

Water-Energy Nexus

Peiyong Hong
King Abdullah University of Science
and Technology, KAUST



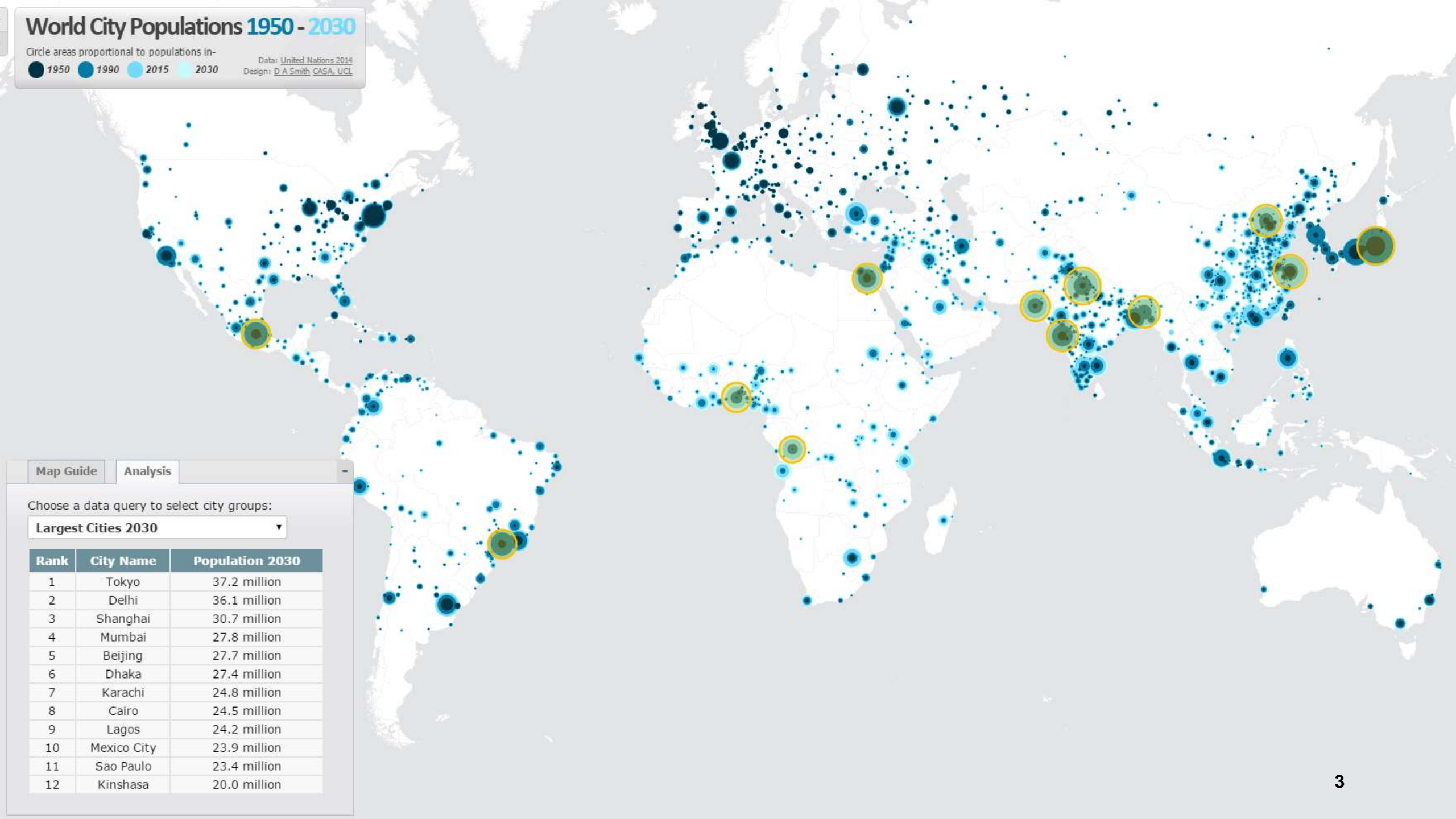


World City Populations 1950 - 2030

Circle areas proportional to populations in-

- 1950
- 1990
- 2015
- 2030

Data: United Nations 2014
Design: D.A. Smith, CASA, UCL




Map Guide

Analysis

Choose a data query to select city groups:

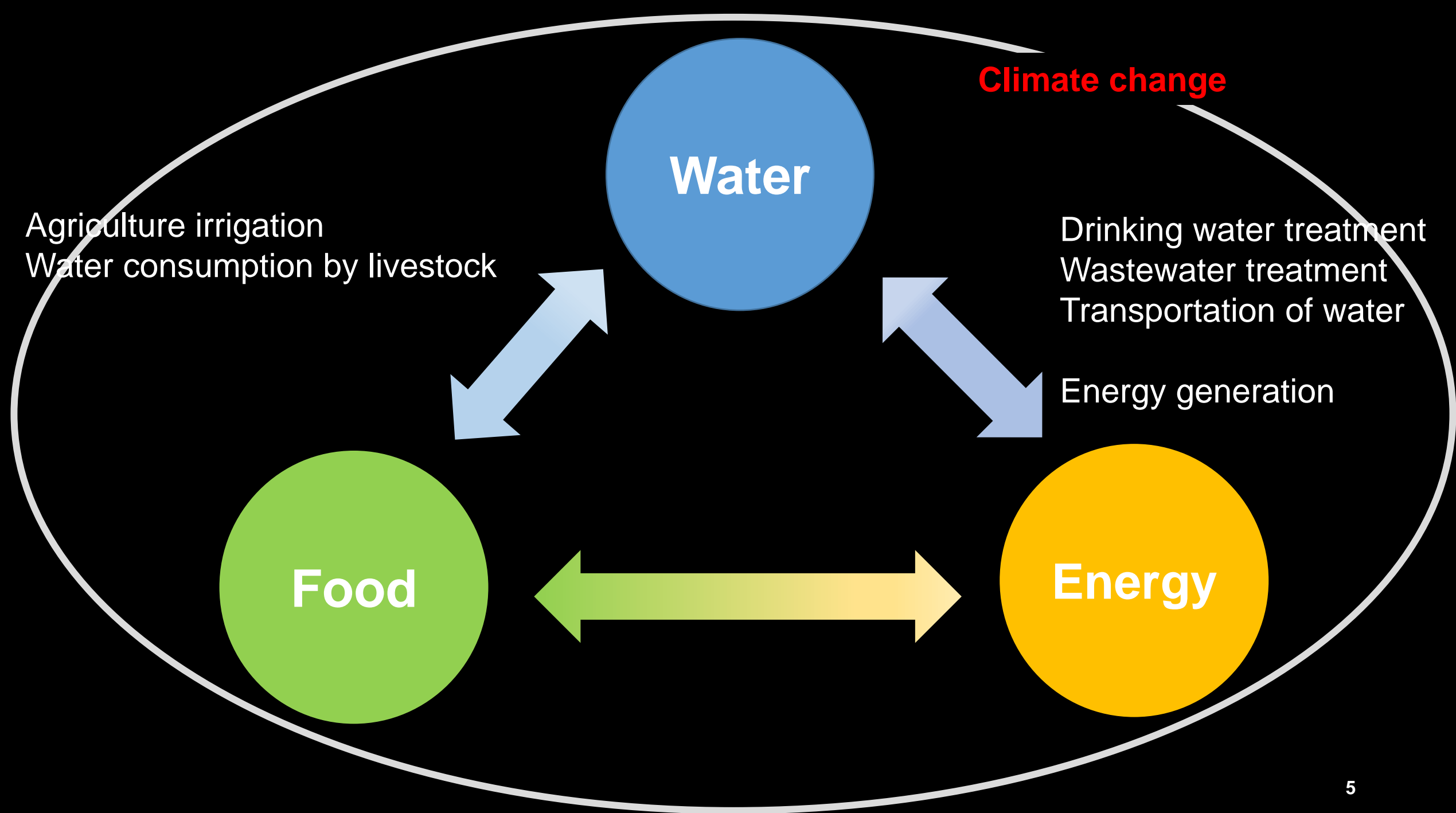
Largest Cities 2030

Rank	City Name	Population 2030
1	Tokyo	37.2 million
2	Delhi	36.1 million
3	Shanghai	30.7 million
4	Mumbai	27.8 million
5	Beijing	27.7 million
6	Dhaka	27.4 million
7	Karachi	24.8 million
8	Cairo	24.5 million
9	Lagos	24.2 million
10	Mexico City	23.9 million
11	Sao Paulo	23.4 million
12	Kinshasa	20.0 million

A close-up photograph of a small, vibrant green seedling with two leaves growing out of a deep crack in parched, cracked earth. The soil is a mix of light and dark brown, showing extensive cracking and desiccation. The seedling is the only source of green in the scene, symbolizing resilience and life in the face of adversity.

**No water, no life
No blue, no green**

- Sylvia Earle

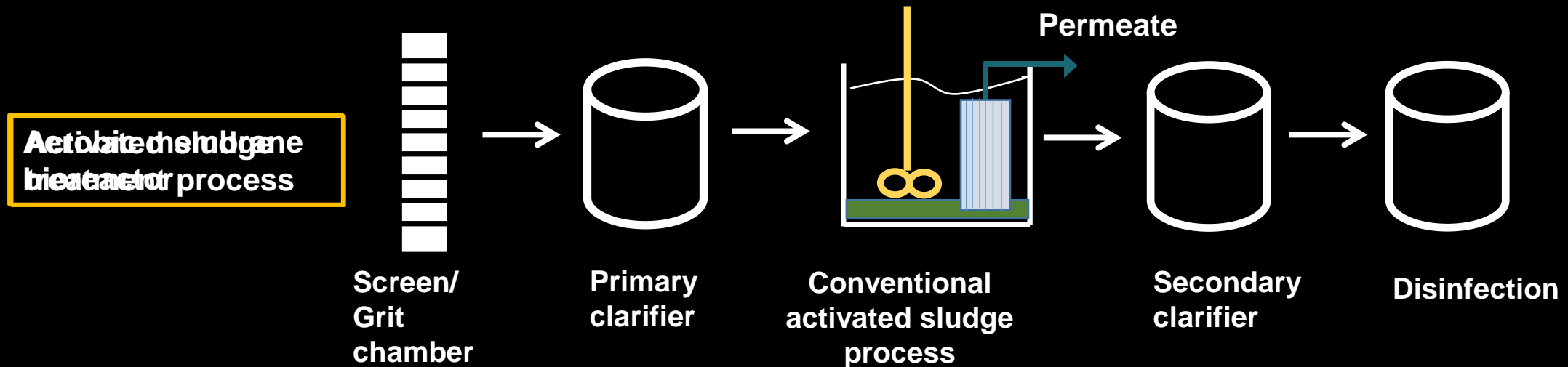


Energy-efficient water systems

- **Develop efficient and sustainable water technological solutions for our future**
 - **Cleaning our “waste” water**

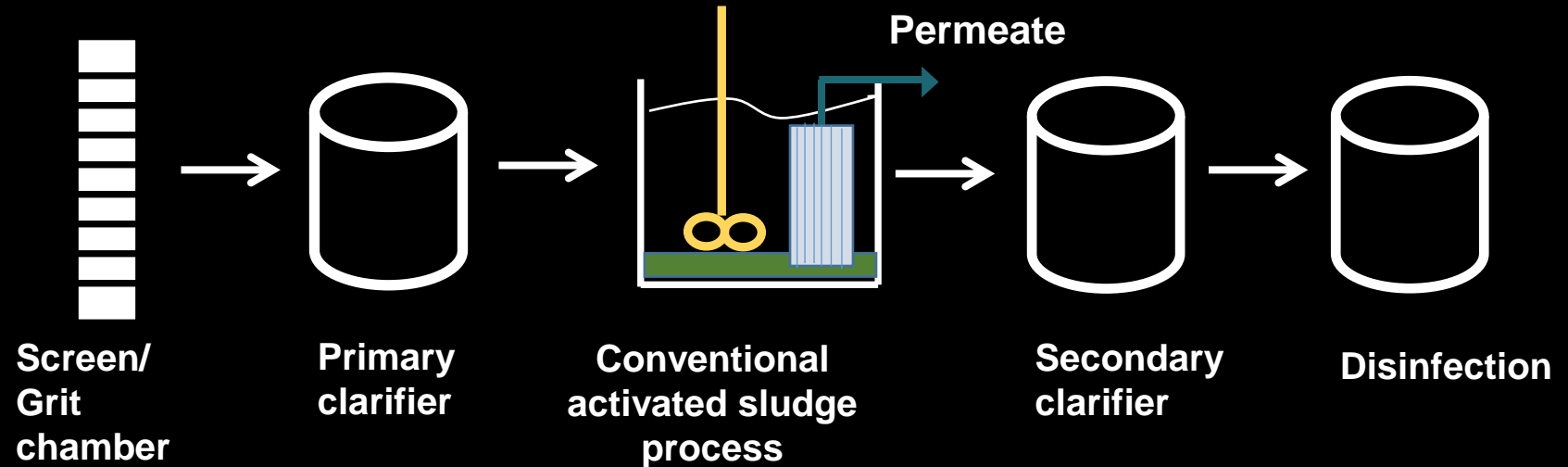


Cleaning “waste” water



- The need for aeration increases energy demand
- About 1 kWh/m³ for activated sludge
- About 3 kWh/m³ for aerobic membrane bioreactor
- 40-60% of energy consumption due to aeration

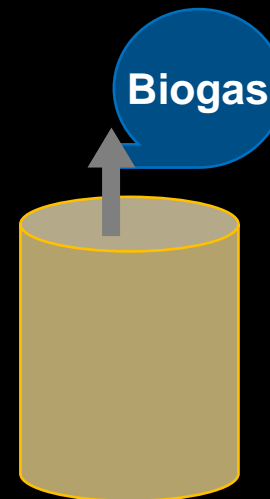
Cleaning “waste”water



Landfill or
incinerate



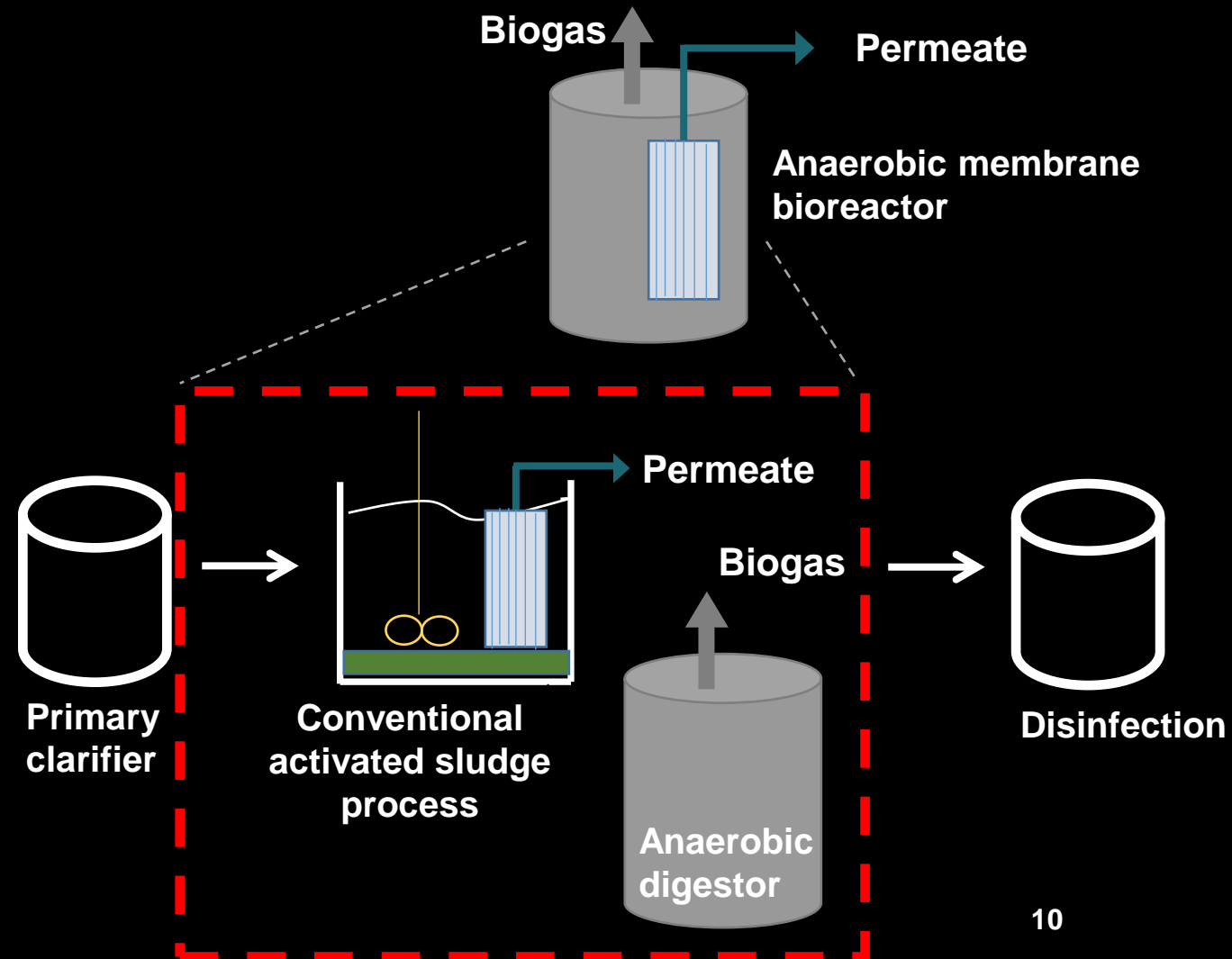
Anaerobic
digester



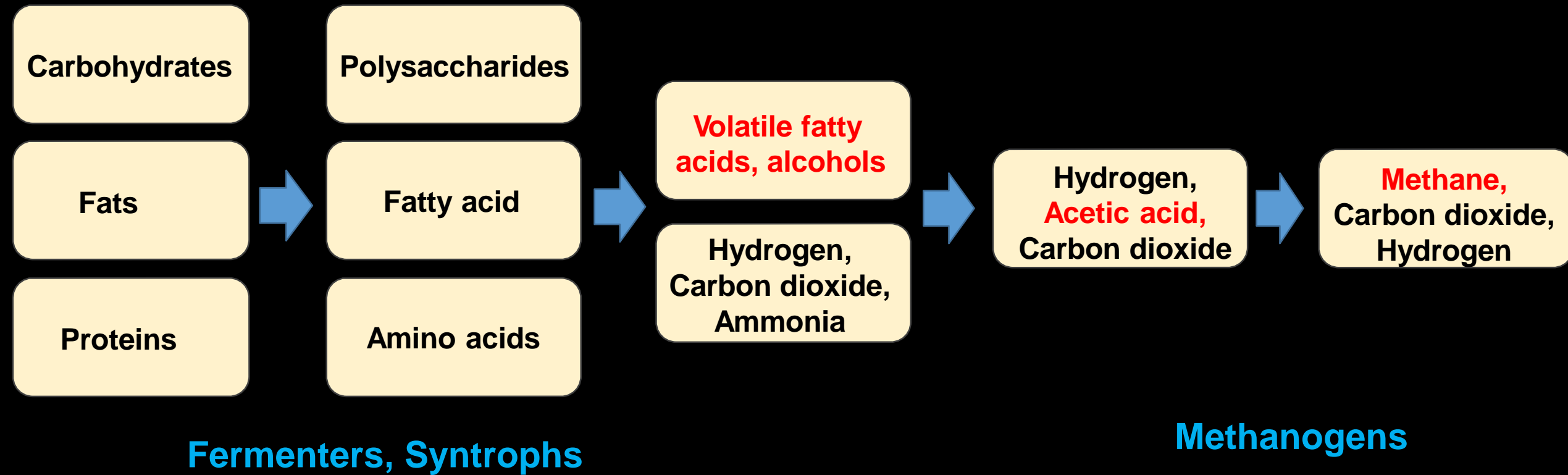
Biogas

New directions: Anaerobic membrane bioreactor

- Improved energy landscape (lower operational cost) due to elimination of aeration needs



Anaerobic fermentation recovers methane as energy source



Improved energy landscape for AnMBR

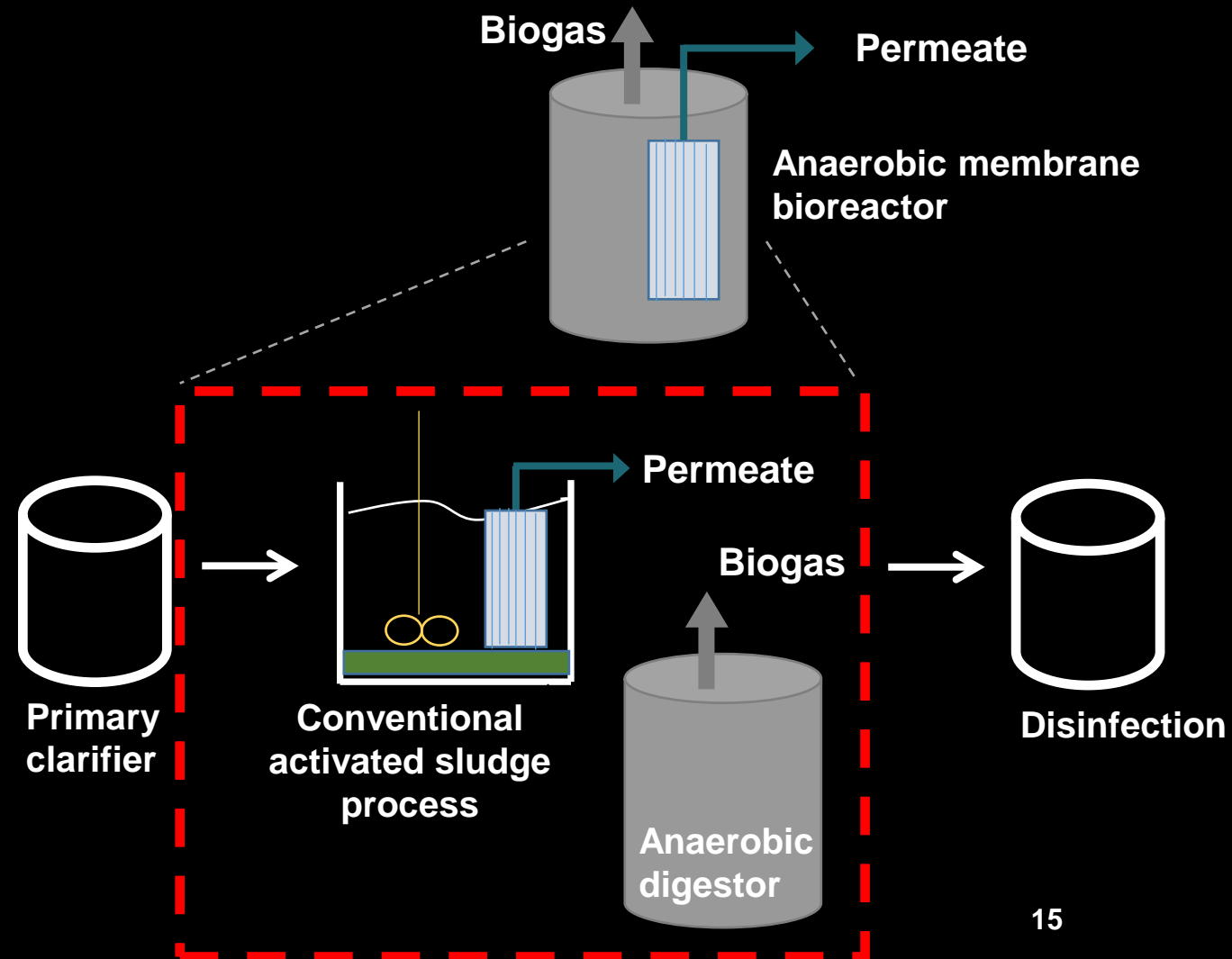
- **Methane, CH₄** (predominant gaseous product in biogas, preferably > 65% v/v)
- CH₄ has a caloric value of 8 kWh/m³
- At 32-40% conversion rate to electrical energy, means ~ 3 kWh/m³ can be recovered
- Theoretical yield of methane can be estimated from COD concentration, ~ **365 mL CH₄ /g COD**
- Energy positive process

Lower sludge production from AnMBR

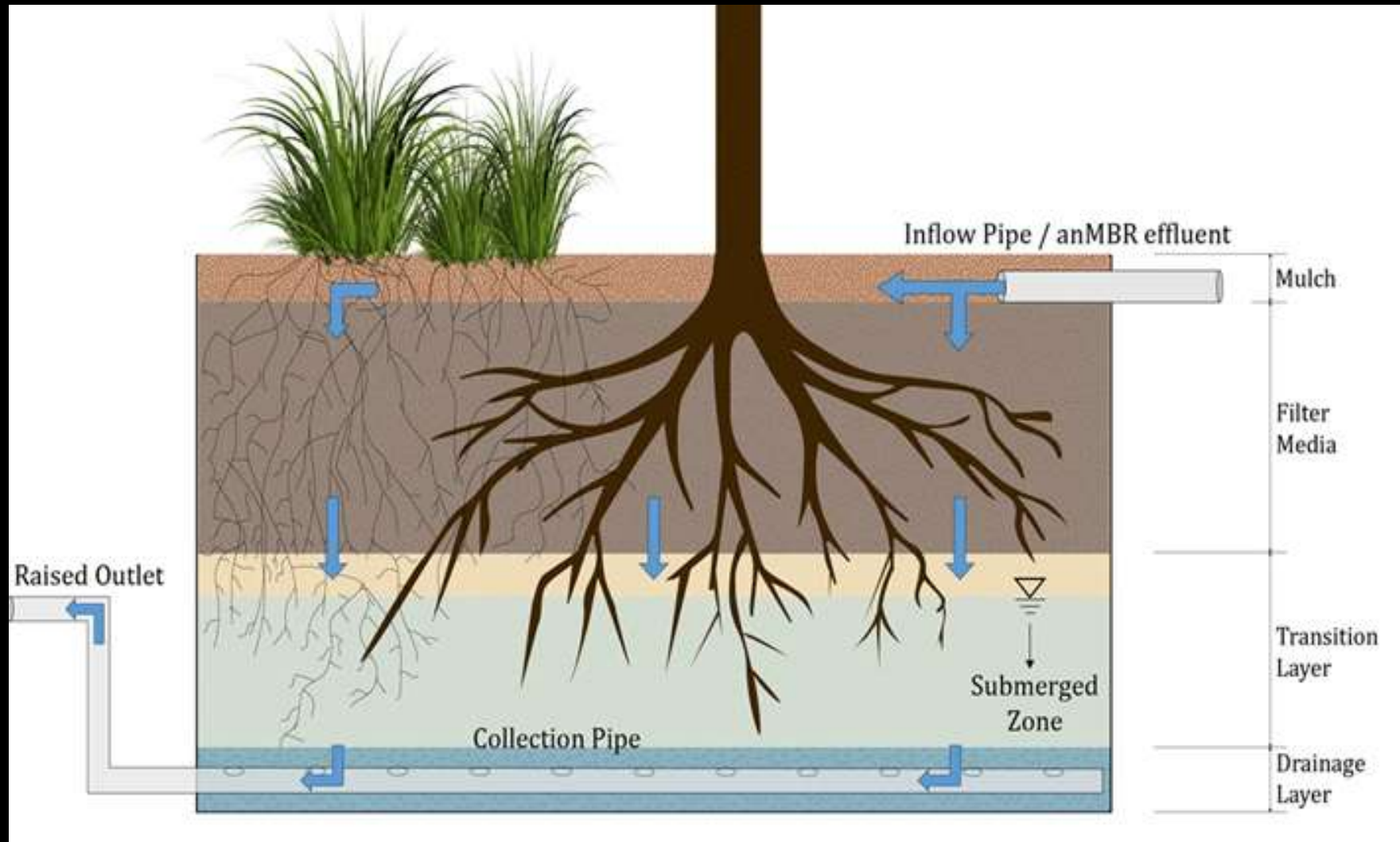
- Solid retention time in a conventional aerobic based treatment plant is maintained at about 20 to 40 days
- Estimated amount of sludge produced in conventional aerobic based treatment plant is about 35-85 g dry solids per population equivalent per day
- Anaerobic based treatment process prolongs the solid retention time by 3 times (120 days)
- Thus 3 times less volume of sludge generated = lower solid disposal costs

New directions: Anaerobic membrane bioreactor

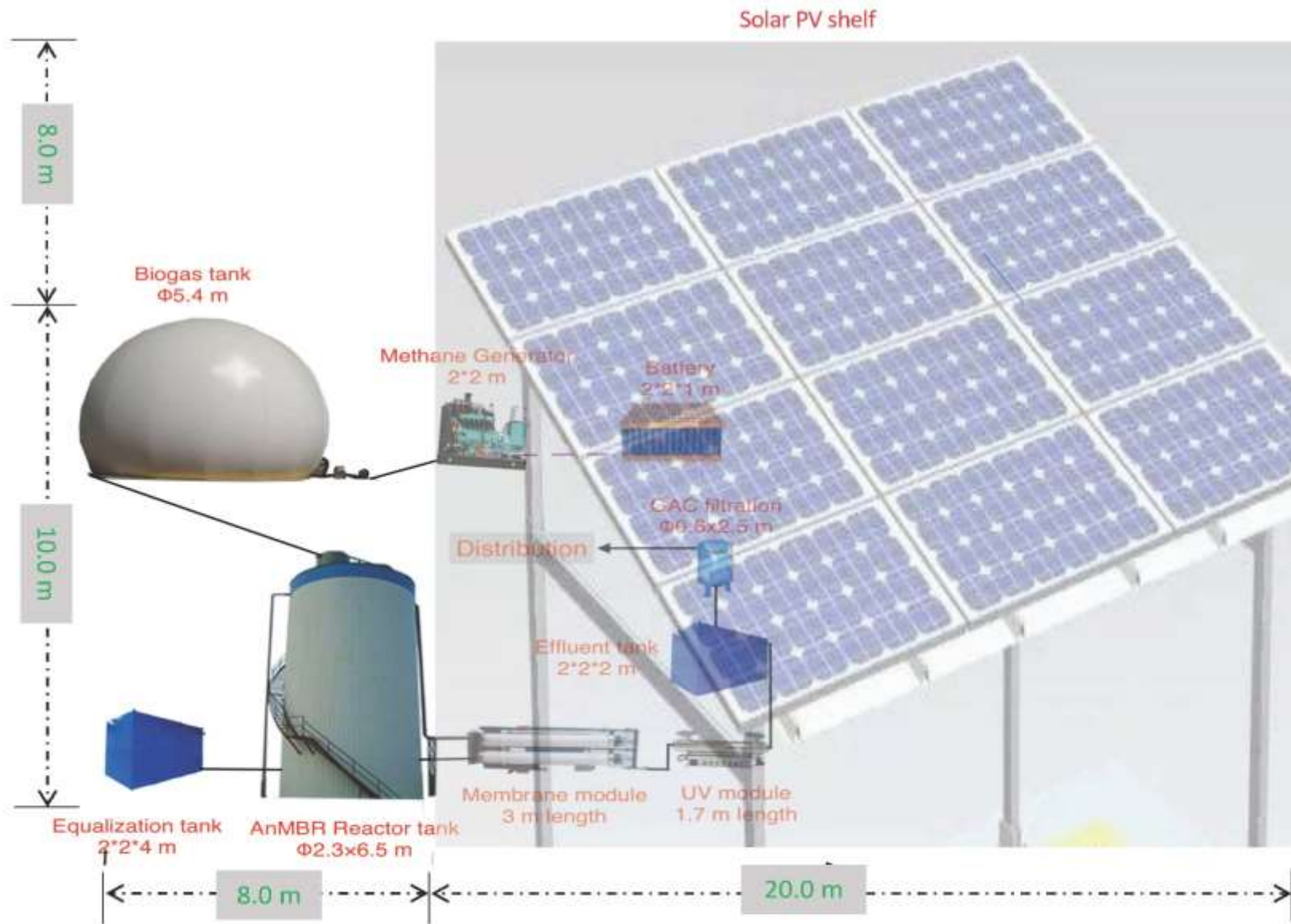
- Ammonium and phosphate retention (suitable for agriculture or landscape irrigation)



Nutrient removal with tree pit gardens







Water-Energy Nexus

- There is an energy cost associated with our water cycle
- Minimizing the associated energy costs is critical in achieving a smart water system
- Rapid development in technologies is significantly lowering the energy costs associated with water production and treatment
- For example, anaerobic-based treatment can clean wastewater with no additional energy costs
- Translation of sustainable technologies from lab to market need to progress rapidly

العلاقة بين المياه والطاقة

- هناك تكلفة طاقة مرتبطة بدورة المياه لدينا
- يعد تقليل تكاليف الطاقة المرتبطة أمراً بالغ الأهمية لإنشاء نظام مياه ذكي
- يؤدي التطور السريع الذي نشهده في التقنيات إلى خفض كبير في تكاليف الطاقة المرتبطة بإنتاج المياه ومعالجتها
- على سبيل المثال : يمكن للمعالجة اللاهوائية تنظيف مياه الصرف الصحي بدون تكاليف إضافية في الطاقة
- تحتاج عملية نقل التقنيات المستدامة من المختبر إلى السوق إلى التقدم بسرعة