Climate Smart Sewage Treatment Plants
Thinking out of the box

Willy Verstraete / Yves Depetter /Silvio Matassa

200 YEARS
GHENT UNIVERSITY

Avecom
Bioproducts & Apps

Università Degli Studi di Napoli Federico II

KWR

Lisbon IWA 2014

To attain the SDGs 6.3: there must be a substantial increase in recycling and safe reuse globally of water resources.

A NEW treatment infrastructure at the size of 500.000 people must be built every day from now until 2030

- Activated sludge = TOP

Blasphemy : 100 years of this technology is enough !!!

Time has come to rethink the whole used air/water /waste -environmental business

Two main story lines

A. Today's STP is all about " dissipation " .... Rethink this !!

*odour --- aeration ---kWh

*organic carbon --- sludge is costly to handle + CH4 losses

*nitrogen --- N2O / Legionella (anammox)

*phosphorous --- complex /hesitant buyers

*pharma ---- advanced oxidation – how about the pieces

*pathogens /viruses ---- disinfection byproducts

B.Hydrogen will become part of the solution !

Circular Economy:
Plenty of Push but little Pull

Eagerness to recover from ‘waste’ and to re-use:

+Energy: Biogas technology - successful and mature

+Reclaimed Water: Some progress, particularly in times of drought

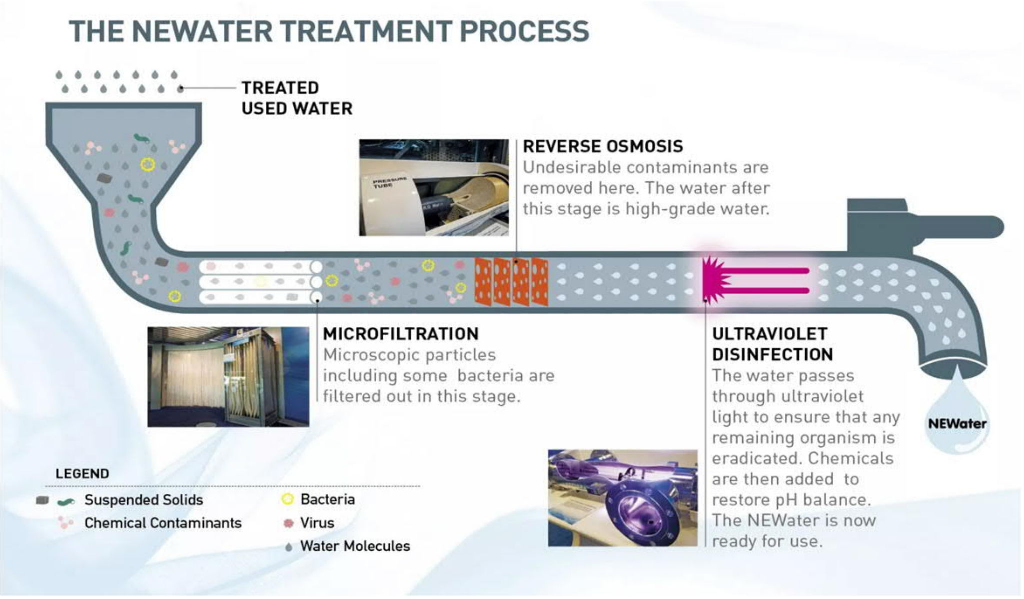
?Nutrients: Phosphorous recovery is struggling / Nitrogen recovery by ammonia stripping is very limited

? Materials: As yet, no major cases of success to my knowledge

Note: On average, recovery products get only 20% of their real value , because of distrust by the subsequent user ...

3 Lessons learned:

1. The consumer is afraid of ‘contaminants’ in general and fecal contaminants in particular: The case of Singapore and NEWATER.



3 Lessons learned:

2. Few processes relieve the Yuck factor :

   a) The involvement of heat / fire

      (CHP, ashes , ..)

   b) Transition into a gas phase

      (methane, CO2, NH3,...)

   c) Change in outlook

   (mushroom on horse manure, ...)

3 Lessons learned:

3. We still NOT live in an Economy for Common Good ,.........but in a Market Economy

The final product from waste recovery must ‘allow to make money’

Take home :

*The psychology of the citizin matters

*Combine a ‘cleansing technology’ with a ‘new outlook‘ and ‘smuggle’ your recovery product in a large and flexible ‘supply chain ‘

Thinking out of the box

<u>INVEST UPFRONT</u> to ‘capture the “disorder ” out of the water ‘

<u>The faster you separate the ‘ water carrier’ from its ‘load of contaminants ‘ , the better !!!!</u>

To drive the process, add a renewable resource which the consumer considers non-food

****

In doing so AVOID diffusive side-effets : N2O /CH4/ microplastics aerosols / disinfection bioproducs ……

Thinking out of the box

* We evolve towards a HYDROGEN economy and should make use of it (Ad Van Wijk, TU Delft /KWR)

10% of the world deserts suffice to empower the world !!

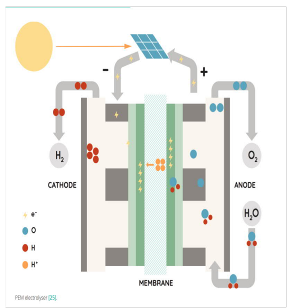
Major renewable energy transition: HYDROGEN!
Low cost and new energy storage

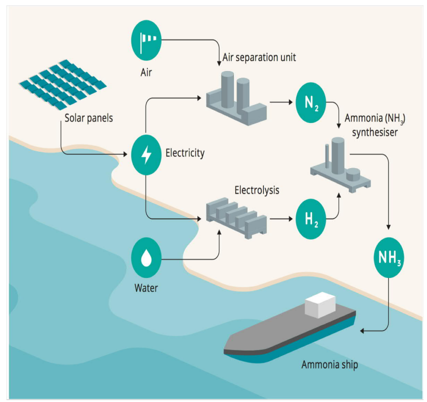
2019: off peak electricity € 50 / MWH; soon it will come to € 30 / MWH

2040: large scale solar & wind power – production to be < € 10 - 30 / MWH

New Energy Storage:

- Hydrogen economy
- Ammonia production





My story:

- Do not downgrade / but upgrade
- Use hydrogen-driven aerobic Microbial Fermentation
- Go for clean microbial biomass as multi-use endproduct

Aerobic Microbial Fermentation
In 2015 we launched :
upgrade recovered nutrients N

Microbial
Protein
PROMIC

Human Food
and
Animal Feed

OR

Organic
Fertilizer to
enhance Soil
Organic Carbon

OR
Biodegradable
composites

Autotrophic route

- Oxygen
- CO_2
- Recovered Nutrients
- HYDROGEN /other fermentable
- gases

In-reactor
Microbial Based
Biomass
production

The autotrophic route

Avecom/KWR /Waternet/AEB:

power to PROTEIN

AUTOTROPHIC upgrading of recovered NH_3

The first hydrogenotrophic biomass producing reactor (0.7 m^3)

NOW RUNNING IN CONTINUOUS MODE

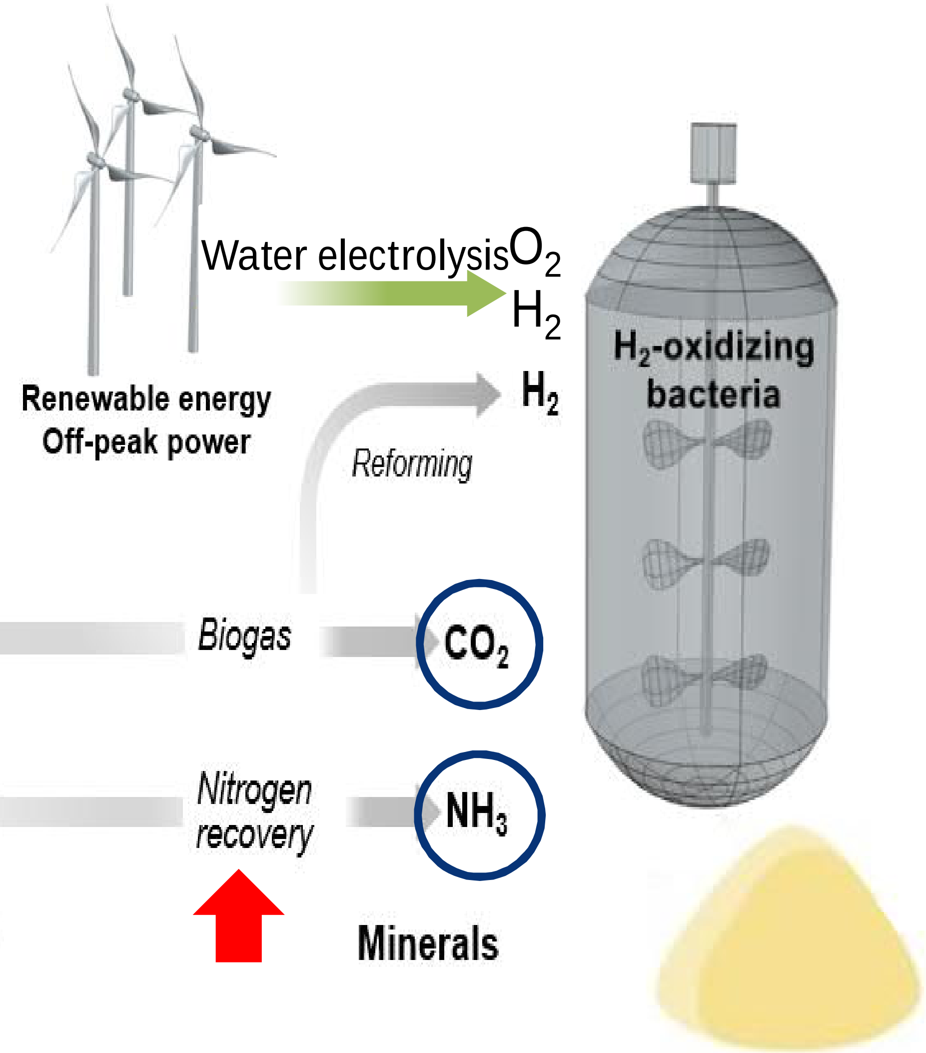
WORLD PREMIER !!

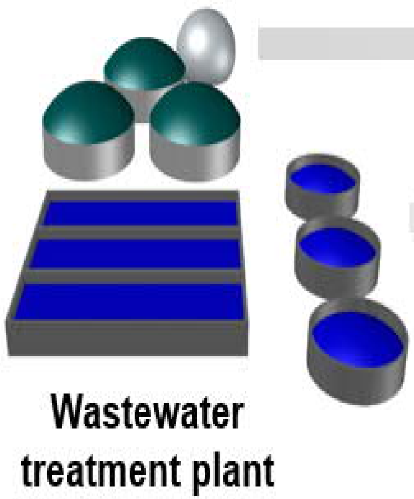
Upscaling to 20 kg DM/d is planned

Ghent: 260 000 inhab
= 20 TONSwaste protein /day

Upgrade with HYDROGEN to Clean Material and Clean Water

NH_3





MICROBIAL
BIOMASS

20 ton PROTEIN /day

CLEAN
Slow Release
Fertilizer
contributing
to
Carbon Capture
and Storage

In 2020 we propose :
Stop the ‘grinding up’ fully !!

- RE-ASSEMBLE UPFRONT THE ORGANICS with GREEN HYDROGEN as driver / do not load up the water matrix with ‘entropy’

VAN RWZI NAAR DUURZAME WATERFABRIEK

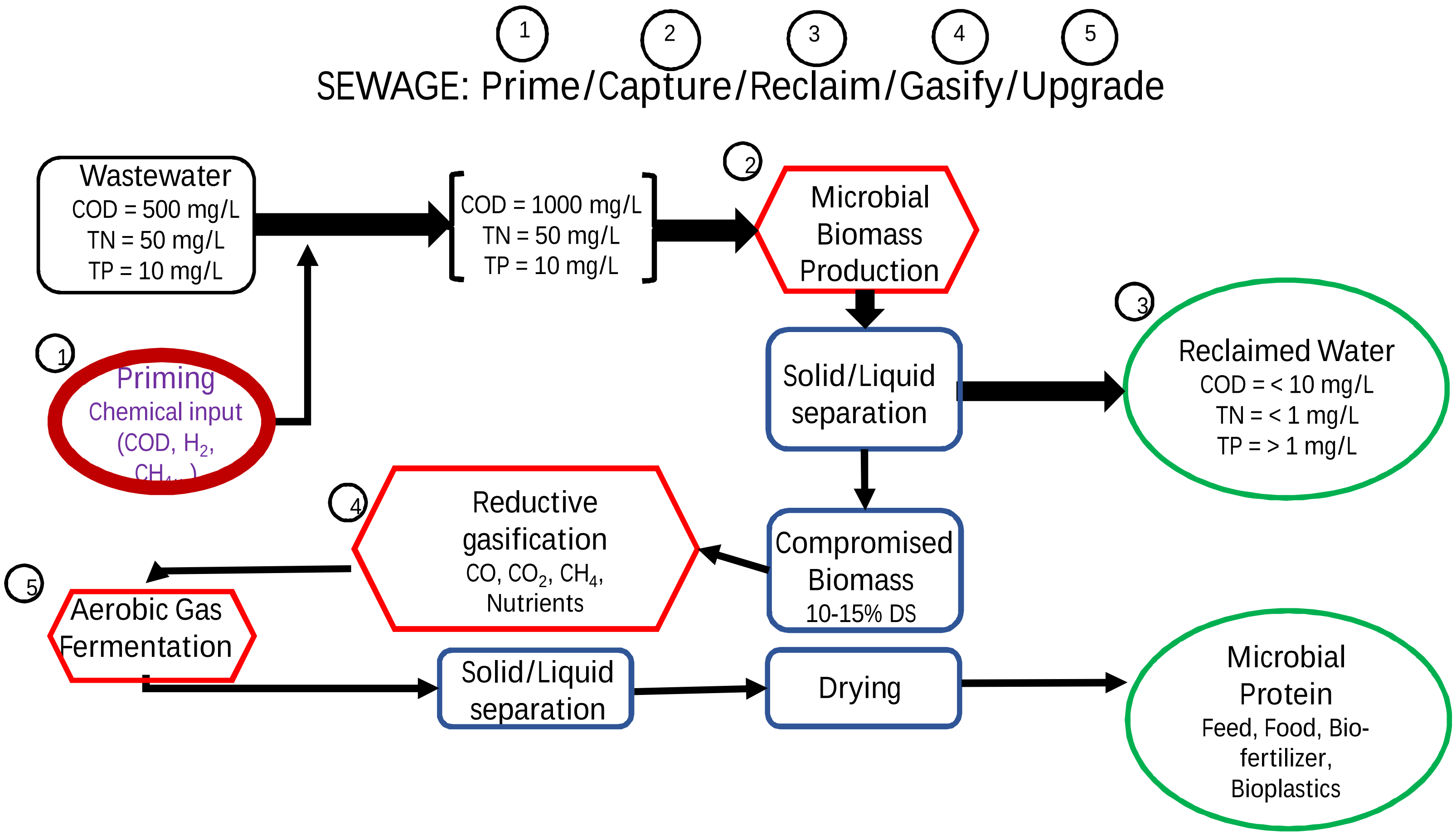
CoRe Water

* Capture the UNCLEAN SOLIDS and gasify them (see Gates Foundation) – the “clean” gases thus produced can subsequently be valorized by aerobic gas fermentation

- Aerobic fermentation as generic upgrader process to Food /Feed /Organic Fertilizer / Biomaterials

Short track reclamation

SEWAGE: Prime/Capture/Reclaim/Gasify/Upgrade



Gasification of biomass /low tar but high H_2 + CO (Burhenne et al. 2013; Hu et al. 2019; Ebadi et al. 2019)

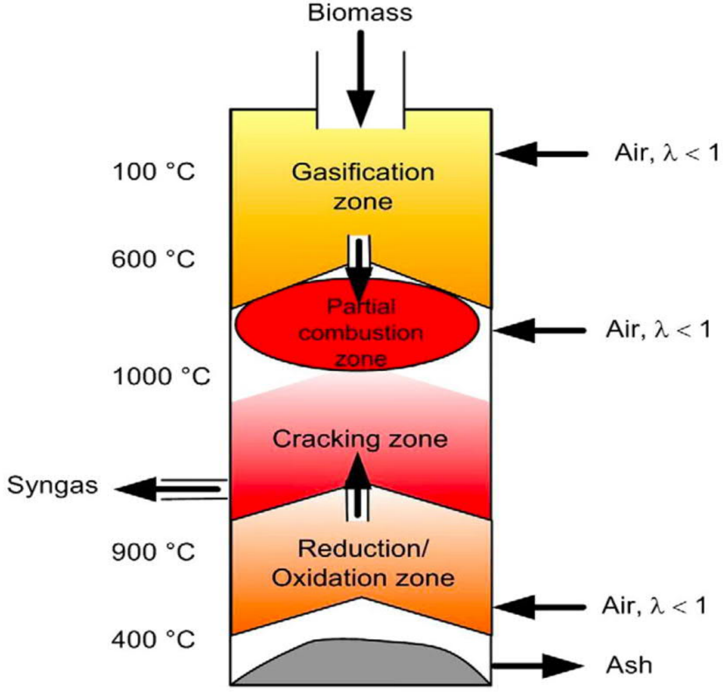
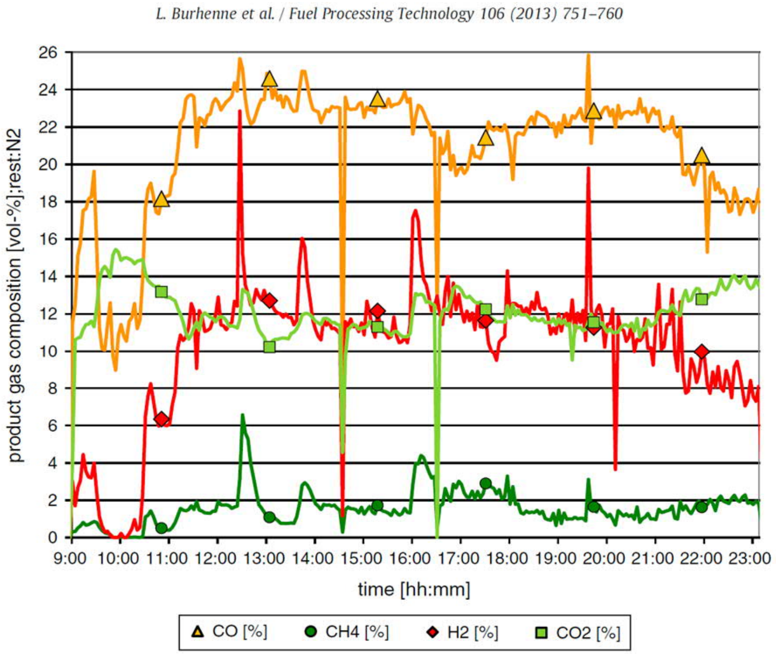


Fig. 1. Scheme of the *Fraunhofer ISE* gasifier.

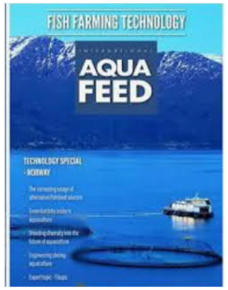


position from operation with wood pellets at a biomass feeding rate of 12 kg/h (LHV of 60 kW) and a stoichiometric air ratio λ between 0.2 and 0.27.

Microbial biomass – grown on gases
Global Market for Protein
– a divers and huge field of application

<u>Human Food:</u> 100 g highly nutritious protein dry matter per person per day / the demand will double in the next decade to a total market potential of some:

Ca. 1,000,000 tons of top-quality protein / year



<u>Animal Feed:</u> The current world market for animal feed has a size of:

Ca. 200,000,000 ton of medium-quality protein / year (= massive!)

<u>Organic Fertilizer:</u> demand is on the rise since chemical fertilizer becomes less reliable in case of climate change, around 5% of the total fertilizer demand (in the form of New MBB Slow release organic fertilizer

Ca. 10,000,000 ton of microbial protein / year

CLEAN microbial biomass
Global Market Potential – a huge demand!

Biobased biodegradable plastics: use protein as a component of bio-degradable plastics, at 2% of all plastics, this represents

Ca. 6,000,000 ton of microbial protein / year

www.ypack.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773872.

Avecom is currently involved in a project where

MICROBIAL PROTEIN INCORPORATED IN

THE PLASTIC POLYMER IS

MAKING THE PLASTIC BIO-

AND

MOREOVER DEGRADABLE

(see public in press)

Novel Bioplastic from Single Cell Protein as Potential Packaging Material

Shuvra Singha[1,], Muhamed Mahmutovic[1], Carlos Zamalloa[2], Lutgart Stragier[2], Willy Verstraete[2,3], Anna Hanner[1], Oisik Das[4], Mikael S. Hedenqvist[1,*]*

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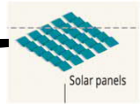
[2]Avecom NV, Industriweg 122 P, 9032 Wondelgem, Belgium.

[3]Center for Microbial Ecology and Technology, University of Gent, Coupure Links 653, 9000 Gent, Belgium.

[4]Structural and Fire Engineering Division, Department of Civil, Environmental and Natural Resources Engineering, Luleå University of Technology, Luleå 97187, Sweden.

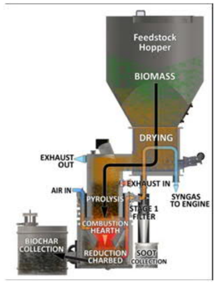
Cyclic economy: The dream

[C, N, P, S]
WASTE



CAPTURE

GASIFY

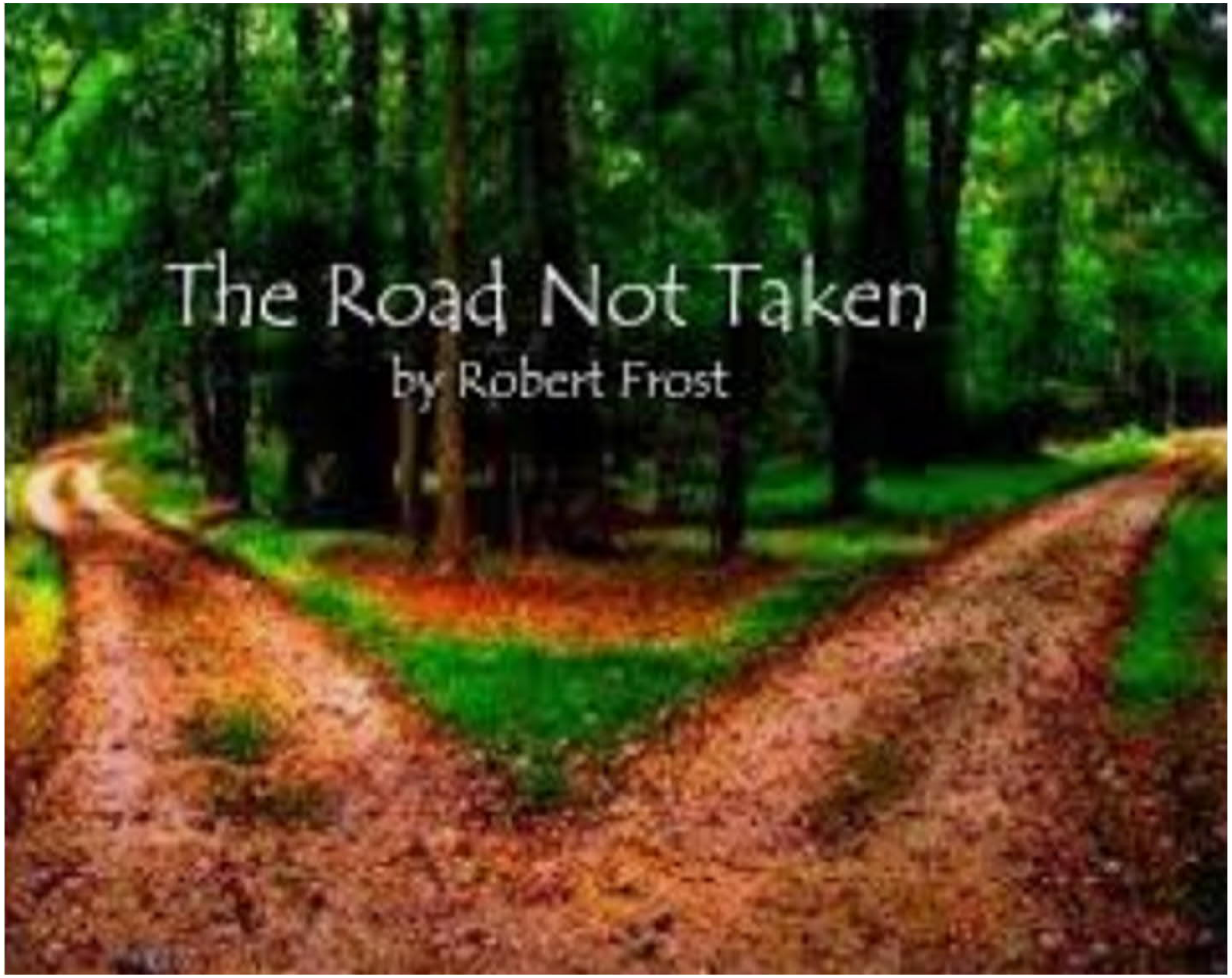


No N2O /CH4....
even no CO2 is possble

AEROBIC FERMENTATION

[C, N, P, S]
SINGLE CELL PROTEIN

The cascade of dissipation processes …….



The STP of the Future

- Photovoltaic panels / Water electrolysers
- Aerobic fermentation (high rate activated sludge), extra empowered for capturing the solubles by means of Hydrogen
- Separator of biomass and water
- Gasifiers (bio and thermo) of the biomass to clean gases
- Aerobic upgrading of the gases to various qualities of microbial proteins


DO SOMETHING
TODAY THAT
YOUR FUTURE
SELF WILL
THANK YOU FOR

Further reading

Upcycling of biowaste carbon and nutrients in line with consumer confidence: the "full gas" route to single cell protein

By: Matassa, Silvio; Papirio, Stefano; Pikaar, Ilje; et al.

GREEN CHEMISTRY Volume: 22 Issue: 15 Pages: 4912-4929 Published: AUG 7 2020

Decoupling Livestock from Land Use through Industrial Feed Production Pathways

By: Pikaar, Ilje; Matassa, Silvio; Bodirsky, Benjamin L.; et al.

ENVIRONMENTAL SCIENCE & TECHNOLOGY Volume: 52 Issue: 13 Pages: 7351-7359 Published: JUL 3 2018

Resource recovery from used water: The manufacturing abilities of hydrogen-oxidizing bacteria

By: Matassa, Silvio; Boon, Nico; Verstraete, Willy

WATER RESEARCH Volume: 68 Pages: 467-478 Published: JAN 1 2015