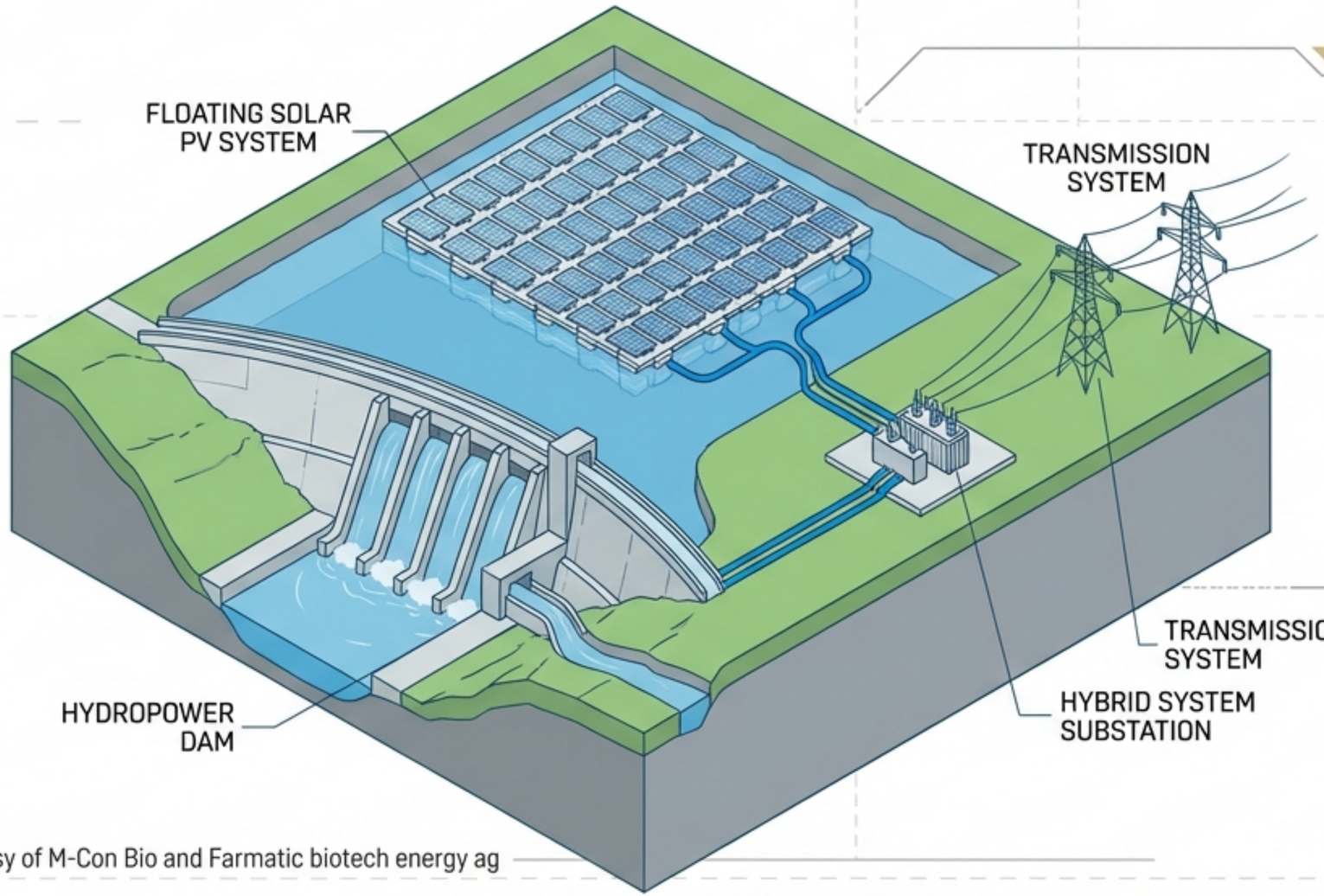
SPATIAL POTENTIAL: FLOATING SOLAR ENERGY

Capitalizing on the surface area of existing hydro infrastructure.

Hybrid Hydro-Solar System



GLOBAL POTENTIAL:
10,600 TWh/year

LAND USE:
0 ACRES

GRID SYNERGY:
HIGH

Courtesy of M-Con Bio and Farmatic biotech energy ag

ENERGY IN THE FLOW: LOW-HEAD AND MICRO HYDRO

Shifting from mega-dams to decentralized flow harvesting.

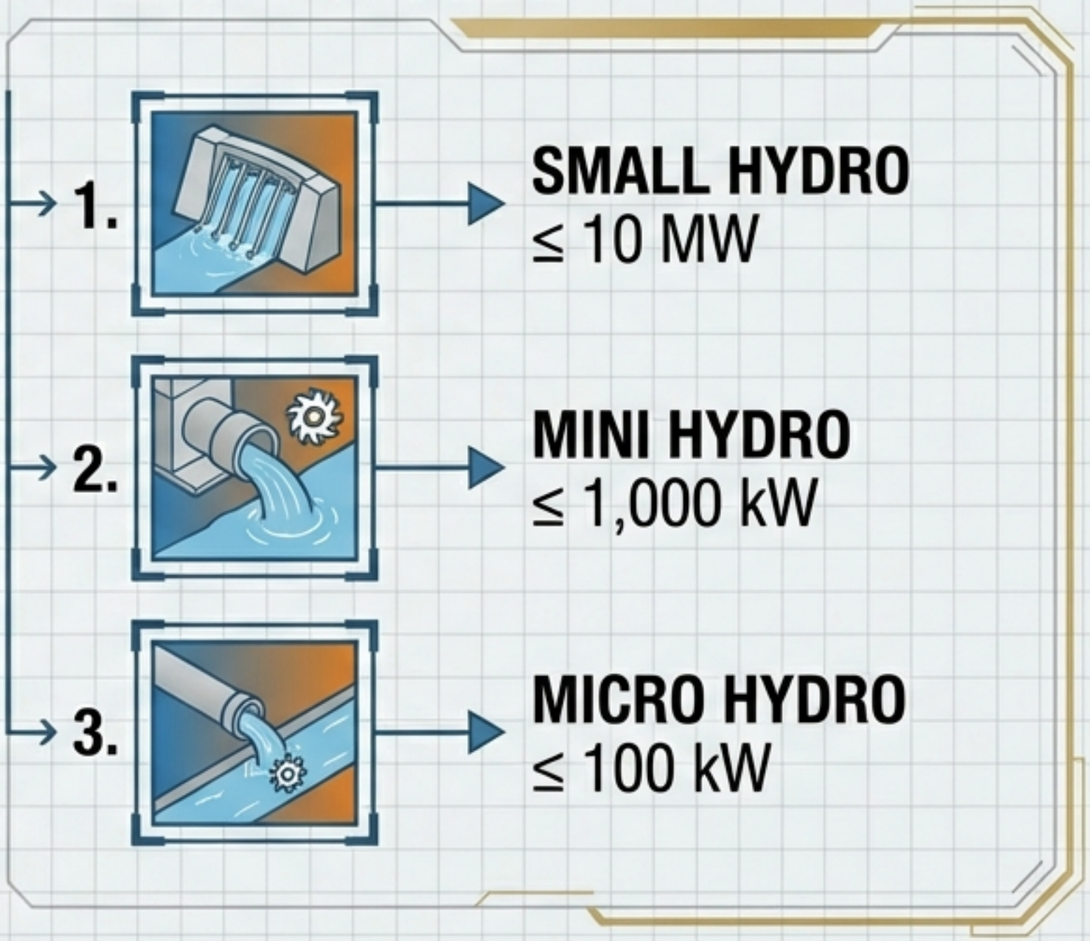
THE PHYSICS OF POWER:

$$P = \eta \frac{(\gamma Q H)}{1000}$$

P = Power (kW)
Q = Flow Rate (m^3/s)
H = Head (vertical drop in meters)

INSIGHT: Power is directly proportional to Head and Flow. Low head requires higher flow.

TAXONOMY OF SCALE



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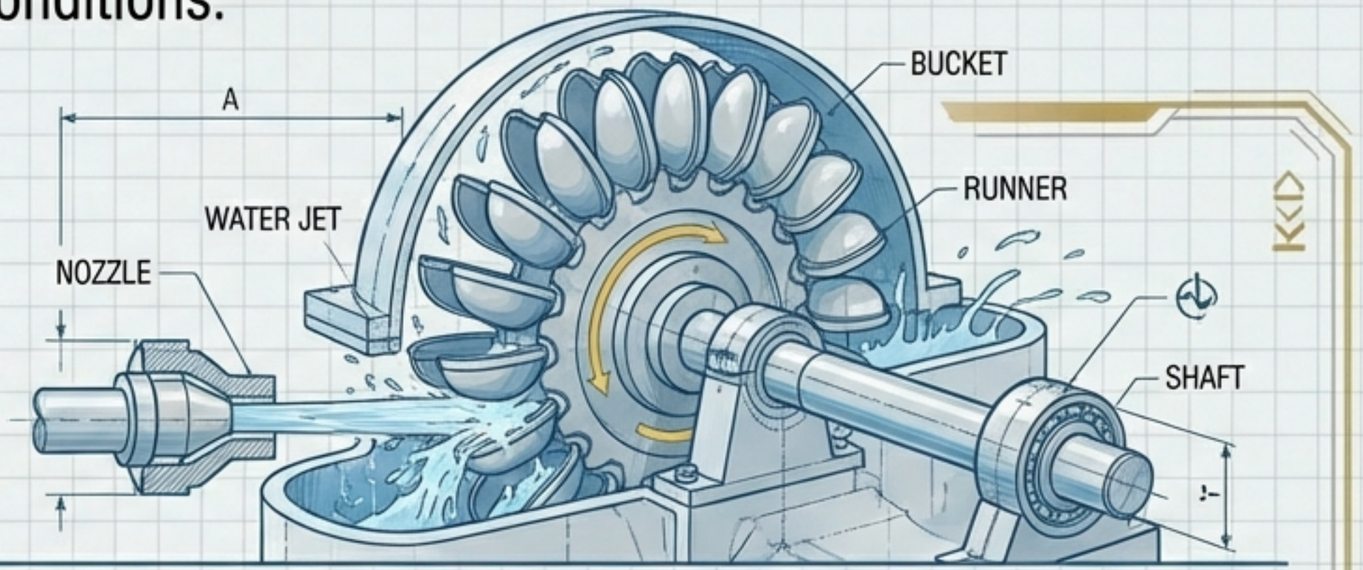
TURBINE TECHNOLOGY: CAPTURING GRAVITY

Matching the machine to the hydraulic conditions.

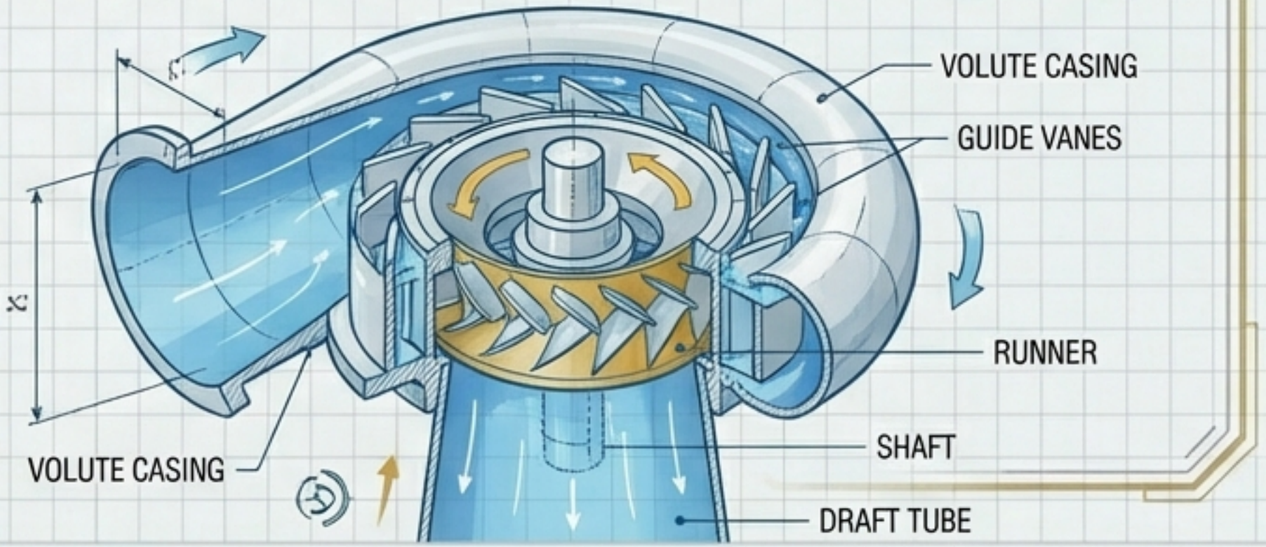
IMPULSE TURBINES (HIGH HEAD / OPEN FLOW)

Uses the velocity of a water jet.
Requires Head > 30ft.



REACTION TURBINES (LOW HEAD / ENCLOSED FLOW)

Uses pressure and moving water.
Submerged operation.



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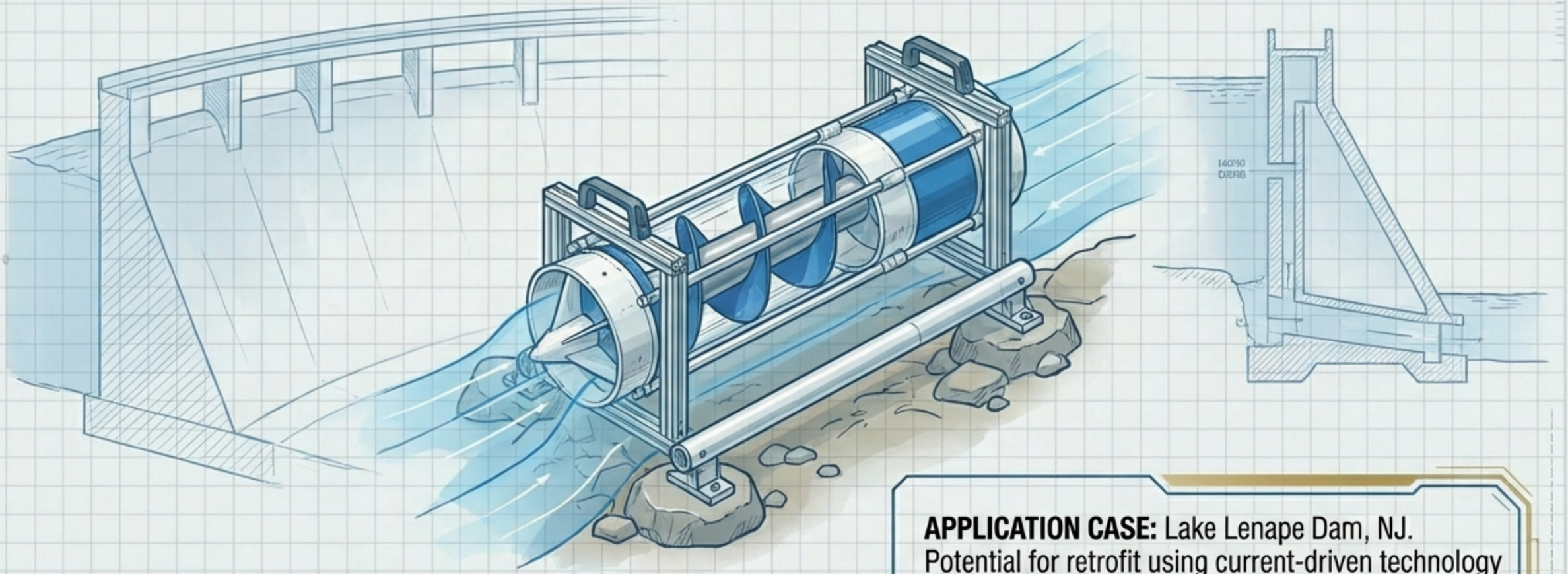
HYDROKINETIC ENERGY: CAPTURING CURRENT

Zero-head generation for rivers, canals, and weirs.



APPLICATION CASE: Lake Lenape Dam, NJ.
Potential for retrofit using current-driven technology to bypass extensive civil reconstruction.

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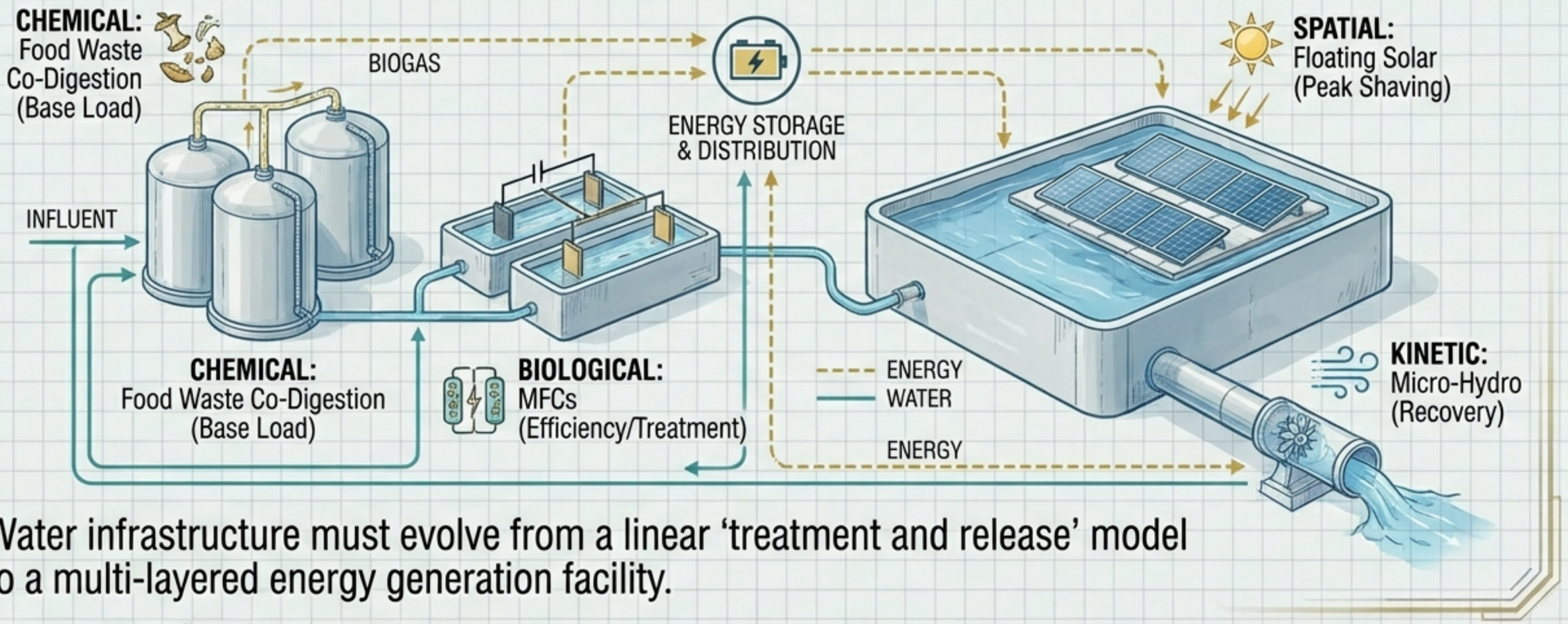
THE INTEGRATED ENERGY FUTURE

A resilient, multi-source profile for water infrastructure.

THE CIRCULAR WATER BATTERY



Water infrastructure must evolve from a linear ‘treatment and release’ model to a multi-layered energy generation facility.

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References & Sources

Primary Source: Topic IV: Energy - Energy Generation and Recovery from Water Infrastructure.

Image Credits:
Microbial Electrolysis Cell Schematic: Zina Deretsky (NSF)
Yanartas Eternal Flame: Nevit Dilmen
Francis Turbine Assembly: Audrius Meskauskas
Francis Turbine Cut-away: Stahlkocher
Pelton Turbine Assembly: Walchensee Power Plant Archive
Hydrokinetic Prototypes: Gizmag/Tom Broadbent
Lake Lenape Dam: Source Archive
Gas Yield Data Chart: M-Con Bio and Farmatic Biotech Energy