Low temperature hydrogen production from 2nd generation biomass

HyTIME
278855

Pieternel Claassen
Food & Biobased Research
www.hy-time.eu

PROJECT OVERVIEW

- SP1-JTI-FCH.2010.2.4 • Hydrogen production • Jan 2012-July 2015
- Total budget M€ 2.92; FCH-JU grant M€ 1.32
- The target of HyTIME is the production of **1-10 kg H_2/day** by fermentation of biomass.
  The process is derived from Anaerobic Digestion but is **novel in the decoupling of hydrogen production from methane production** in dedicated bioreactors. Hydrogen is harvested and biogas from the effluent of the H_2 reactor is used to cover the energy demand.

FOOD & BIOBASED RESEARCH WAGENINGEN UR

ENVIRONMENT PARK

heijmans

WIEDEMANN-Polska Projekt

Awite Bioenergie GmbH

RWTH AACHEN UNIVERSITY

HYGEAR

VEOLIA ENVIRONNEMENT Recherche & Innovation

TU WIEN TECHNISCHE UNIVERSITÄT WIEN Vienna University of Technology

PROJECT TARGETS AND ACHIEVEMENTS

Programme objective/ target	Project objective/ target	Project achievements to-date	Final achieve ment
AIP			
Efficient biological systems for digestion of 2nd generation biomass	Supply of biomass. Mobilisation of fermentable components	Optimized protocols for straw and grass (steam ex, chemical, enzymatic). Energy demand, reduction of enzymes	100%
Low temperature H_2 production process	Efficient H_2 fermentation in dedicated reactors	Grass : 90% yield at 5.7 L. Larger scale: 25-30% yield at 58-225 L scale	35%
Development of bioH_2 production systems	Optimisation of gas upgrading, AD, process monitoring and system integration	MC successful, AD potential sufficient, new devices for online control, mass and energy balances, techno-economics overall process	Circa 75%

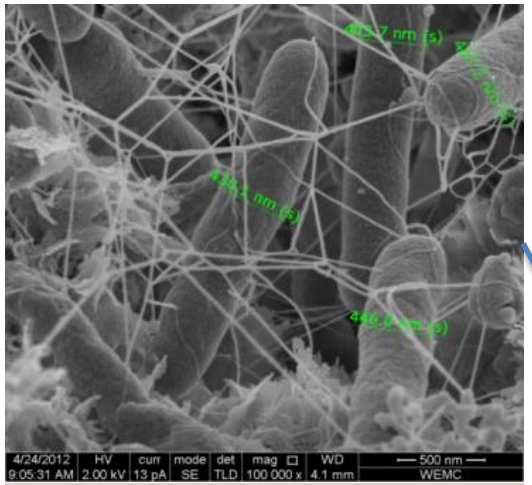
Validation of pretreatment

Wheat straw

1. Steam explosion or acid impregnation
2. Enzymatic hydrolysis
3. Hydrogen fermentation in 35 L CSTR:
4. Anaerobic digestion in 250 L CSTR:

Hydrolysate/ inoculum	T reactor	HRT(h)	% H_2	H_2 in g/day
C+E/Anaerobic sludge	37	178	9.6	0.8
S+E/*C. saccharolyticus*	70	37	44.3	3.0
C+E/*C. saccharolyticus*	70	37	47.1	2.0

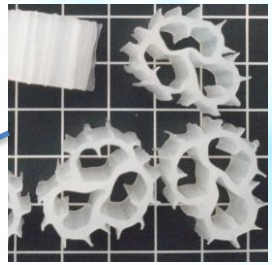
Dedicated bioreactors and upscaling



Cell retention

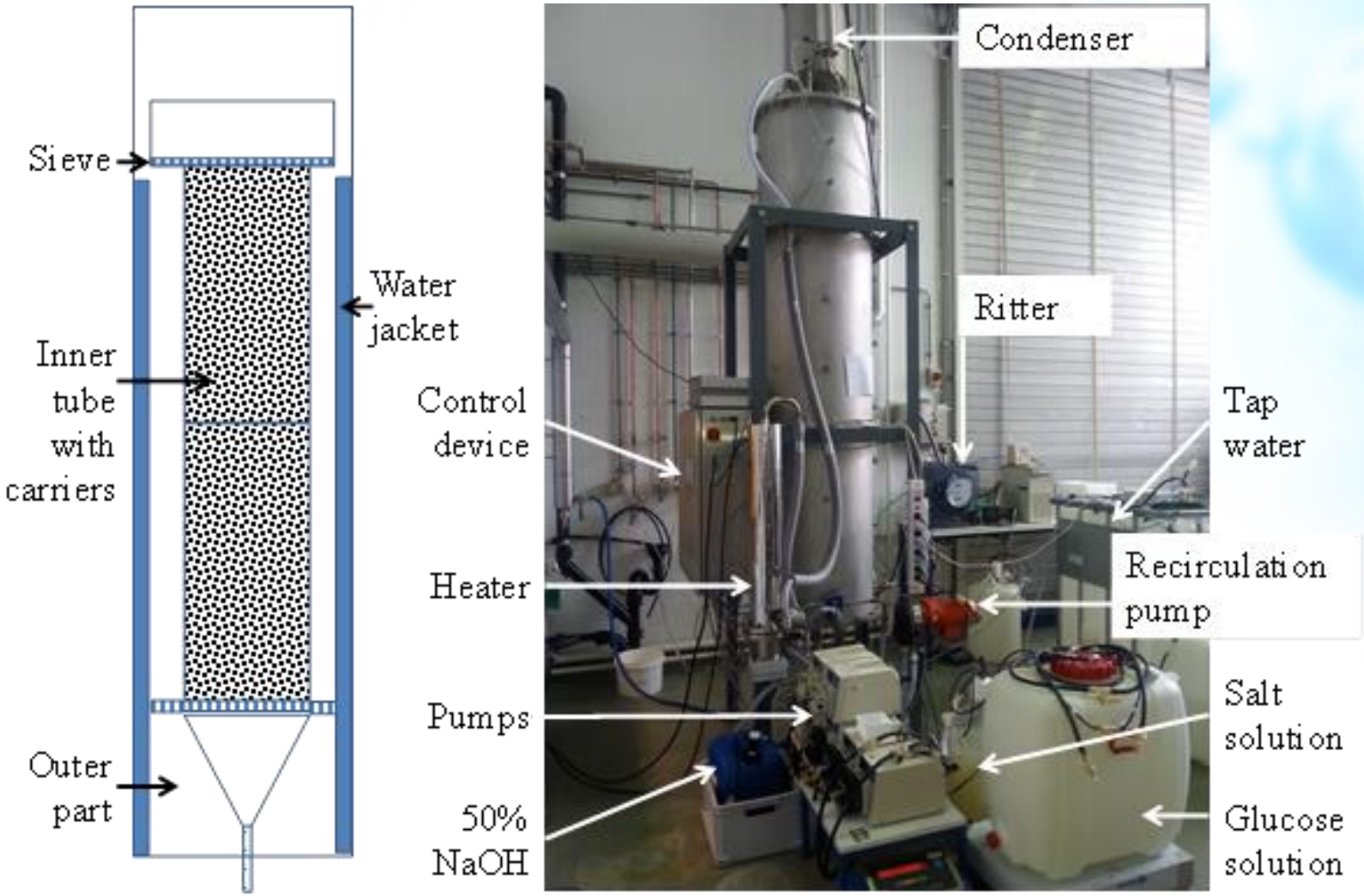
Verge grass

Packed bed reactor (5.7 L)



1 m^3 grass hydrolysate:
4.7 m^3 H_2
6.8 m^3 CH_4
at 6 g H_2/day

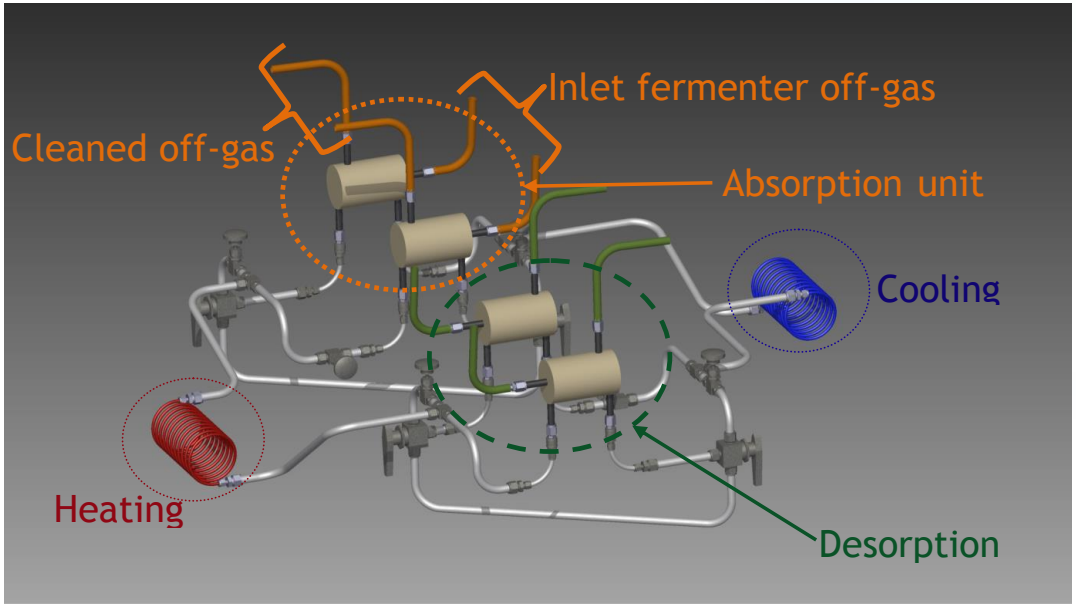
Final scale: 225 L



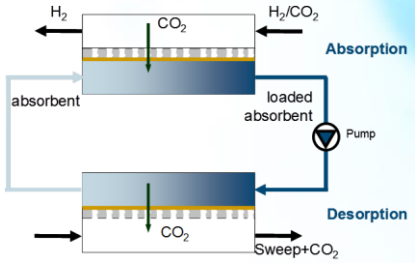
Results of upscaling in dedicated reactors

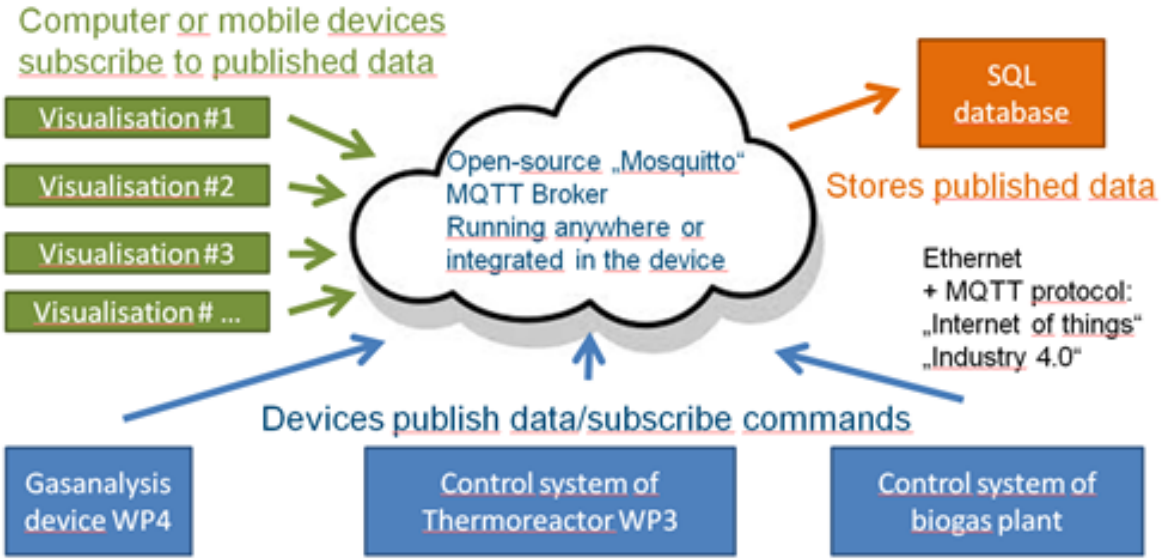
Feedstock	Volume L	Type reactor	T reactor	HRT (h)	Yield %	% H_2	H_2 in g/day
Straw(C)	35	CSTR	70	37	n.d.	47	2
Grass(C)	5.7	PB/GD	70	10	90	19	6
Sucrose	58	PB/GD	70	20	87	18	23
Molasses	58	PB/GD	70	10	20	12	18
Glucose	225	PB/GD	77	10	25	8	109

Biohydrogen production system



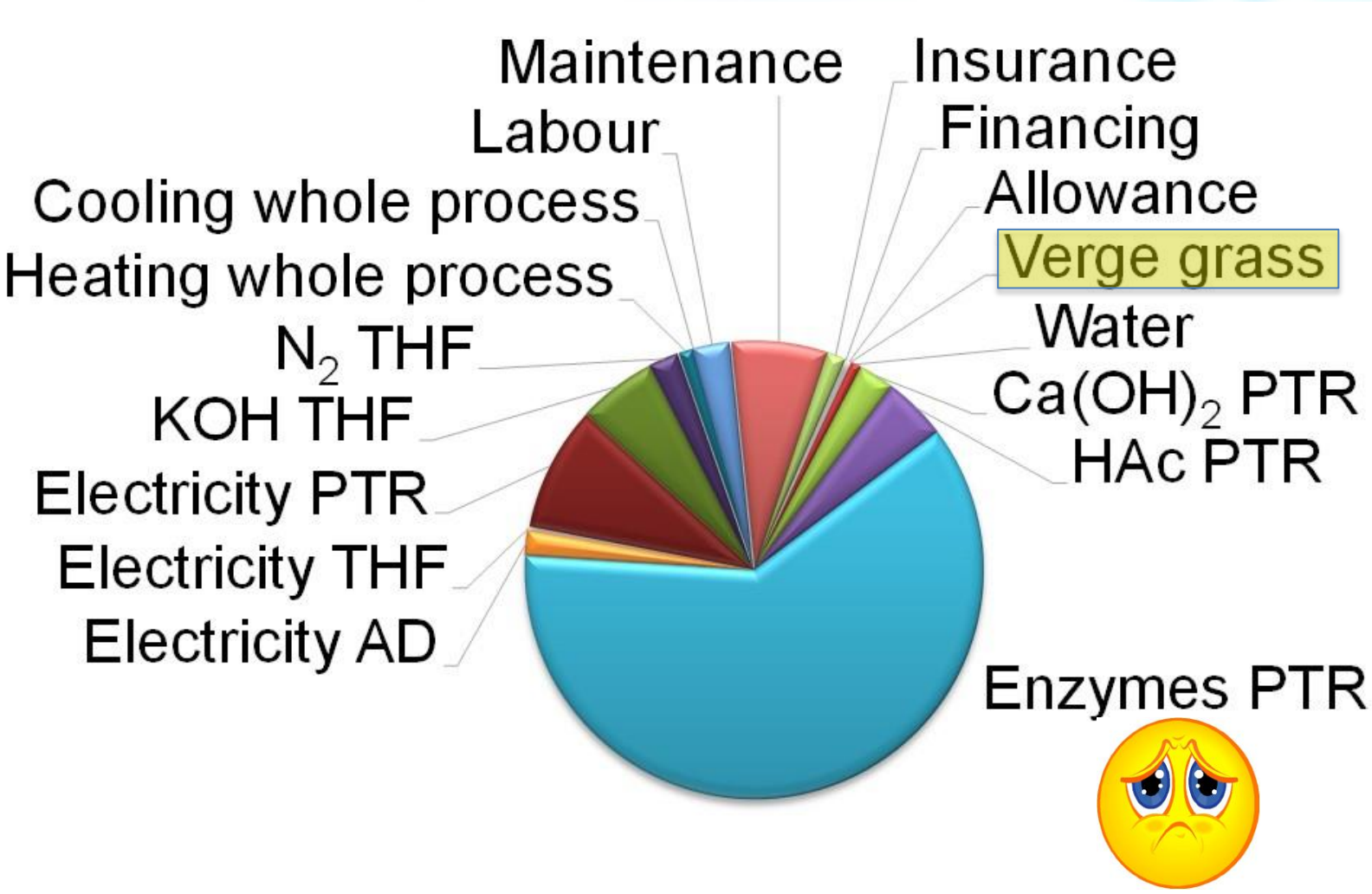
Membrane modules for CO_2 removal





Visualisation software for remote process control

Techno-economic analysis



Objective: 1-10 kg H_2/day

- Achieved: 109 g H_2/day
  - Yield only 25% instead of 90% (*contamination*)
  - Reactor size 225 L instead of 500 L (*defaulting partner*)
  - Low organic loading (*lack of time*)

- Main contingency plans:
  - Exploration “new” bacteria
  - Carbohydrate vs lignocellulose -derived biomass

SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

- Co-funding by Dutch ministry of Economic Affairs: Topsector AgriFood
- FCH JU interactions: UNIfHY (*HyGEAR*), FITUP (*ENVIPARK*), HYPROFESSIONALS (*ENVIPARK*), ENE.FIELD (*ENVIPARK*), FLUMABACK (*ENVIPARK*), Knowhy (*ENVIPARK*)
- EU interactions: SAHYOG (*DLO-FBR*), Ambigas (*RWTH*), TMFB (*RWTH*)
- International-level projects: SEBE (*ENVIPARK*), BioH2 regional (*ENVIPARK*), HySTREM (*ENVIPARK*), H2MemClean (*TUW*), Biomethair (*ENVIPARK*), Thai-German Seed Fund (*RWTH*)
- HyTIME is a direct continuation of FP 5 BIOHYDROGEN (Proof of principle) and FP 6 HYVOLUTION (increase of H_2 yield); Coordinated by DLO-FBR

HORIZONTAL ACTIVITIES

- Training activities
  - 2 practical training of students, 1 workshop, 3 training courses on production of $BioH_2$ and AD (ENVIPARK)
  - 1 PhD, 2 Masters, 1 Bachelor student (TUW)
  - 1-4 Masters, 2 Bachelors, 1 Diplom student and 15 undergraduates (RWTH)
  - 1 PhD student, external training (DLO-FBR)

DISSEMINATION ACTIVITIES (2014-2015)

- Conferences with presentations:
  - PRES, Prague 2014
  - DECHEMA , Aachen 2014
  - Fuels of the Future, Berlin 2014
  - Beyond Biogas, Wageningen 2014
  - EBCE, Vienna 2015
  - PRES, Kuching 2015
  - Bioethanol & Bioconversion Technology, Detmold 2015
  - Hypothesis XI, Toledo 2015

EXPLOITATION PLAN/EXPECTED IMPACT

- Change i… …rama:
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- Exploitat…
  - A hydr… …al and a thermal condu…
  - Comm…
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- Main RTD… …-Art:
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