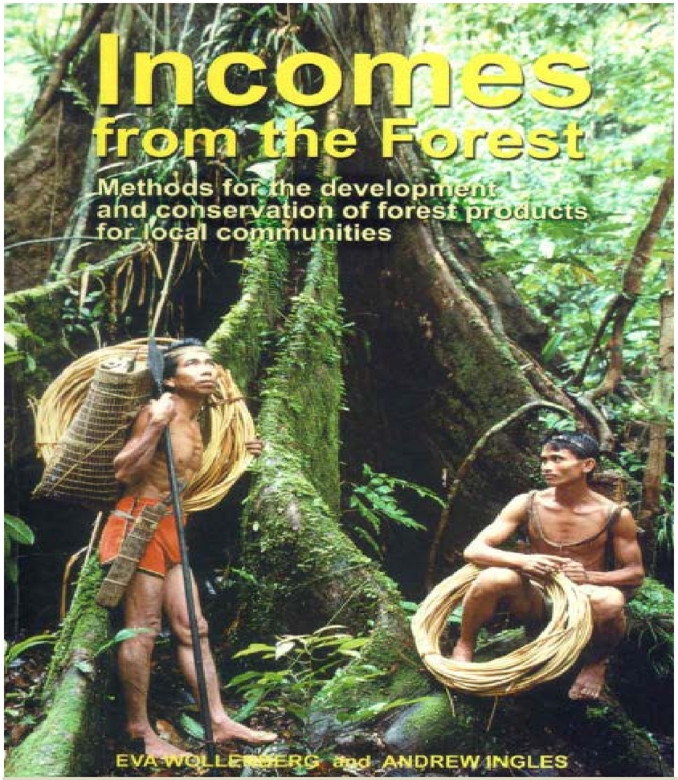
Burning Carbon to Energy to Mitigate Haze

Prof. Dr. Ir. Haslenda Hashim

Introduction

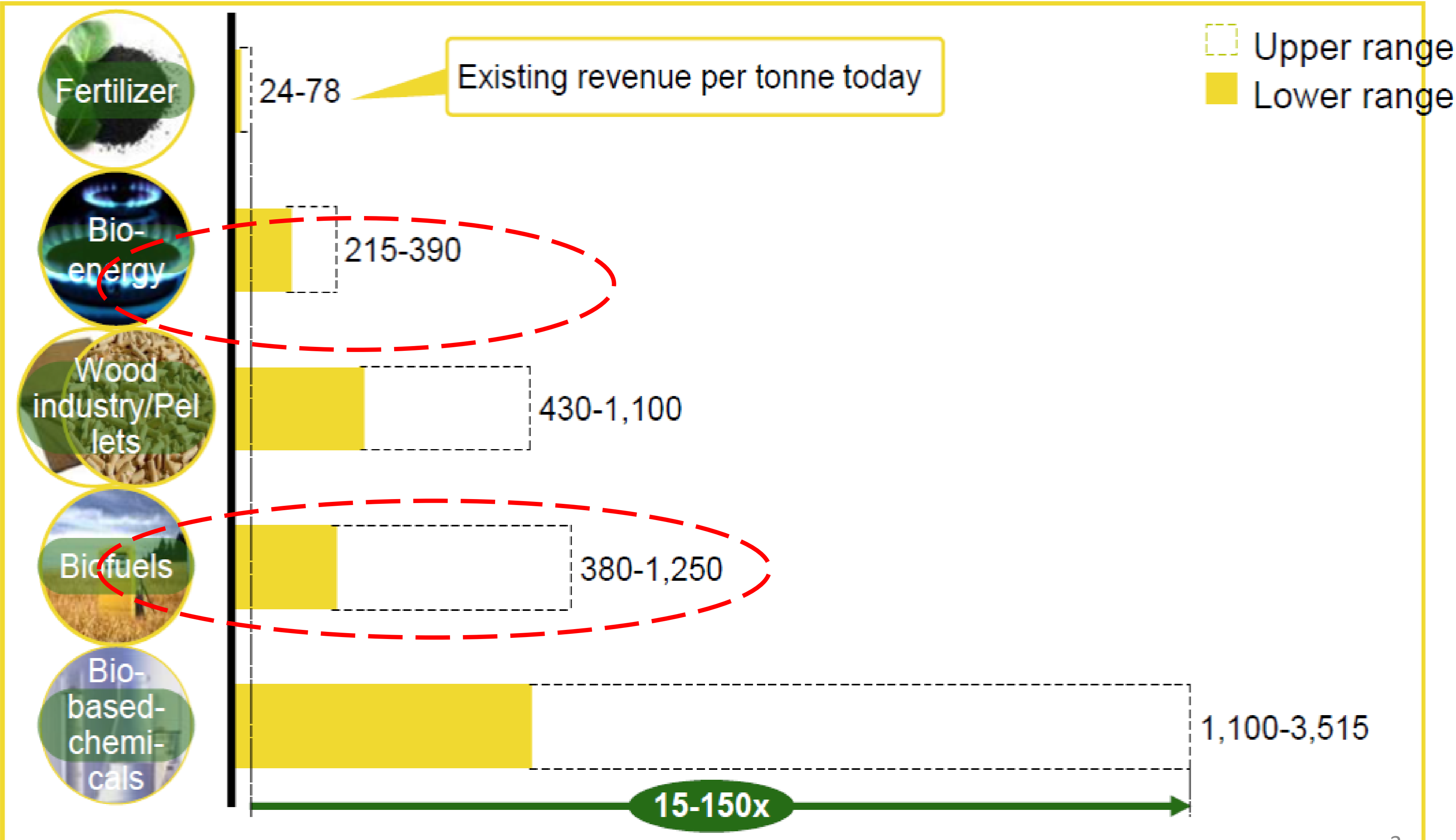
SLASH AND BURN??



SLASH AND EARN INCOME

Value of Biomass

Revenue generated per tonne of lignocellulosic biomass input (dry weight)
RM



Availability of Biomass

Type of biomass

- Forest biomass
- Oil palm biomass
- Peat land biomass

Properties of Biomass

	Forest biomass [a]	Oil Palm Plantation Biomass		Empty Fruit Branch (EFB) [c, f]
		Oil Palm Trunk [b, c]	Oil Palm Frond [d, e]	
Proximate analysis (wt% dry basis)				
Moisture content	n.a	8.34	16.00	4.68
Volatile matter	n.a	79.82	83.50	76.85
Fixed carbon	n.a	13.31	15.20	5.19
Ash	1.70	6.87	1.30	18.07
Ultimate analysis (wt% dry basis)				
C	48.10	40.64	44.58	46.36
H	5.99	[illegible]	[illegible]	[illegible]
O	45.72	[illegible]	[illegible]	[illegible]
N	n.a	2.15	0.71	2.18
S	n.a	n.a	0.07	0.92
Lignocellulosic content (wt% dry basis)				
Cellulose	45.80	45.90	50.33	57.80
Hemicellulose	24.40	25.30	23.18	21.20
Lignin	28.00	18.10	21.7	22.80
HHV (MJ/kg)	15.00	17.27	17.28	20.54

High cellulosics content → Ethanol production

Properties of Biomass

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Ultimate analysis (wt% dry basis)				
C	48.10	40.64	44.58	46.36
H	5.99	5.09	4.53	6.44
O	45.72	53.12	48.80	38.91
N	n.a	[illegible]	[illegible]	[illegible]
S	n.a	[illegible]	[illegible]	[illegible]
Lignocellulosic content (wt% dry basis)				
Cellulose	45.80	45.90	50.33	57.80
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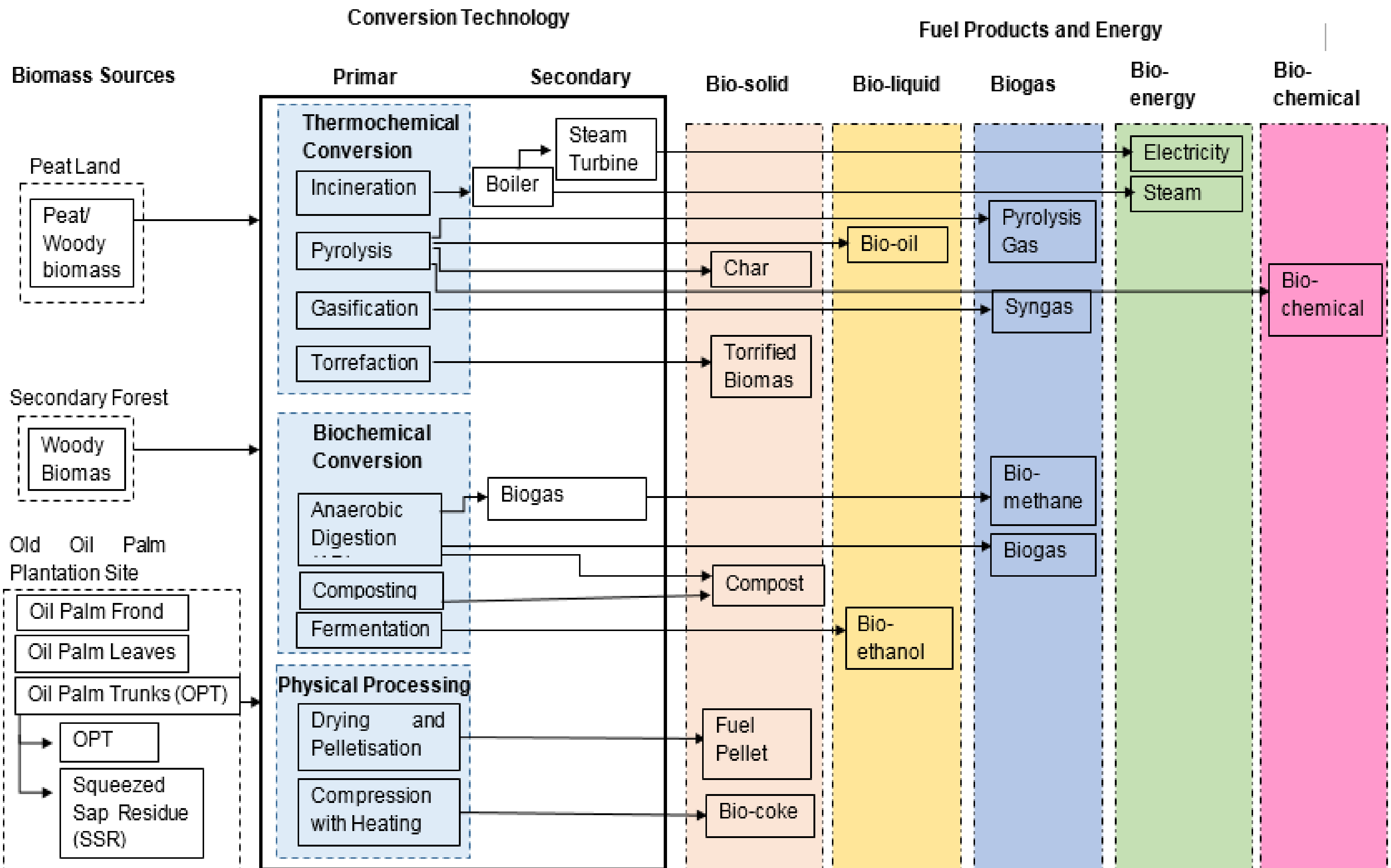
High HHV → Power Production

Biomass-to-Resource Potential Roadmap



Comparison of Biomass-to-Power Conversion Technologies

Technology	Direct Combustion	Gasification
Technical Aspect	**Mature** technology High commercial availability Larger capacity (300 – 1,000MW) High thermal efficiency: 60 – 85%	More recent; vulnerable to **explosion** Lower commercial availability Lower capacity (< 100MW) Lower thermal efficiency ✓2-stage combustion ✓Need thermal input
Financial Aspect	Lower CAPEX ✓USD 1 million/ MWe	Higher CAPEX ✓USD 1.5 – 1.75 million/ MWe

*Direct Combustion is **more favourable**

Comparison of Direct Combustion Technologies

Direct Combustion Technology	Stoker Combustion	Fluidized Bed Combustion
A) Operation		
Fuel-air mixing efficiency	Fair	High
Maintenance requirement	Low	High (corrosion problem)
B) Fuel/ feed condition		
Applicability to various fuels	Fair	High
Fuel pre-treatment	Generally not necessary	Lumps must be crushed
Tolerance to fuel moisture content	Fair	High (but not desirable)
C) Cost		
Unit Capital Cost (RM/kg steam)	1633	3379
Total Annual O&M, (RM/1,000 kg Steam)	25	29.5

*Stoker combustion is **more favourable**

Comparison of Biomass-to-Ethanol Conversion Technologies

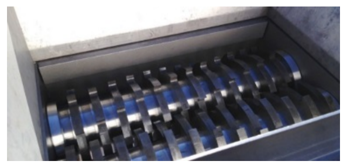
Biomass	Pre-Treatment: Break down Cellulose to Smaller Fiber	Hydrolysis - Fermentation: Conversion of Biomass to Sugars to Ethanol

Oil Palm Frond
Oil Palm Trunks

Forest Residue

Pre-Treatment

Physical



Milling, Radiation, Electric Pulse, Pyrolysis

Chemical

Alkaline hydrolysis, Acid, Organosolv, Ionic Liquid, Oxidation

Physicochemical

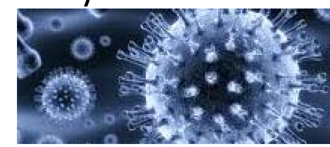
Steam explosion, Ammonia Fiber Explosion, Supercritical CO2, Liquid Hot Water, Microwave, Ultrasound

Biological

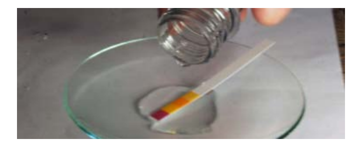
Fungi, Actinomycetes

Hydrolysis - Fermentation

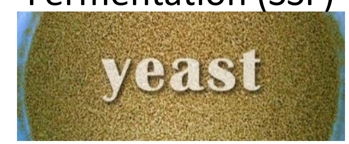
Enzymatic Reaction



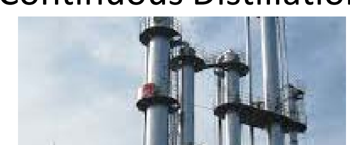
Acidic Reaction



Separate Hydrolysis and Fermentation (SHF)
or
Simultenuous Saccharification Fermentation (SSF)



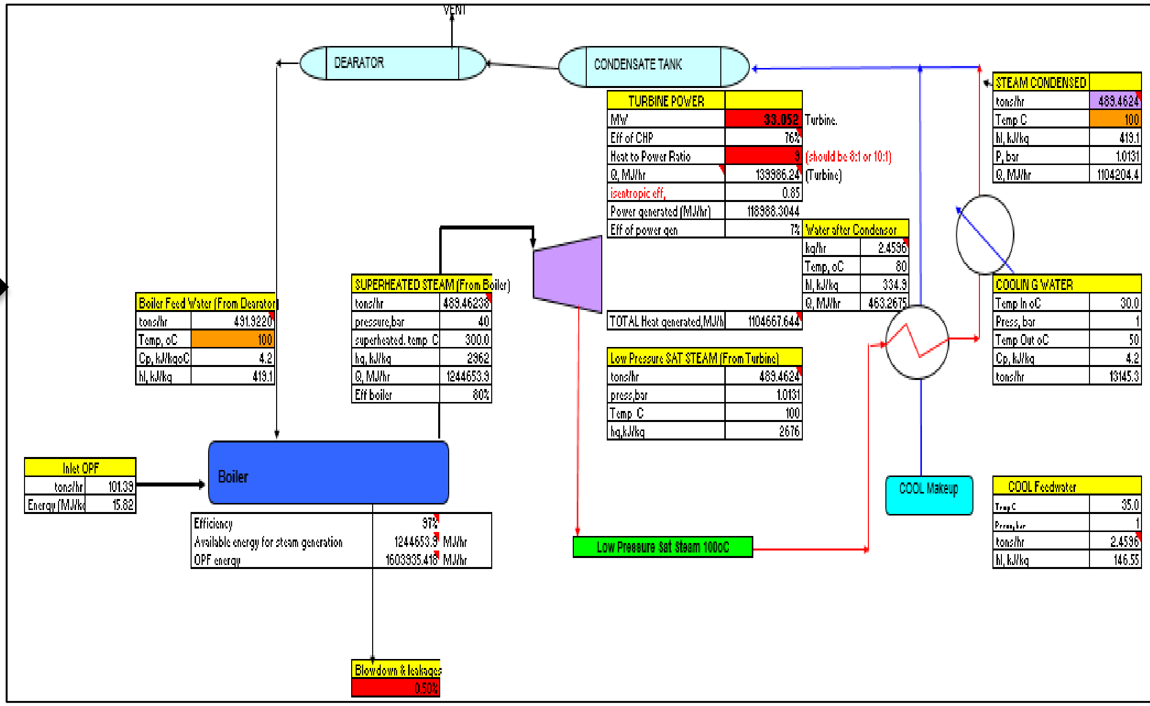
Continuous Distillation



Case study 1: Biomass-to-Power

Input

Biomass 2000t/d



Electricity

236,520,000 kwh/y @ 27 MW

Heat

3,524,129 ton/y

- Technology
  - direct combustion with 76% efficiency
- Feedstock
  - Biomass - calorific value of 15.82MJ/kg and 16% moisture content (dry basis)

Case study 1: Biomass-to-Power

Parameters	Unit Value	Total Value
Process Information		
Plant life		30 y
Efficiency		76%
Feedstock	2000 ton/d	730000 ton/y
Electricity Production		236,520,000 kwh/y
heat production		3,524,129 ton/y
Costing Information		
Feedstock cost		
Transportation costs	10 $/ton	$ 7,300,000
Harvesting and collection cost	10 $/ton	$ 7,300,000
Pre-processing cost	5 $/ton	$ 3650000
Investment cost of boiler	900 $/kW	$ 24,300,000
Investment cost turbine	1050 $/kW	$ 28,350,000
Fixed capital	3000 $/kW	$ 81,000,000.00
Variable cost		$ 1,111,644.00
Operation cost	150 $/kW	$ 4,050,000.00
Electricity price	0.07 $/kWh	$ 16,556,400.00
Heat price (by-product)	12.65 $/ton	$ 44,575,375

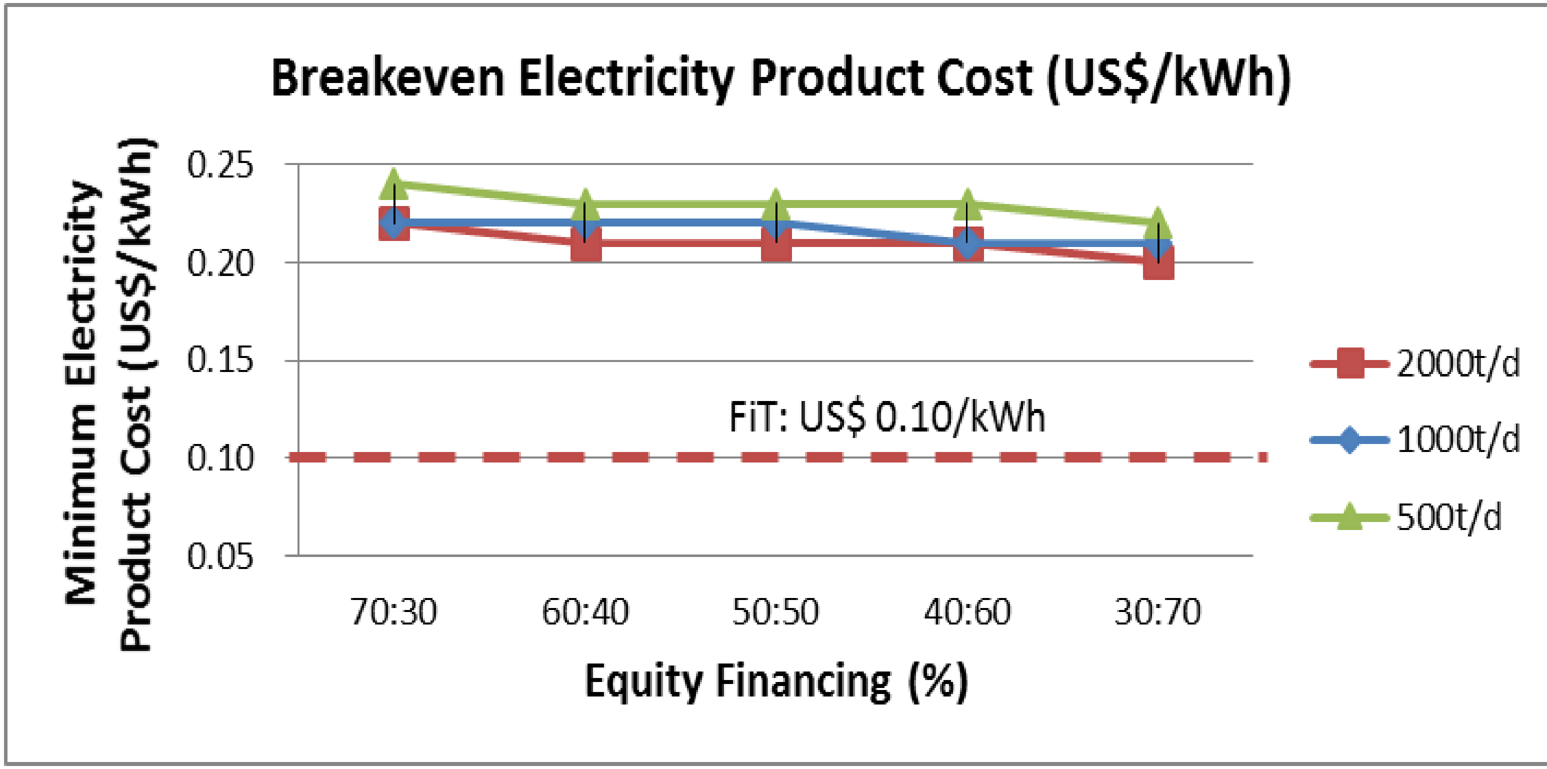
- Costing information:
  - Mensilin incineration plant
- Financing information:
  - NREL report

Case study 1: Biomass-to-Power

Parameters	Unit Value	Total Value
Financing information		
Discount rate		4.1%
Plant depreciation DB		150%
Plant recovery period		20 y
Corporate tax rate		25%
Loan - terms loan APR		5.0%
Loan period		10 y
Construction period		3 y
Start-up time		3 month
Revenues during start-up		50%
Variable costs incurred during start-up		75%
Fixed costs incurred during start-up		100%
BNM Government Securities Yield		4.0%

Case study 1: Biomass-to-Power

Breakeven Electricity Selling Price



- **Minimum electricity price: $ 0.19/kWh to $ 0.23/kWh**
- **Current FIT: $ 0.10/kWh.**

Case study 1: Biomass-to-Power

Production cost

	Interest rate		
Debt:Equity ratio	8%	5%	3%
70:30	0.32	0.22	0.16*
60:40	0.30	0.21	0.16 *
50:50	0.29	0.21	0.17 *
40:60	0.27	0.21	0.17 *

$$* \ WACC = \frac{E}{V} * Re + \frac{D}{V} * Rd * (1 - Tc)$$

Modigliani and Miller’s with-tax model: As debt becomes even cheaper (due to the tax relief on interest payments), cost of debt falls significantly from Rd to Rd(1-Tc).

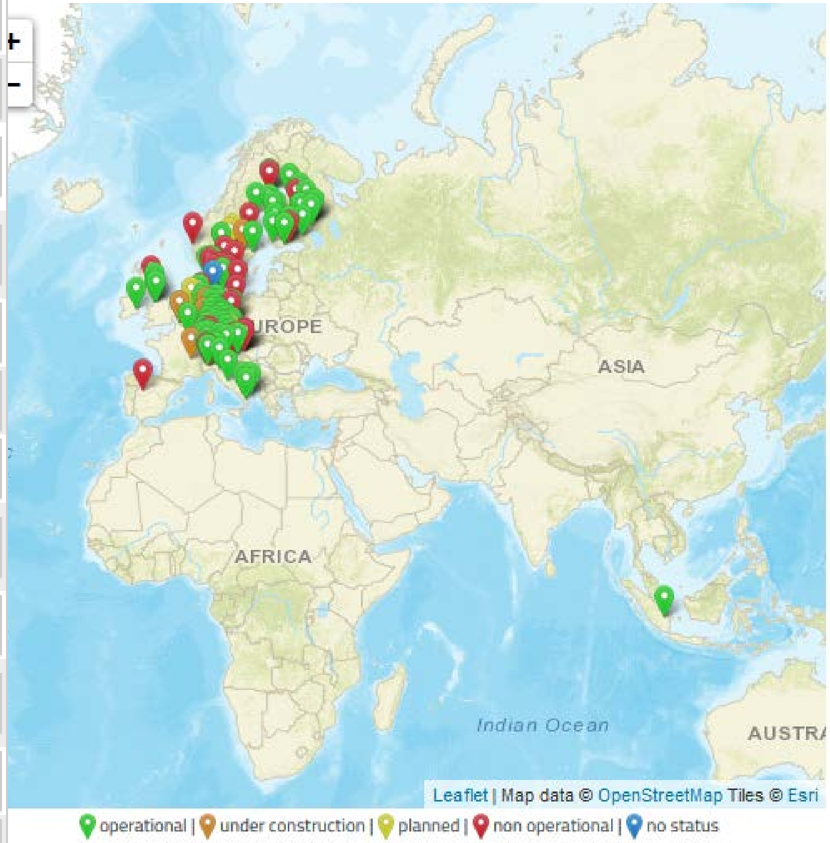
- BIOENERGY FOR..

RESEARCH

INDUSTRY

EVERYONE

Owner	Name	Country	
Aarhus University	Center for Biorefining Technologies	Denmark	Info
Abengoa Bioenergy	demo	Spain	Info
Aerni Pratteln	CHP Pratteln	Switzerland	Info
AEW Energie AG	Pelletvergasser AEW Rheinfelden	Switzerland	Info
Agnion Technologies GmbH	CHP Agnion Biomasse Heizkraftwerk Pfaffenhofen	Germany	Info
AustroCel Hallein	biorefinery	Austria	Info
Autogasnord	-	Italy	Info
Azienda agricola Camardo	-	Italy	Info
Azienda Agricola Isca di Calvello	Urbas Calvello	Italy	Info
Azienda Agricola San Vittore	-	Italy	Info
Azienda Tenca dei Fratelli Zanotti/AB energy	Orzinuovi	Italy	Info
Babcock&Wilcox Volund	CHP B&W Harboore	Denmark	Info
Beta Renewables	Biochemtex	Italy	Info
Beta Renewables (joint venture of Mossi & Ghisolfi Chemtex division with TPG)	IBP - Italian Bio Fuel	Italy	Info
Bioenergie Schnellingen	Bioenergie Schnellingen	Germany	Info
BioGasol	BornBioFuel 2	Denmark	Info

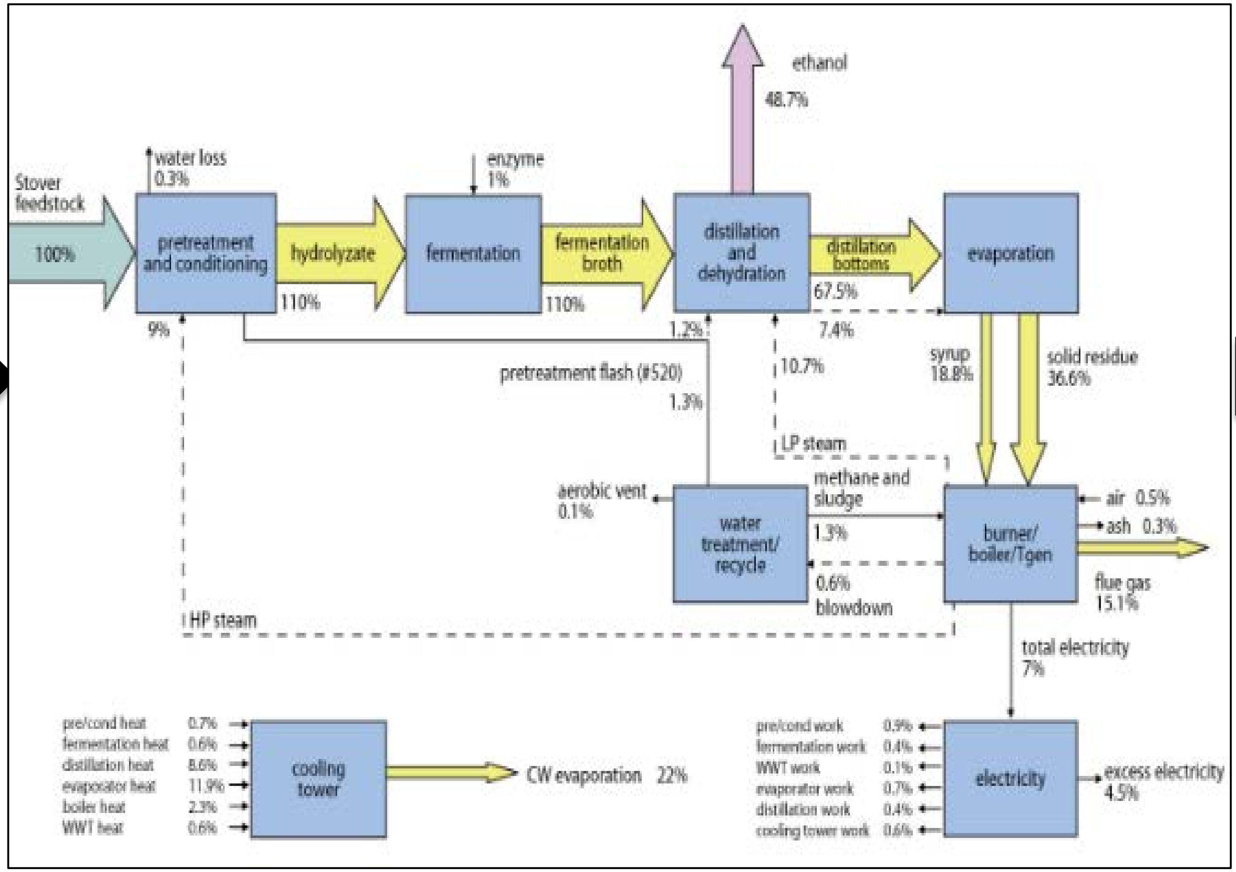


http://www.etipbioenergy.eu/databases/production-facilities

Case study 2: Biomass-to-Ethanol

Input

Biomass
2000t/d



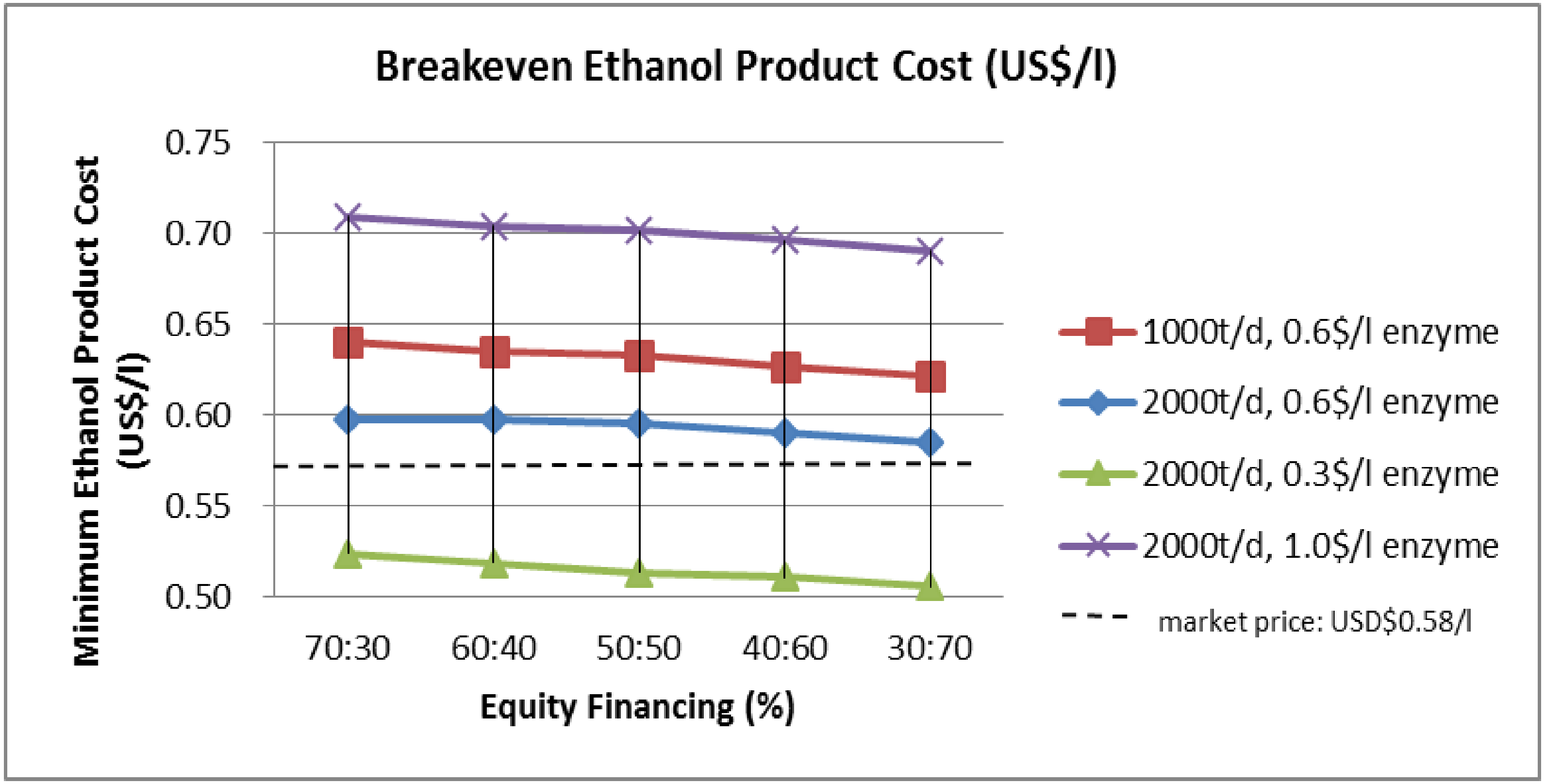
Bioethanol

65,887,070.60
gallon/yr

- Technology: Enzymatic hydrolysis followed by fermentation
- Feedstock
  - Biomass with cellulosics content of 70%;
  - Conversion to C5 and C6 sugars of 95%;
  - Fermentation using high substrate tolerant recombinant yeast

Case study 2: Biomass-to-Ethanol

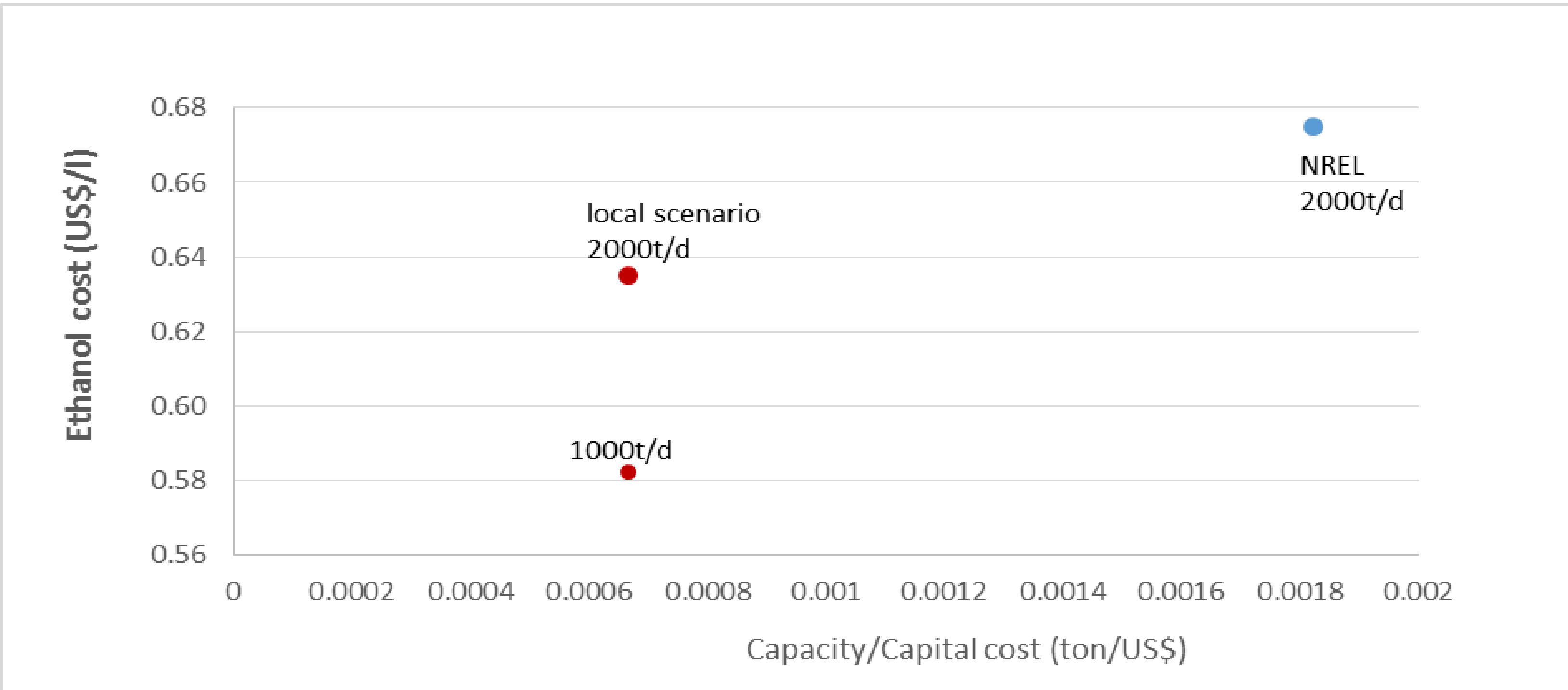
Breakeven Ethanol Selling Price



- Ethanol price: $0.64/l to $ 0.62/l
- Current market price : $ 0.58/l

Case study 2: Biomass-to-Ethanol

Comparison between U.S and local scenario



- **Compared local and US scenario**
- **Localised scenario has lower ethanol cost**

Case study 2: Biomass-to-Ethanol

Production cost

Debt:Equity ratio	Interest Rate		
	8%	5%	3%
95:5	0.77	0.61	0.52
70:30	0.73	0.60	0.53
60:40	0.71 (0.57[a])	0.60	0.53
50:50	0.69	0.60	0.54
40:60	0.67	0.59 (0.52[b])	0.54

a US NREL (2011)

b Adapted from US NREL analysis

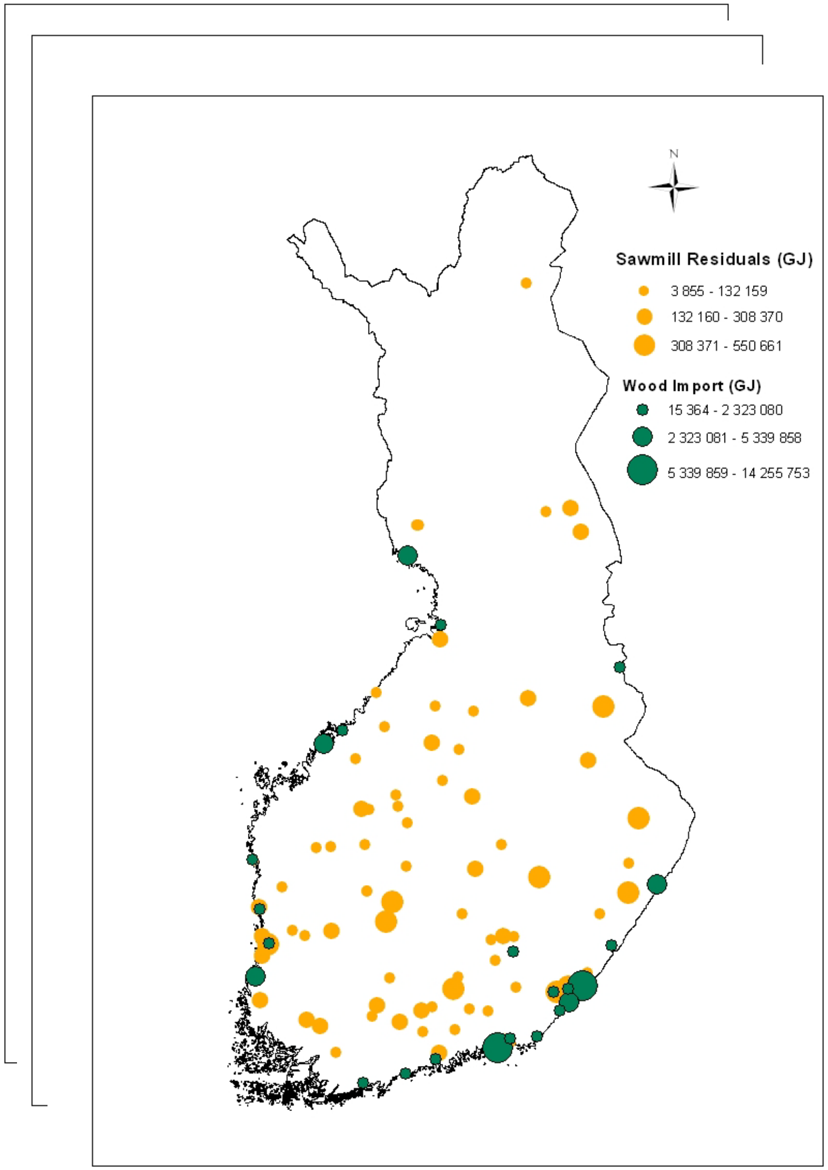
Table: Ethanol Production Cost Reduction by Improving Debt:Equity (D:E) Ratio or Interest Rate (iR) (USD/Litre)

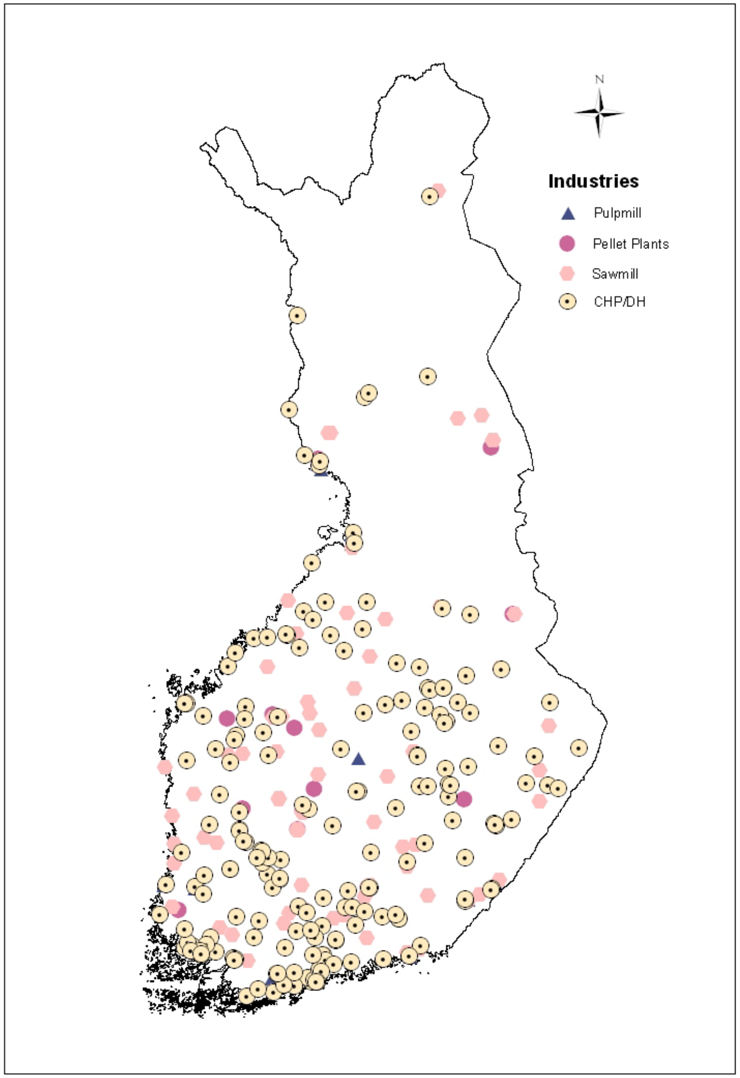
D:E Ratio\iR	8%	5%	3%
70:30			
60:40	0.57[a]		
50:50			
40:60	0.54	0.52[b]	

[a]US NREL (2011)
[b]The retail market price: USD 0.58/litre

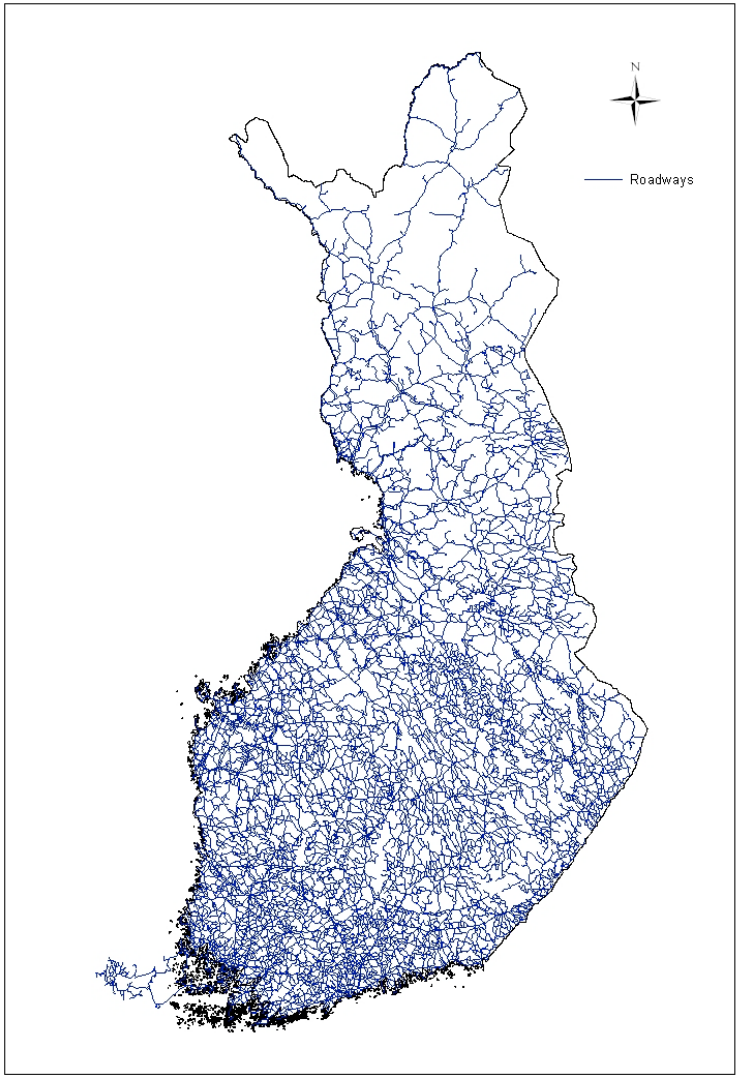
Ethanol (E-85) retailed at USD 2.39/gallon= USD 0.58/litre]

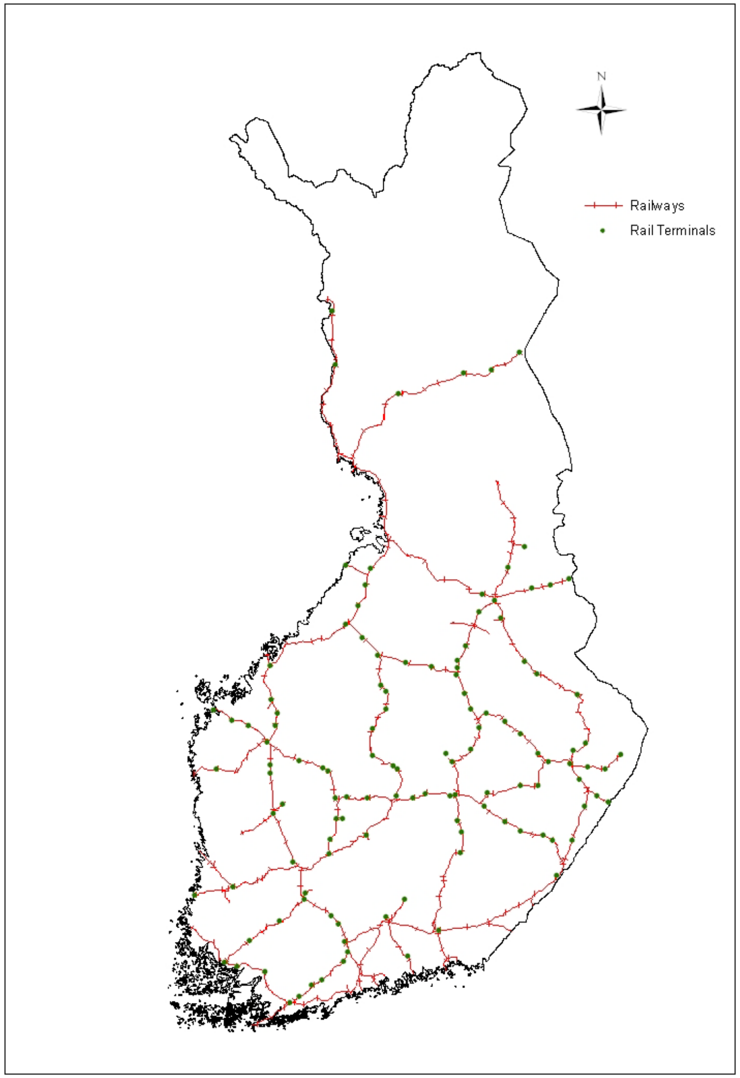
Spatial distribution of feedstock resources





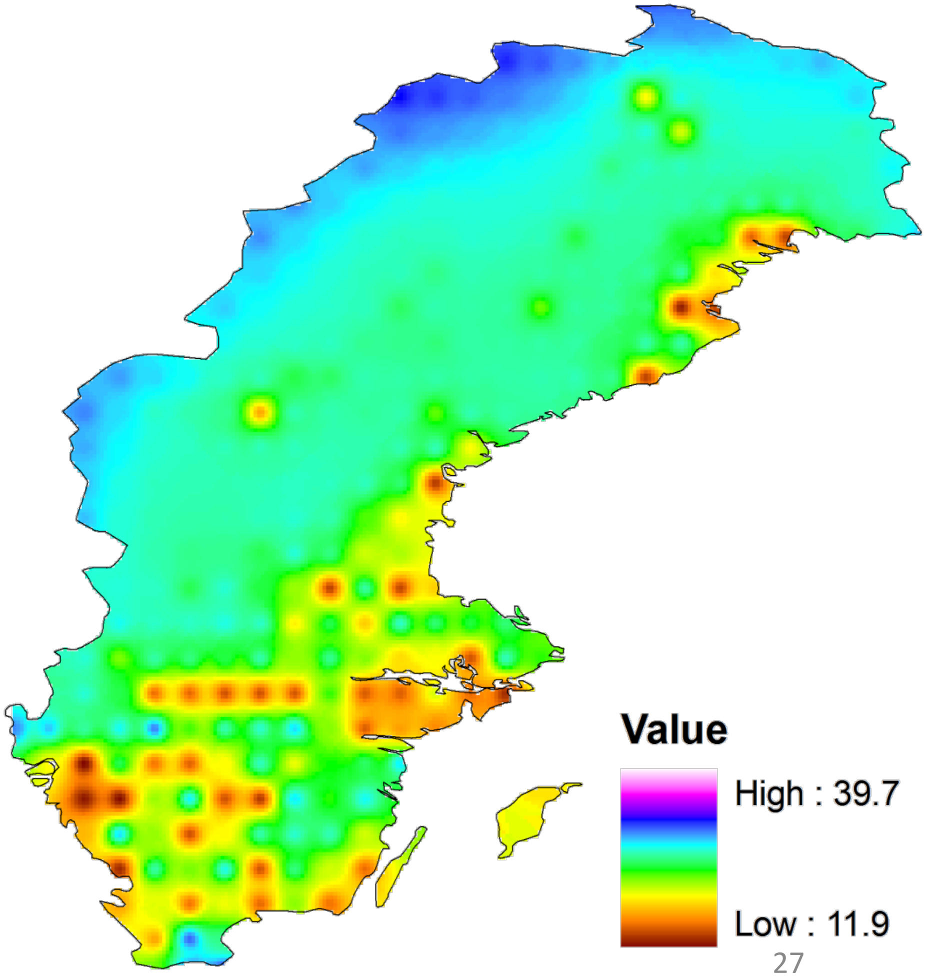
Transport Network





Sweden

Ethanol Production Cost (€/GJ)



Biethanol Target in Indonesia

IN COOPERATION WITH:

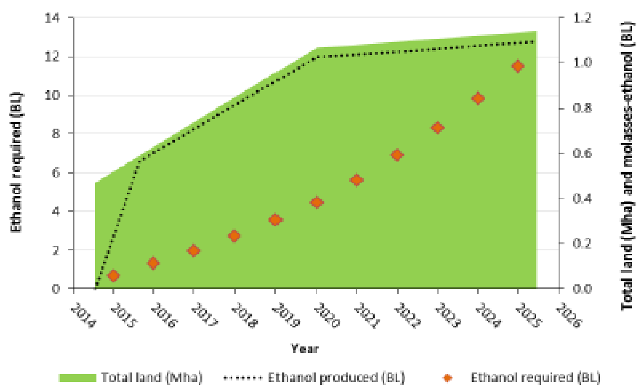
Swedish Energy Agency

DEN

Reference:
Khatiwada, D., & Silveira, S. (2017). Scenarios for bioethanol production in Indonesia: How can we meet mandatory blending targets? Energy, 119, 351–361.

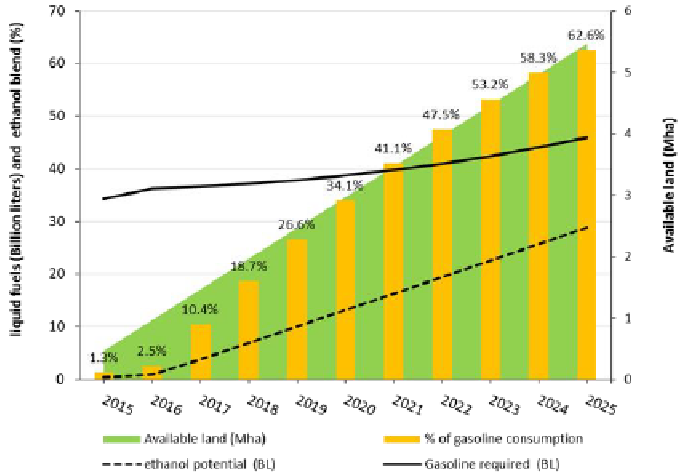
Estimating Bioethanol Potential and Required Land for Meeting the Targets

- Ethanol can substitute around 1% of gasoline in 2015.
- At present land use conditions, it would be difficult to meet the bioethanol and sugar self-sufficiency targets.
- 1.07 Mha sugarcane field is needed to meet the sugar demand by 2020, while ethanol can meet only 23% of the targeted bioethanol volume.
- In order to meet the sugar demand and bioethanol mandate by 2025, 2.76 Mha is required.
- 34% bioethanol blend by 2020 and 63% by 2025 can be achieved when available land (5 Mha) is used for sugarcane cultivation.

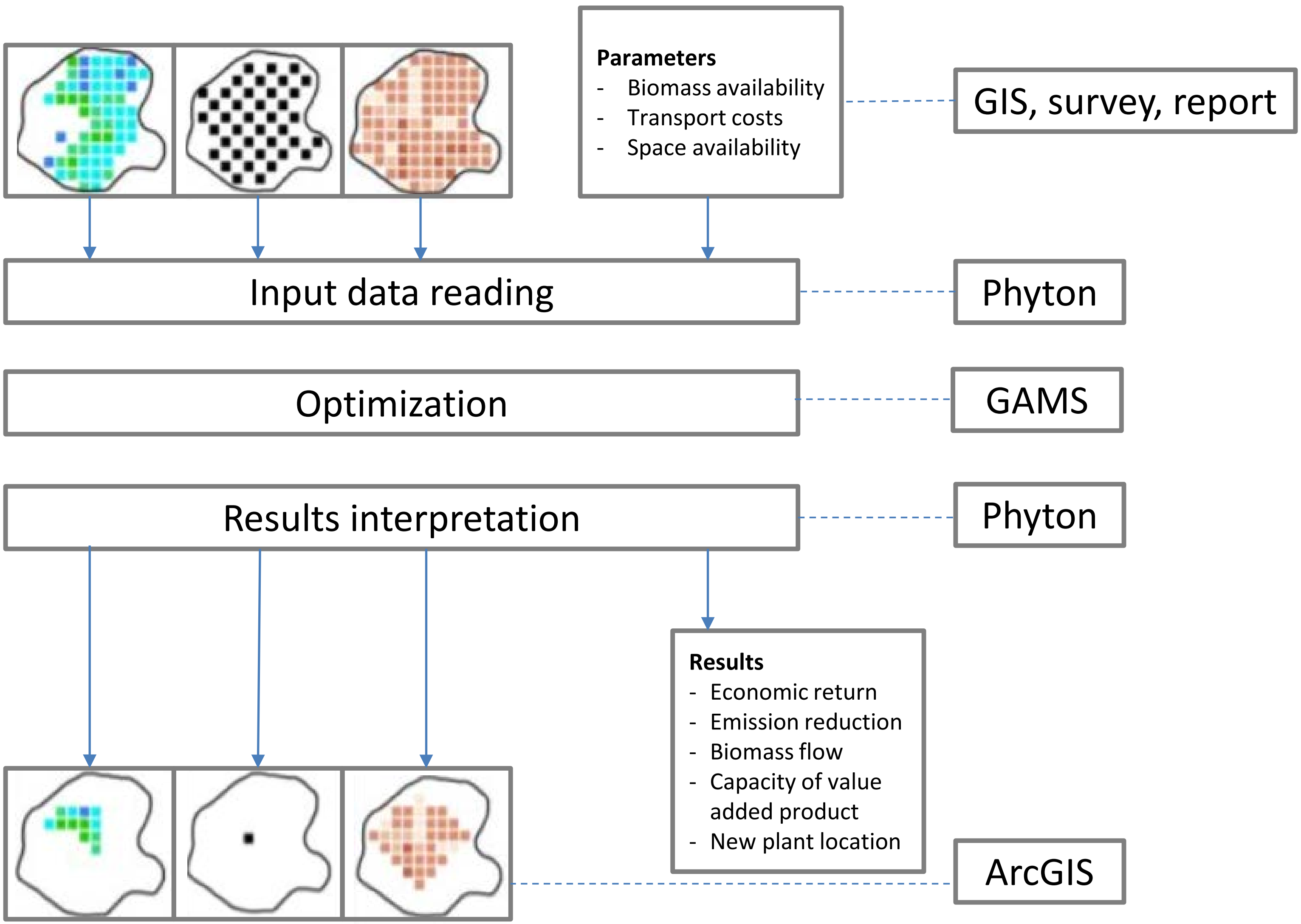


Land required for producing ethanol to meet the bioethanol blend

Particulars	2015 (2% blend)	2020 (10% blend)	2025 (20% blend)
Land required (Mha)	0.71	1.60	2.76
Molasses ethanol (BL)	0.68	1.02	1.09
Juice ethanol (BL)	-	3.42	10.39
Total ethanol (BL)	0.68	4.45	11.48



Biomass Mapping for Plant Location



Challenges for biomass-to-resources utilization

- Data & supply chain
- Investment
- Logistics Transportation network and collection
- Technology
- Social / Cultural

Policy Recommendation

Policy to ensure sustainable supply of biomass
Identifying the type, location and amount of available biomass, fixed a stable pricing of biomass

Effort to improve bio technology (increase efficiency, reducing cost)
Providing Fund for Bio-Tech improvement (R&D), provide tax exemption

Marketing biomass products
Identify suitable and marketable bio-products

Key Success Factors

- Proposed economic approach is attractive to investors
- Creation of public-private partnership
- Sustainability of materials
- Cost of logistics not prohibitive
- Availability of the best technology
- Favorable regulatory environment

Together We Mitigate Haze!

Thank you for your attention!

Thank You Terima Kasih 谢谢 धन्यवाद ありがとう

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