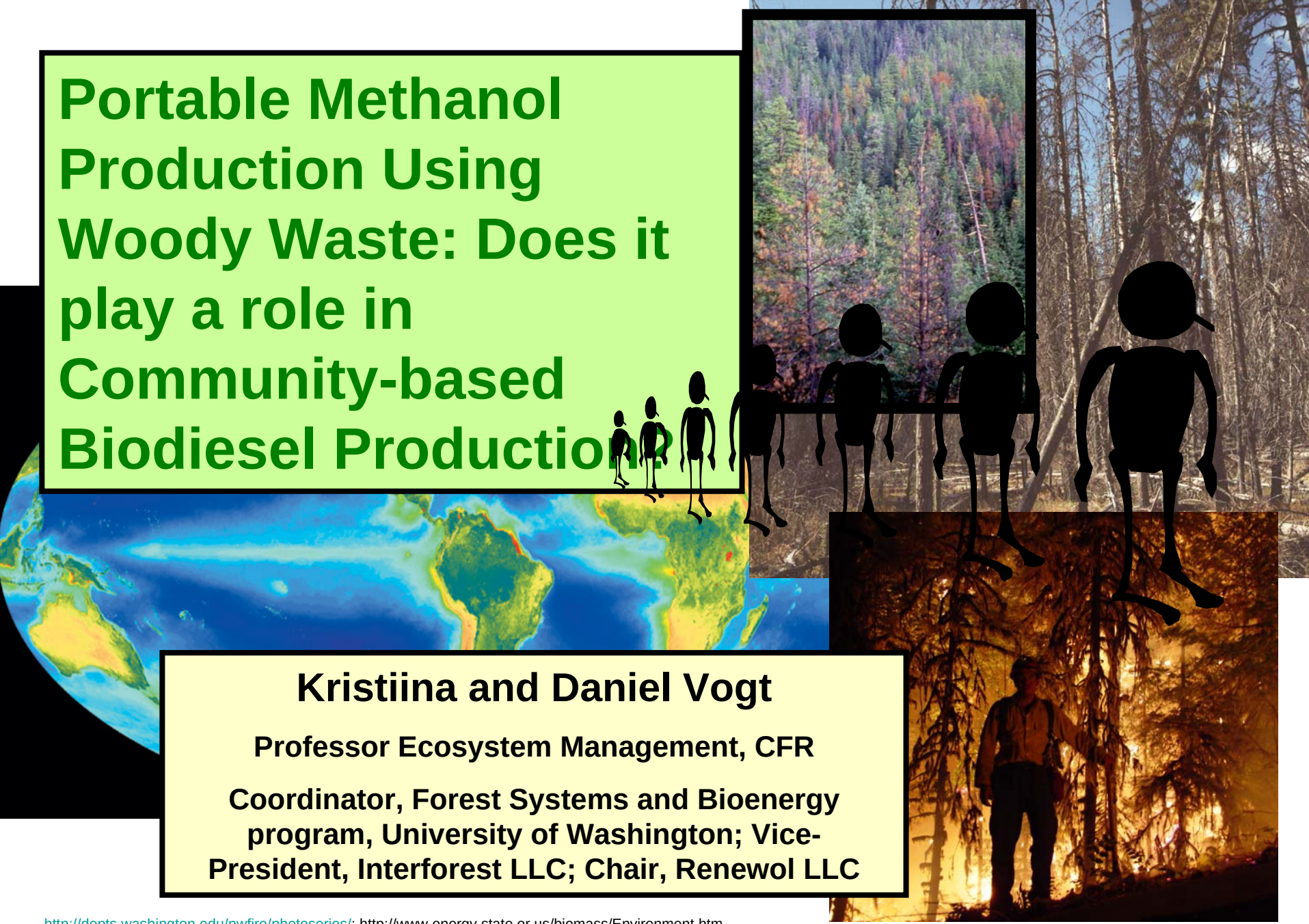
Portable Methanol Production Using Woody Waste: Does it play a role in Community-based Biodiesel Production?



Kristiina and Daniel Vogt

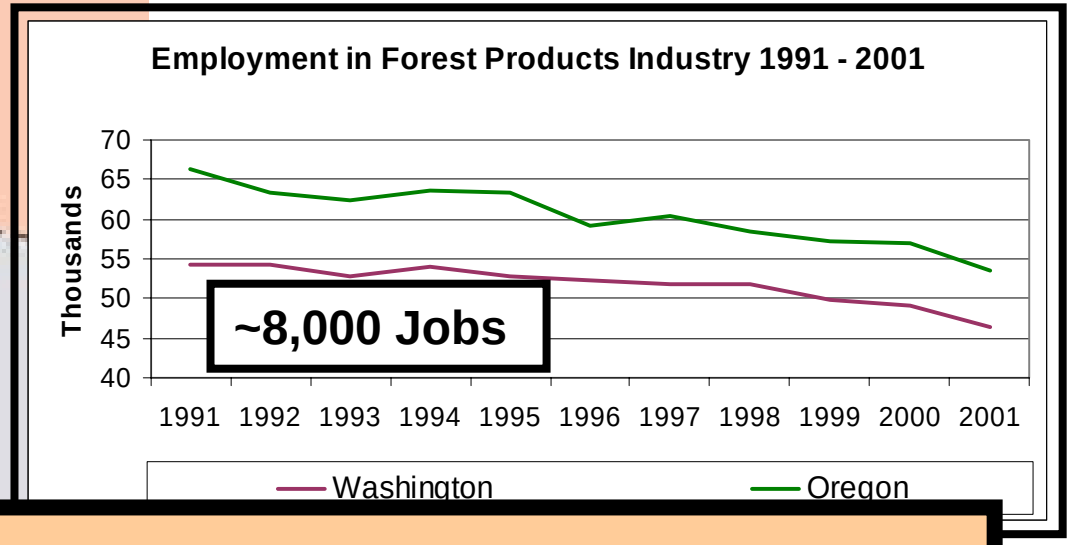
Professor Ecosystem Management, CFR

Coordinator, Forest Systems and Bioenergy program, University of Washington; Vice-President, Interforest LLC; Chair, Renewol LLC

http://depts.washington.edu/nwfire/photoseries/; http://www.energy.state.or.us/biomass/Environment.htm

USFS 2003 A strategic assessment of forest biomass and fuel reduction treatments in western states

WESTERN BARK BEETLE REPORT April 22, 2002



Less fiber comes from western forests in globally driven markets

SOLUTION?
Re-build traditional infrastructure that has been lost is cost prohibitive
(e.g. pulp mill, OSB plant, co-gen facility)

From 1988 - 2000, number operating mills in Columbia Basin dropped by ~50%

From 1989 – 2001, number Pulp Mills in PNW dropped by ~35%

PUBLIC LANDS

As Logging Fades, Rich Carve Up Open Land in West

Monica Almeida/The New York Times

William P. Foley II, in Whitefish, Mont., is part of a new wave of investors in the West.

By KIRK JOHNSON
Published: October 13, 2007;
New York Times

With the timber industry in steep decline, recreation is pushing aside logging …. people who enjoy outdoor activities and … have the means to take title to what they want.

Some old-line logging companies, including Plum Creek Timber, the country's largest private landowner, are cashing in, putting tens of thousands of wooded acres on the market from Montana to Oregon. Plum Creek, which owns about 1.2 million acres here in Montana alone, **is getting up to $29,000 an acre for land that was worth perhaps $500 an acre for timber cutting**.

Plum Creek Quantifies Fire Impact, Updates Land Sales Timing and 2007 Outlook

SEATTLE--(BUSINESS WIRE)--Oct. 4, 2007--Plum Creek Timber Company, Inc. (NYSE:PCL) today reported the company will **record a $4 million non-cash fire loss during the third quarter**. An active fire season in western Montana **damaged approximately 41,000 acres**, or one-half percent, of the company's timberlands. The extreme fire risk in western Montana this season led the company to halt timber operations in the region during August. As a result, sawlog harvest levels were nearly 150,000 tons lower than expected in the company's Northern Resource segment. Salvage operations have begun and the company expects a portion of the standing timber on the land will be salvaged in the coming months.

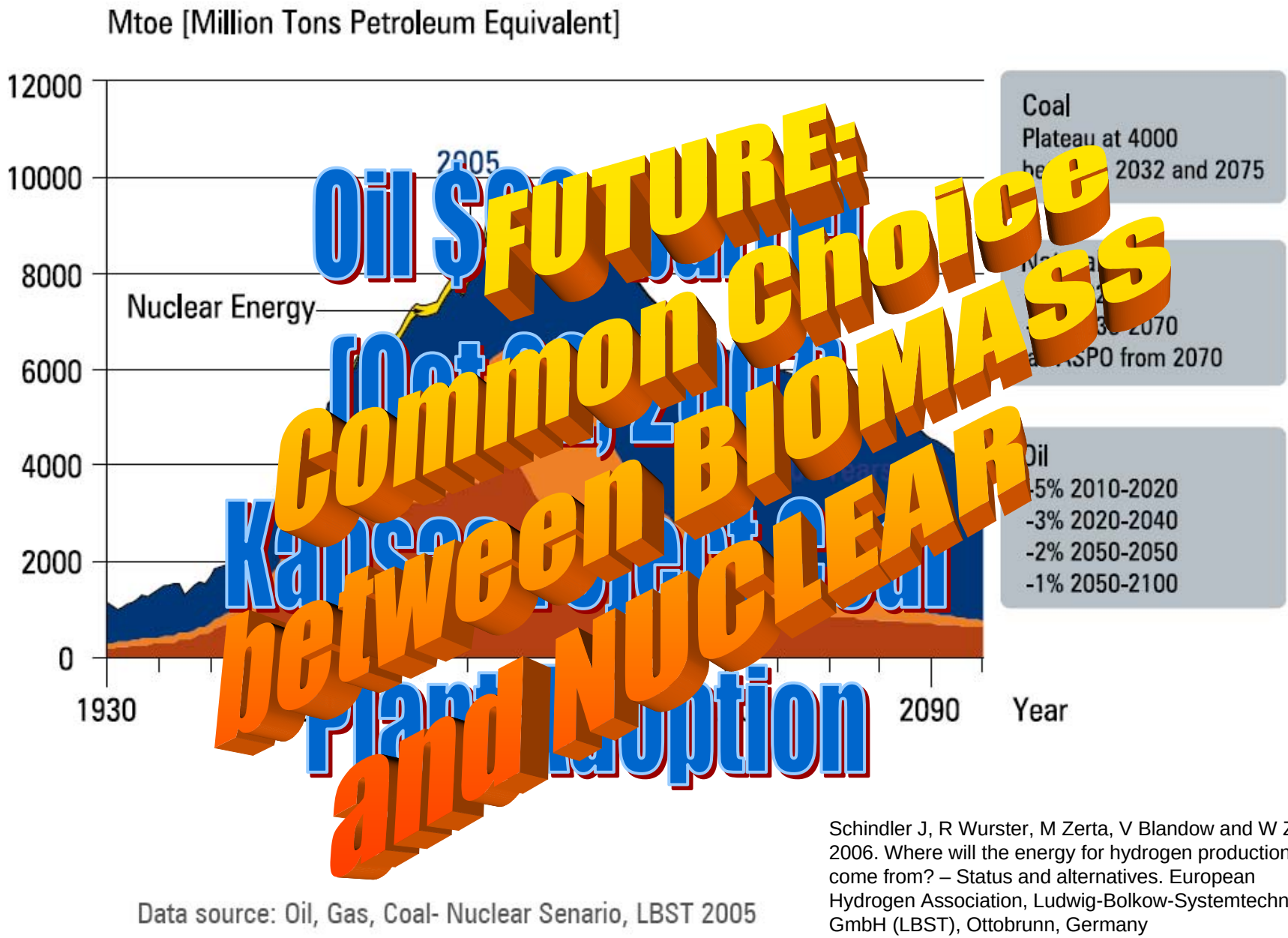
Western US, **30%** forests are:

- **overstocked**
- **have insect and fire risk problems**

Forest fires significant source of CO_2 emissions and air pollution

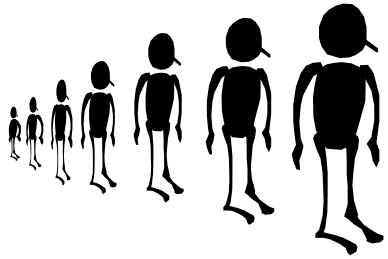
1992-2001, forest wildfires emitted 65 million metric tons CO_2 in Oregon = C in ~740,700,00 barrels crude oil

Abundance of underutilized WOOD with environmental problems & no economic return



FUTURE: Common Choice between BIOMASS and NUCLEAR

Schindler J, R Wurster, M Zerta, V Blandow and W Zittel. 2006. Where will the energy for hydrogen production come from? – Status and alternatives. European Hydrogen Association, Ludwig-Bolkow-Systemtechnik GmbH (LBST), Ottobrunn, Germany



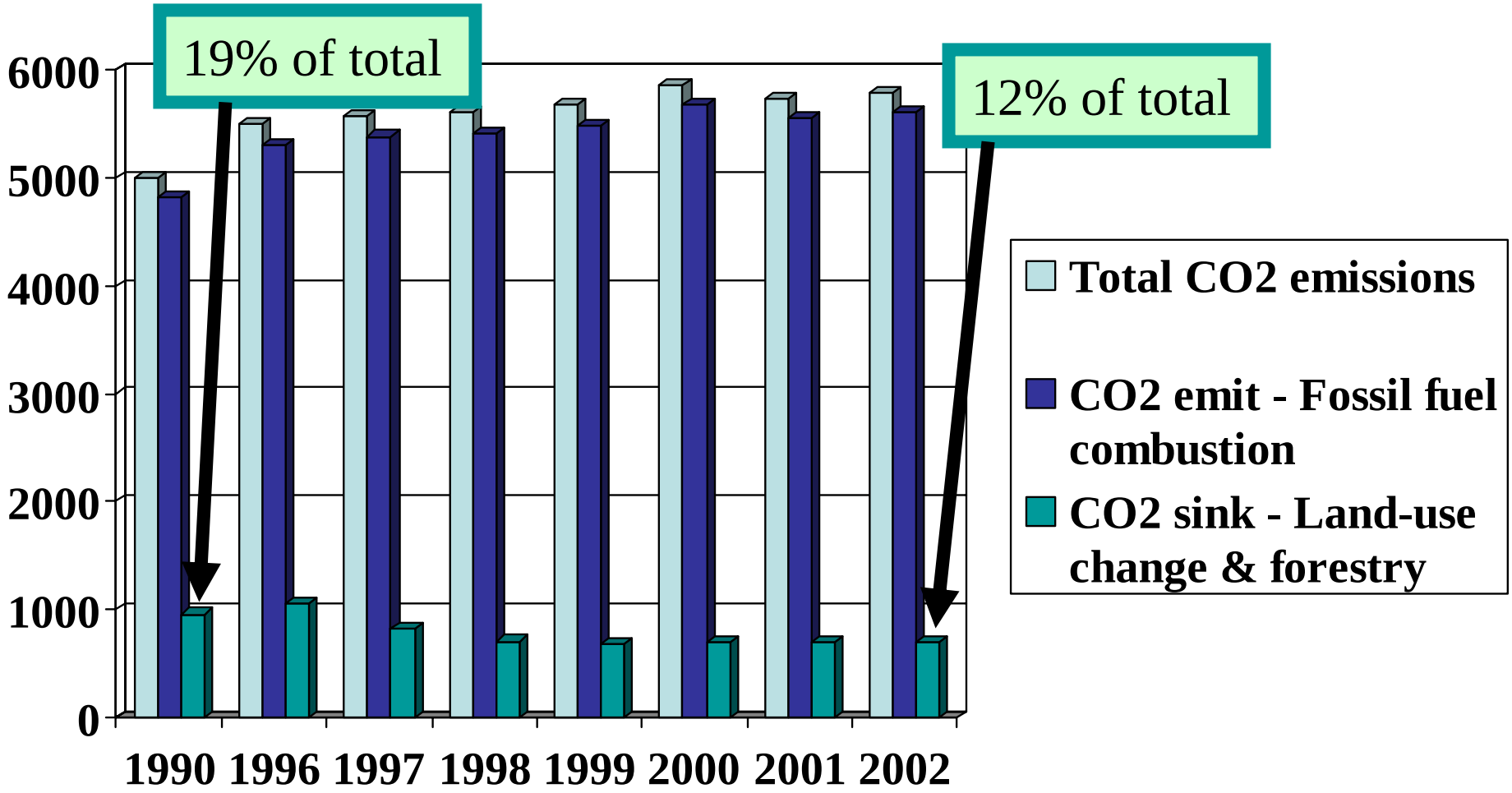
Driver for BIOFUELS

Transportation sector **emits 22%** of the global CO_2 emissions and **consumes 25%** of the w[illegible] (A[illegible] 19[illegible] Azar et al. 2003).

Reason why solutions are being pursued in the transportation sector today even in US

US CO_2 emissions & C Trading Markets

Forests sequestering less C from 1990 to 2002 in US



Source: U.S. Greenhouse Gas Emissions and Sinks: 1990-2002. EPA 430-R-04-003 (April 15, 2004)

Critics See Too Little Significant Change By Steven Mufson, Washington Post Staff Writer, Wednesday, January 24, 2007; A14

***New renewable-fuel target*: Bush said he will ask Congress to require oil companies to use 35 billion gallons of renewable and alternative fuels by 2017. The a**

p

If all corn stover in US used to make ethanol = <u>provide 7 – 12% transport fuel</u>

Corn Stover as a transportation fuel (Glassner et al. 1999, www.hort.purdue.edu/ newcrop/proceedings1999/v4-074.html)

Photo Credit: By Aaron Eisenhauer -- Associated Press

Photo: Lynn L. Walters for The New York Times

Issues with ETHANOL still Developing

President "signed accord with businesses to curb soaring tortilla prices and protect Mexico's poor from speculative sellers and **a surge in the cost of corn driven by the U.S. ethanol**

Technical NICHE MARKET???

"We have an under-expanded distribution system," said Mr. Rastetter. Ethanol cannot be distributed via the current gasoline pipeline network because it would corrode the pipes.

Photo: Lynn L. Walters for The New York Times

BIODIESEL:

10% of bio-diesel is methanol

Figure 10 - UofI Volkswagen, which runs on 100% biodiesel from mustard seed oil, sits on a Rapeseed field on the Palouse.

http://www.idwr.idaho.gov/energy/alternative_fuels/FeasibilityStudy.pdf

SOLUTION:

- Use technology to make economic by-products and energy from biomass wastes and forest thinnings that currently have no economic return

- Bioenergy creates lots of jobs that are higher paying than service jobs

Biomass availabilities; pink highest

	Sustainable collection every year			One time collection
	Total Biomass - Municipal Wastes (Mg/yr X 1,000)	**Total Aboveground Biomass – Agriculture** (only collect 25% of total) (Mg/yr X 1,000)	**Total Aboveground Biomass - Forests** (Mg/yr X 1,000)	**Aboveground Biomass with High Fire Risk in Timberlands** (2-8 inch diameter) (Mg X 1,000)
CA	38,000	4,200	26,830	113,490
ID	**427**	**1,788**	**5,873**	**72,940**
MT	500	1,560	2,641	70,220
OR	1,653	1,500	12,700	82,550
WA	**3,472**	**2,412**	**8,104**	**57,150**

Data show why forest biomass (forest thinnings, mill residues, land clearing debris) should be used

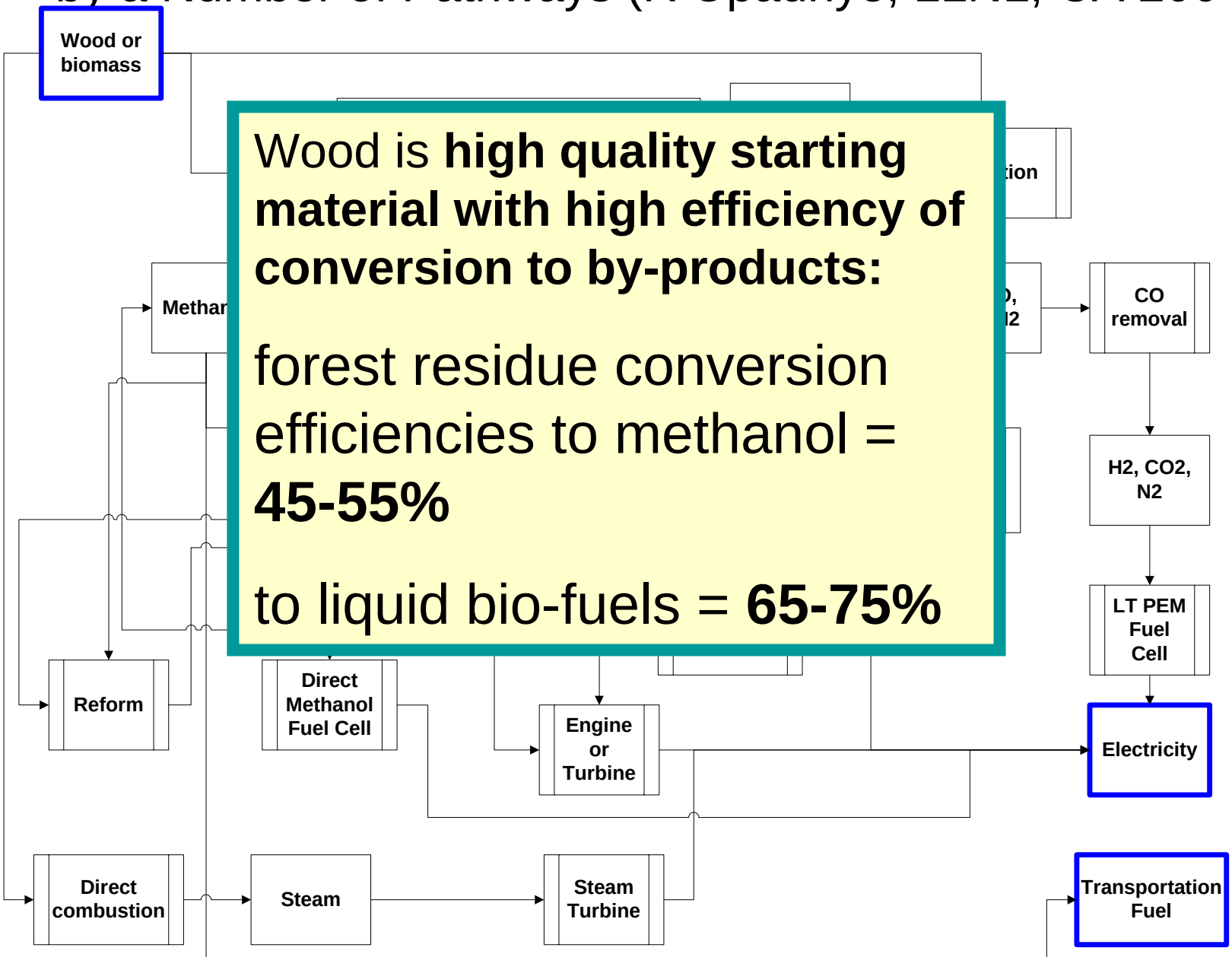
BIOMASS ENERGY SYSTEMS:

Convers. approach	Integrated Gasification / Reformer	Fermentation (ET synthesis)	Fermentation (Methane synthesis)	Direct Combustion
Material used	[illegible]	[illegible]	[illegible]	Total Biomass
Products produced	Methanol, Di-methyl ether	Ethanol	Methane	Electricity with Steam turbines
Conversion efficiency	ME 40 – 50% (ME-fuel cell 33%)	20%	low	<25%
Facility size	Small or large	Large not best, react rate slow	Small	Small or large
Comments	**Higher conversion efficiency, scale limit produced minutes**	**Competes food [illegible] Re[illegible]**	**Gas: storage transport problem; must [illegible]ct produce electricity**	**Must directly produce electricity, lower efficiency**
Develop. status	developing	Commercialized	Small scale commercial	Commercialized

Many ways to convert biomass

-All needed

Electricity and Liquid Fuels can be Obtained from Biomass by a Number of Pathways (R Upadhye, LLNL, CA 2004)



Wood is **high quality starting material with high efficiency of conversion to by-products:**

forest residue conversion efficiencies to methanol = **45-55%**

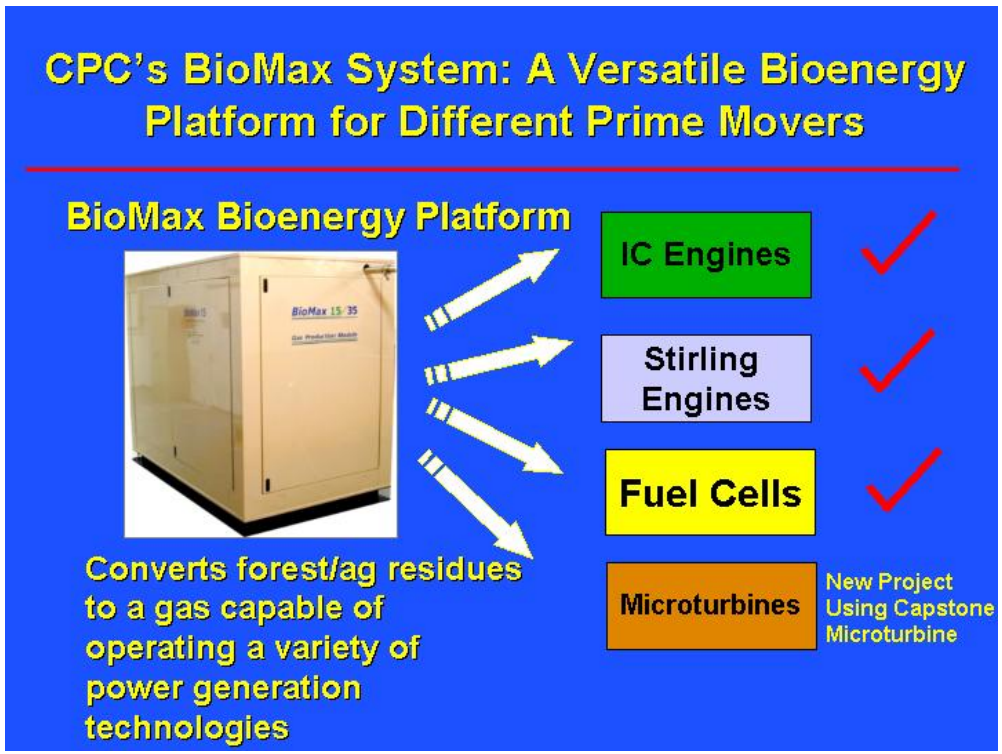
to liquid bio-fuels = **65-75%**

Gasification systems

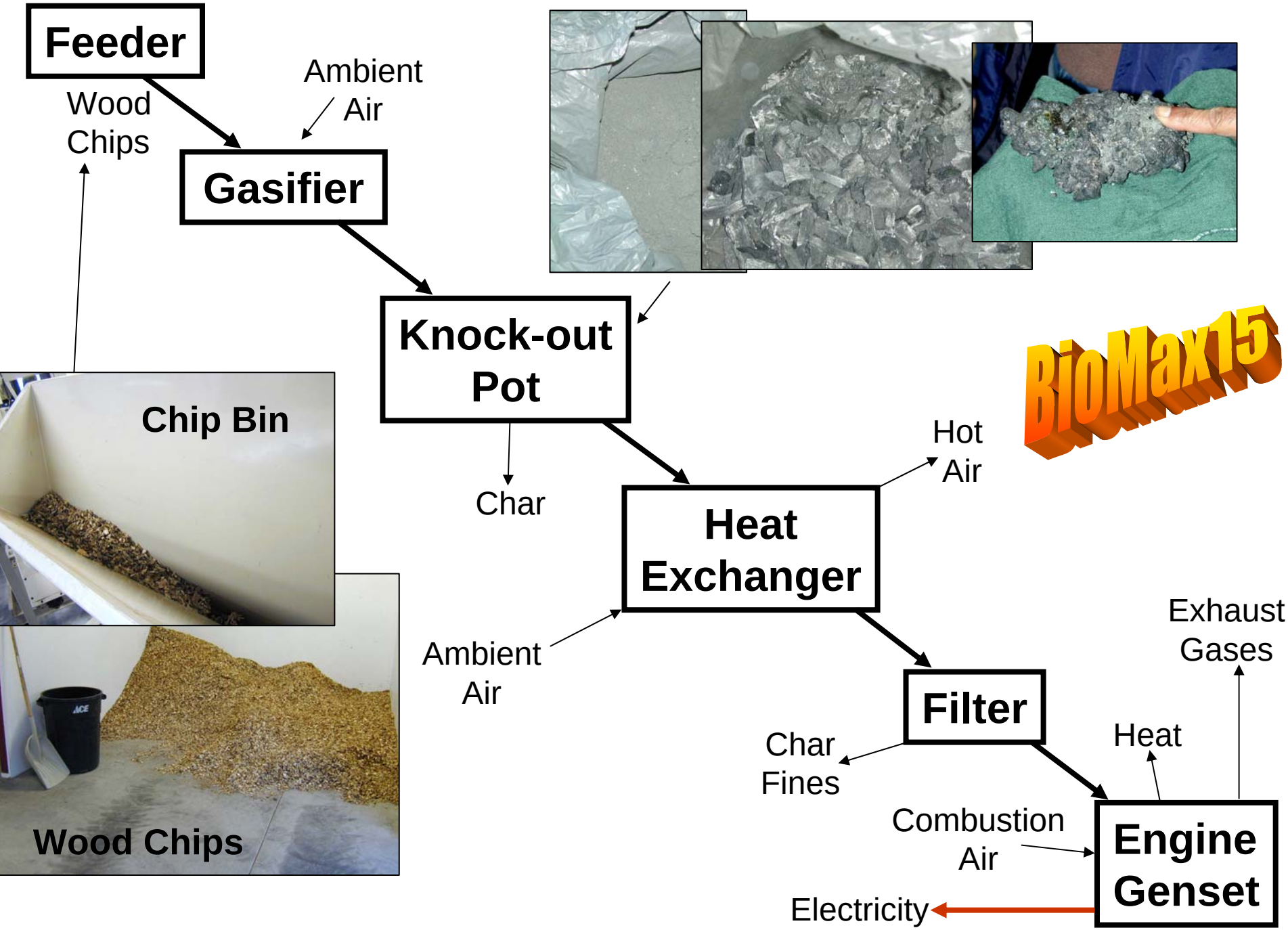
– converts biomass to flammable gas (syn gas, biogas)

POSITIVE: syn gas can be cleaned of chemicals with negative environmental impacts; gas more efficient (~ 60%) power generation using combined gas & steam turbines to produce electricity (www.eere.energy.gov 6/25/05); large or small scale modular; qualifies for renewable energy credits

NEGATIVE: stationary; would have to store electricity since is on-demand system



http://www.gocpc.com/


Feeder
Wood Chips
Ambient Air
Gasifier
Knock-out Pot
Char
Chip Bin
Wood Chips
Heat Exchanger
Hot Air
Ambient Air
Filter
Char Fines
Heat
Exhaust Gases
Combustion Air
Engine Genset
Electricity
BioMax15

Bio-oil Plant, Canada (Bradley D. 2004. IEA Bioenergy Task 38)

System:

- Harvest waste at roadside costs $29.96US/odt; 70% burnt
- 400 T/day plant at sawmill
- 2 sawmills produce 44,684 dry T bark, > 35,000 to landfill at $11.25/odt = $393,750/yr
- Products 1) char for North America markets; 2) bio oils European markets
- Bio oils produced gasification
- Tradable C value expected at US$5 – 10/T [not included below]

Bio oil Plant Cost Structure (for 35,154 bdt bark) = **$10,072** ($3.49/bdt)

Cost savings: landfill transport, tipping fee, fuel oil transport, fuel oil = **$4,614**

Revenues bio oil sales, charcoal = **$9,972**

INCOME: $4,514

New Energy Technologies becoming commercialized

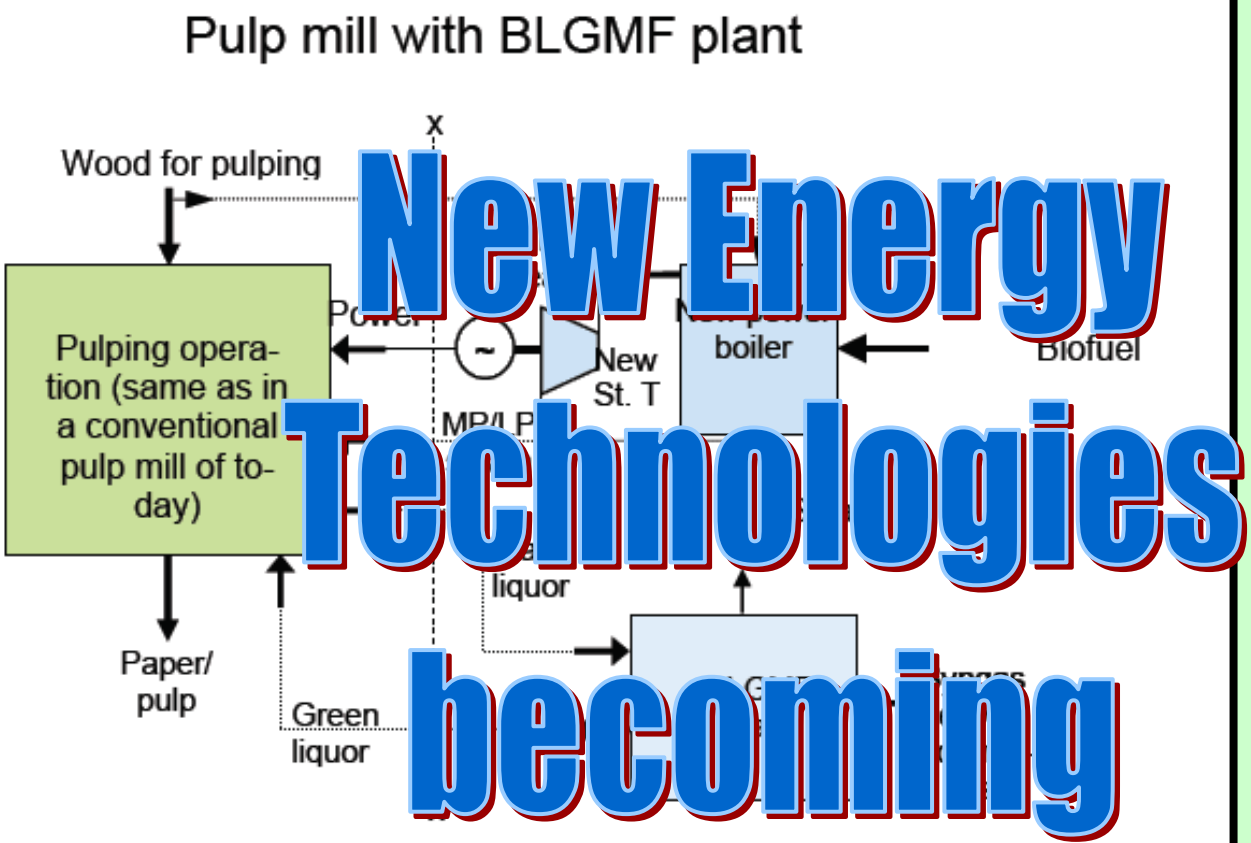


Figure 3.3. A simplified block flow diagram of the entire plant complex of a pulp m combined with a BLGMF process, where the re ery bo nd the ba

Sweden example:

USES: 2000 tons/day of dry pulp waste

Biomass to methanol conversion efficiency = 66%

Consumer price for petrol and methanol are the same

Internal Rate of Return = 26-37% with a payback in 3.7-4 years

http://www.nykomb.se/pdf/BLGMF.pdf

Hydrogen Fuel Cells

- Clean energy - emitting < 1 ppm of CO & < 5 ppm of CO_2 when run on MeOH
- Quiet & low heat signatures, 1 – 5 kW can be run indoors
- Systems small - ranging in size of 100 W to 100kW
- Estimate <3 dry tons wood needed to power an average Seattle household for a month

Mobion technology – fuel cells to power PDA/ smartphone

MethanolInstitute2004-5milestones

Boeing prepares Fuel Cell Demonstrator Airplane flight testing

Boeing News Now, March 27, 2007 6:30 am CT

Toshiba

IdaTech.com

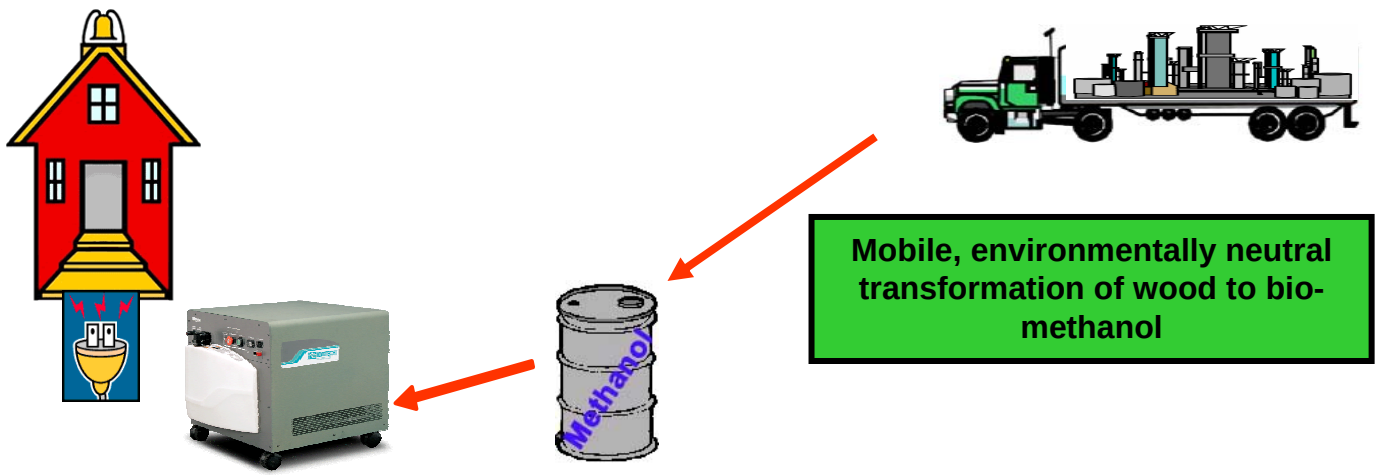
Casio

Methanol - fuel cells

– converts biomass to syn gas reformed to methanol

POSITIVE: ideal small scale, distributed energy systems; technology to store and transport methanol been around > 350 years; methanol not legacy environmental problems if spilled; commercially available fuel cells [IdaTech] run on liquids; coupled to fuel cells means little GHG emissions and mainly water vapor released; qualifies for renewable energy credits

NEGATIVE: humans can't drink methanol will go blind



Technological breakthroughs facilitating development of new biomass energy systems

OLD

WW II - gasifiers in cars

G.B. Kobelt and fitted gas producer approx 1942-43;
http://www.fortunecity.com/greenfield/bp/16/woodfire3.htm

NEW

- New C neutral chemical transformation processes efficiently convert biomass to methanol
- Developments in hydrogen fuel cells

Wood Conversion to Energy

What is new about that?

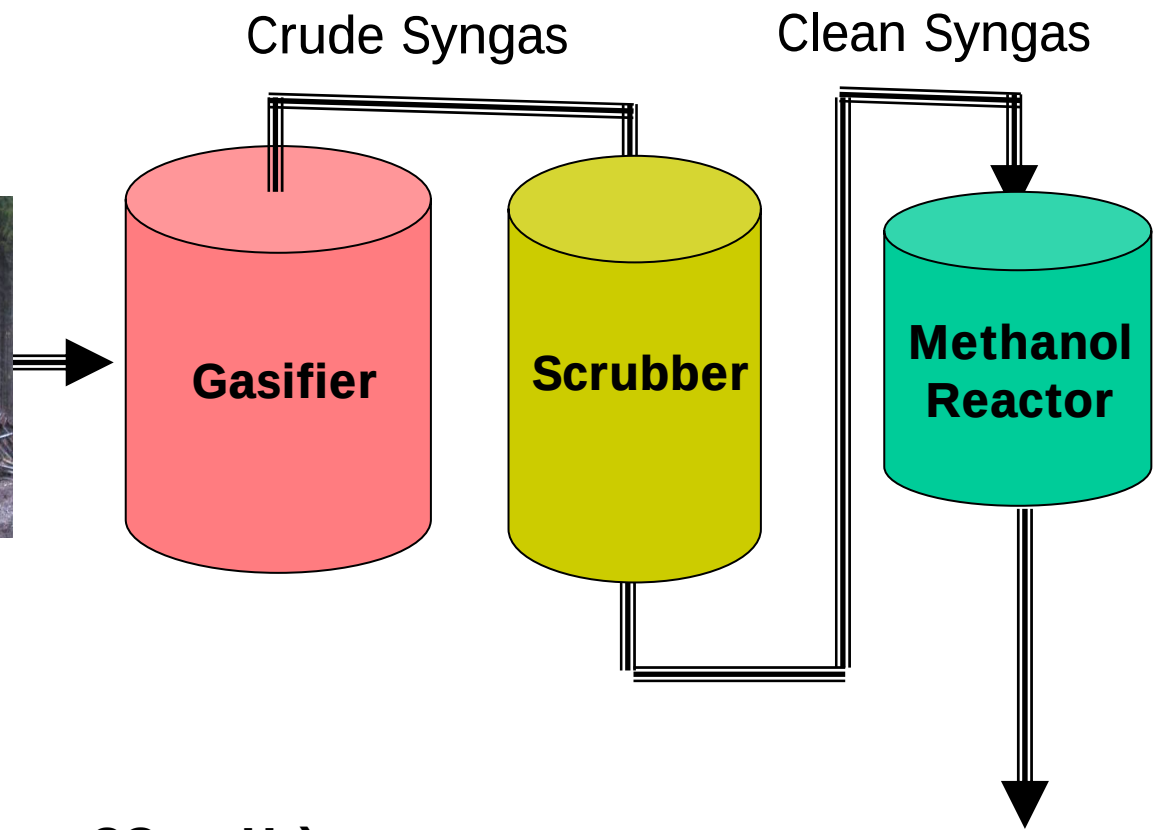
Methods of conversion have advanced from simple combusting wood to produce energy (direct heat or steam). **Wood used to make methanol – wood alcohol – for over 350 years**

Pyrolysis or Gasification methods to convert wood to methanol or bio-oils – **environmentally neutral**.

50% efficiency of conversion to wood to methanol

Biomass to Liquid Fuel

Wood Biomass



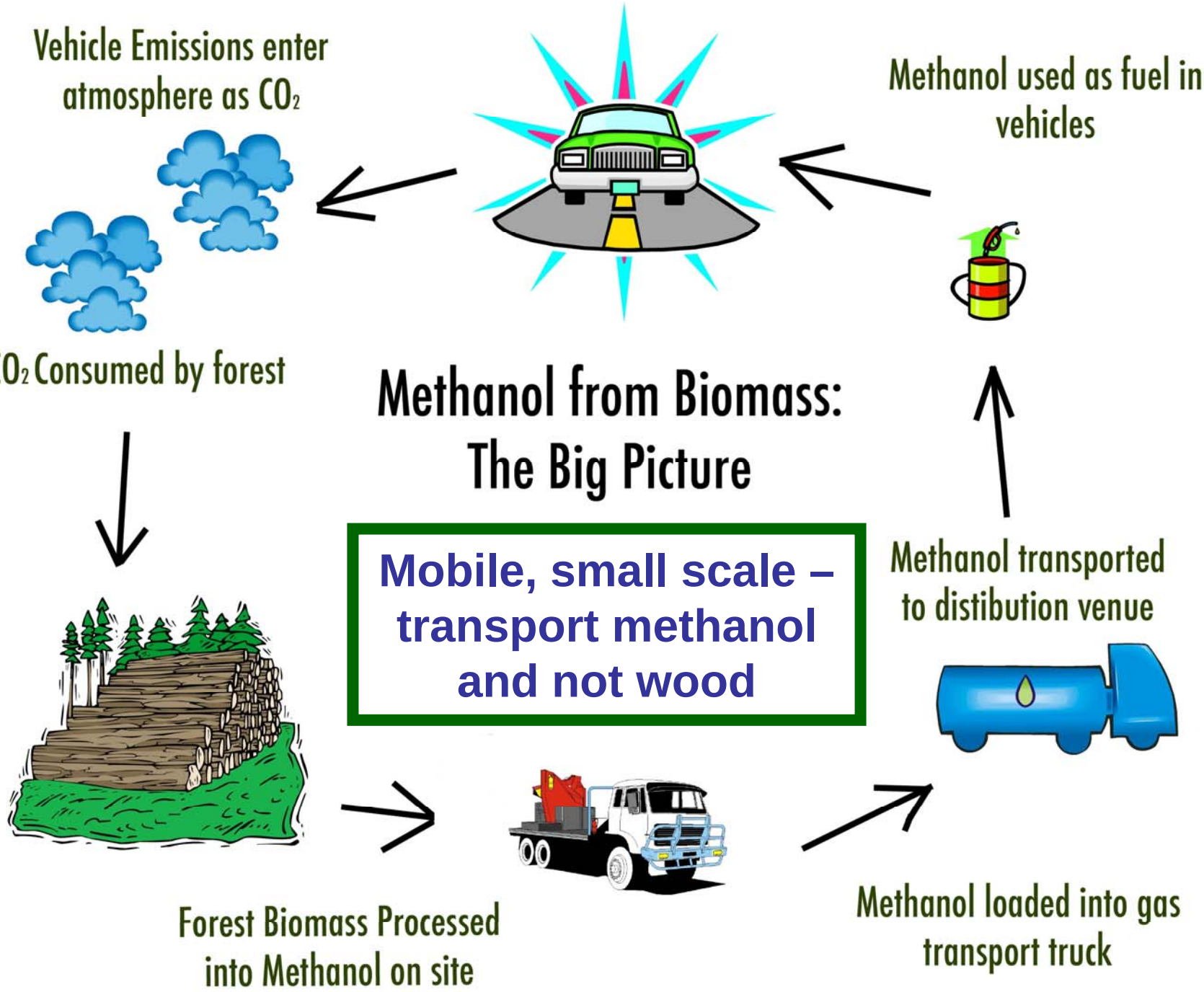
(Syngas = CO_2 + CO + H_2)

Bio-Methanol

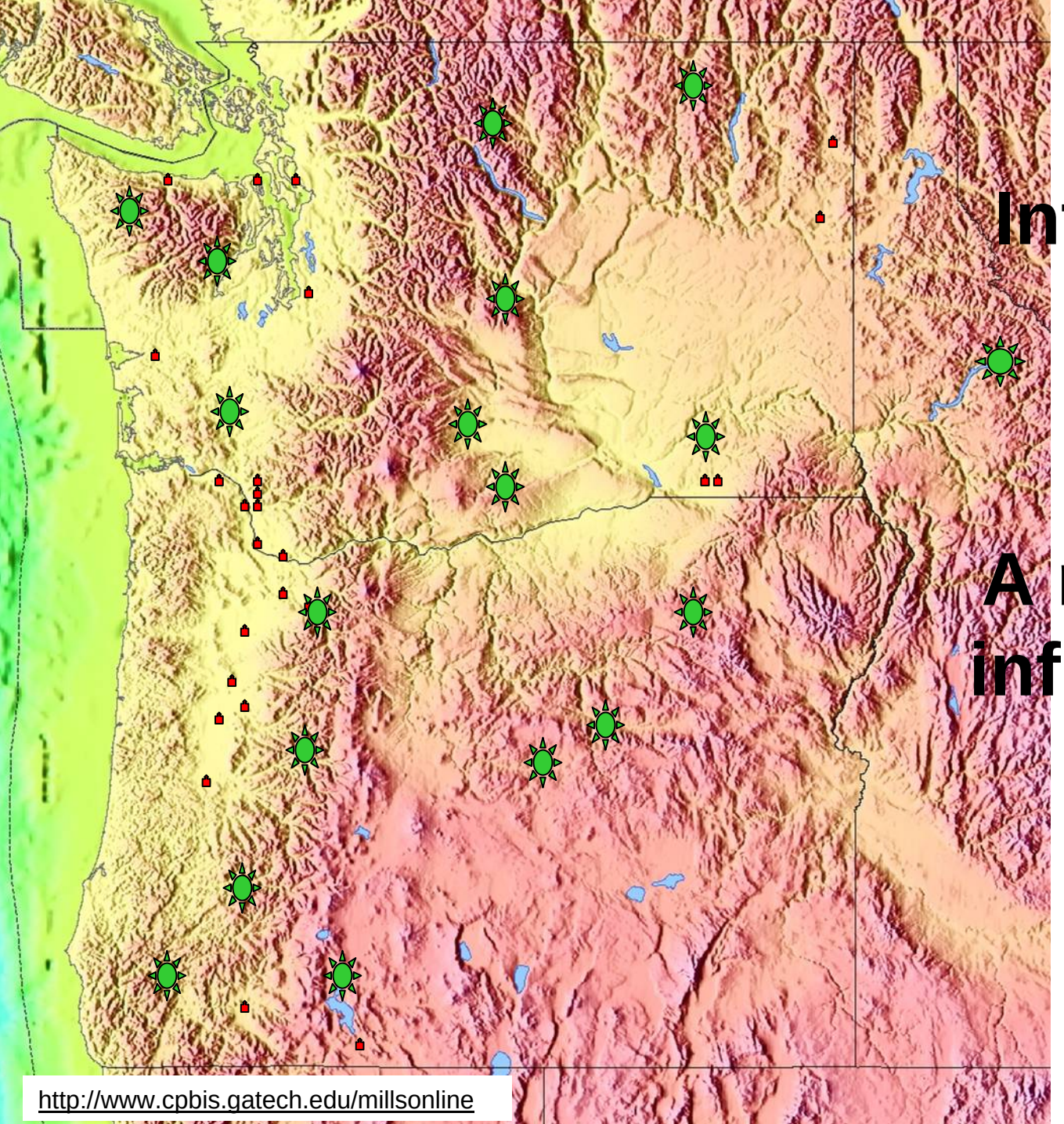
(Wood Alcohol)

Not that kind
of Alcohol

Methanol from Biomass: The Big Picture



Mobile, small scale – transport methanol and not wood



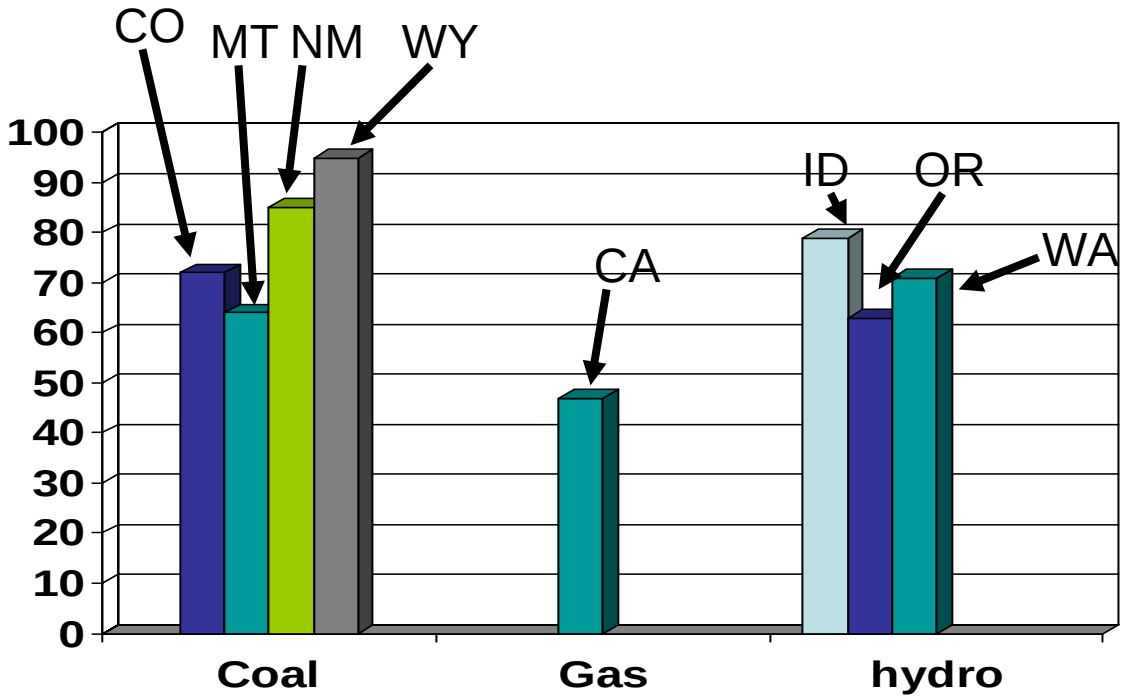
Existing Infrastructure

=

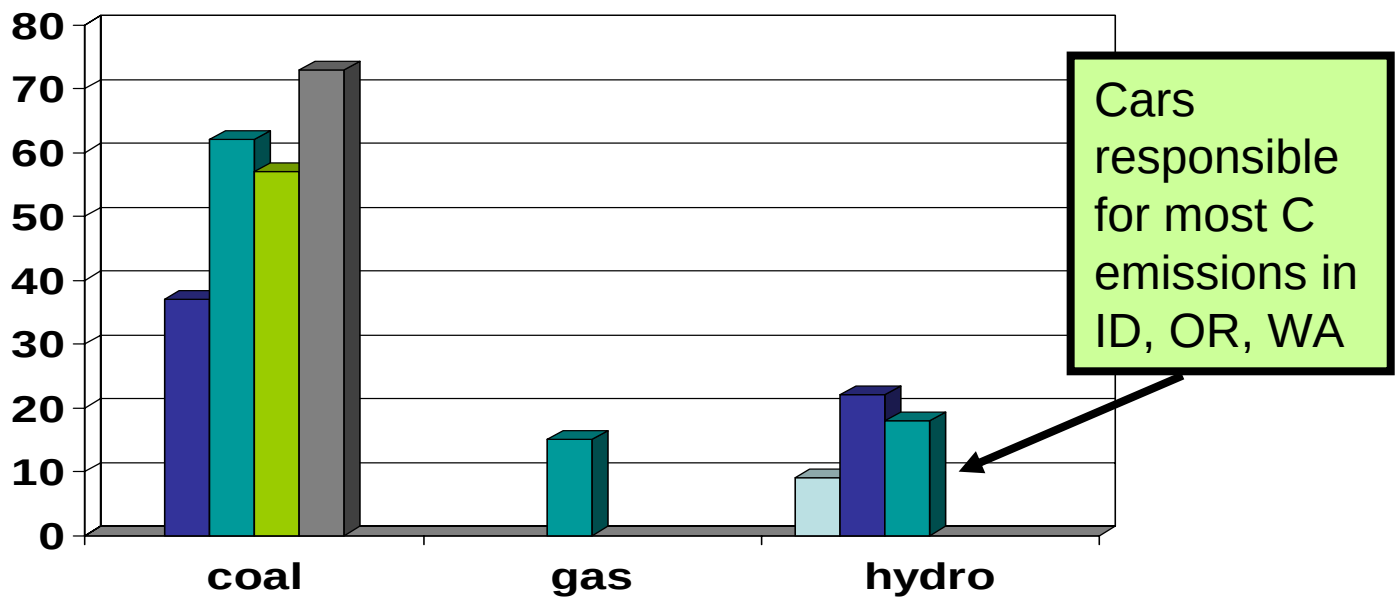
A new kind of infrastructure!

http://www.cpbis.gatech.edu/millsonline

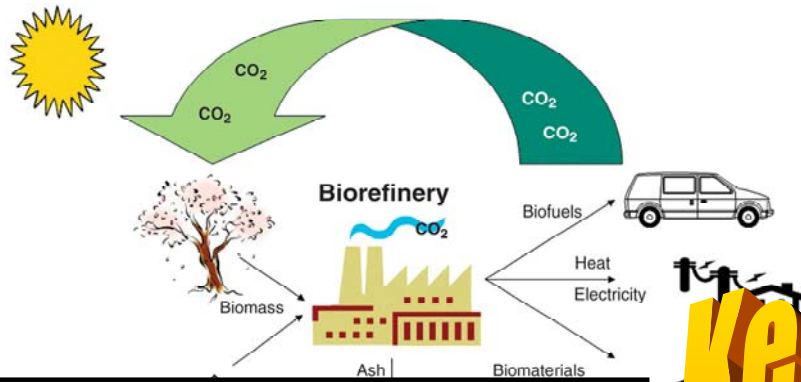
% Electricity Generated using Primary Energy Source/Total Electricity Consumed at the State Level



% C Emitted Generating Electricity/Total State Emissions C



Key to Technology Acceptance is C Emissions Avoided

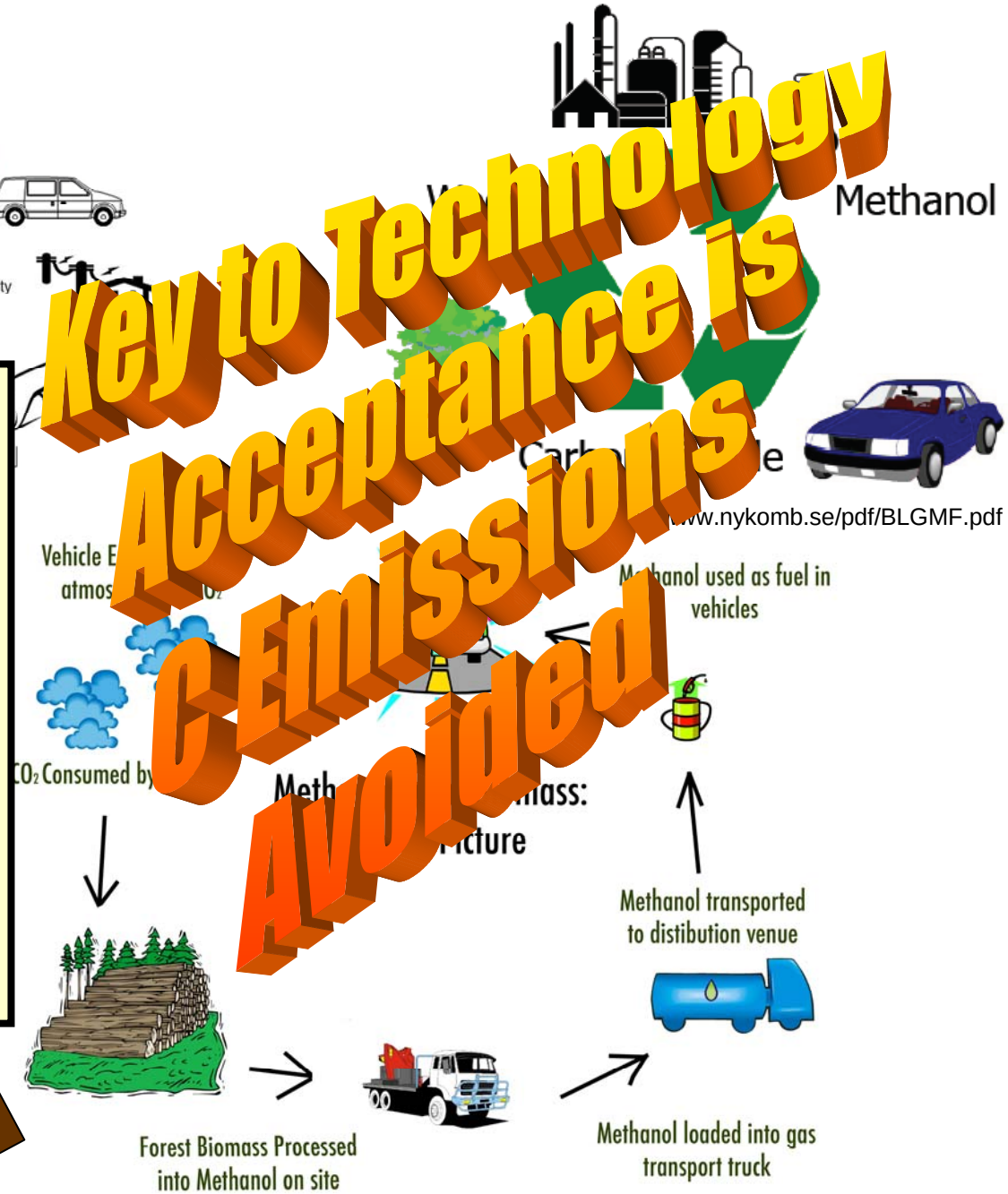


One dry Ton biomass gives:

166 gallons of methanol

666 kWh of electricity

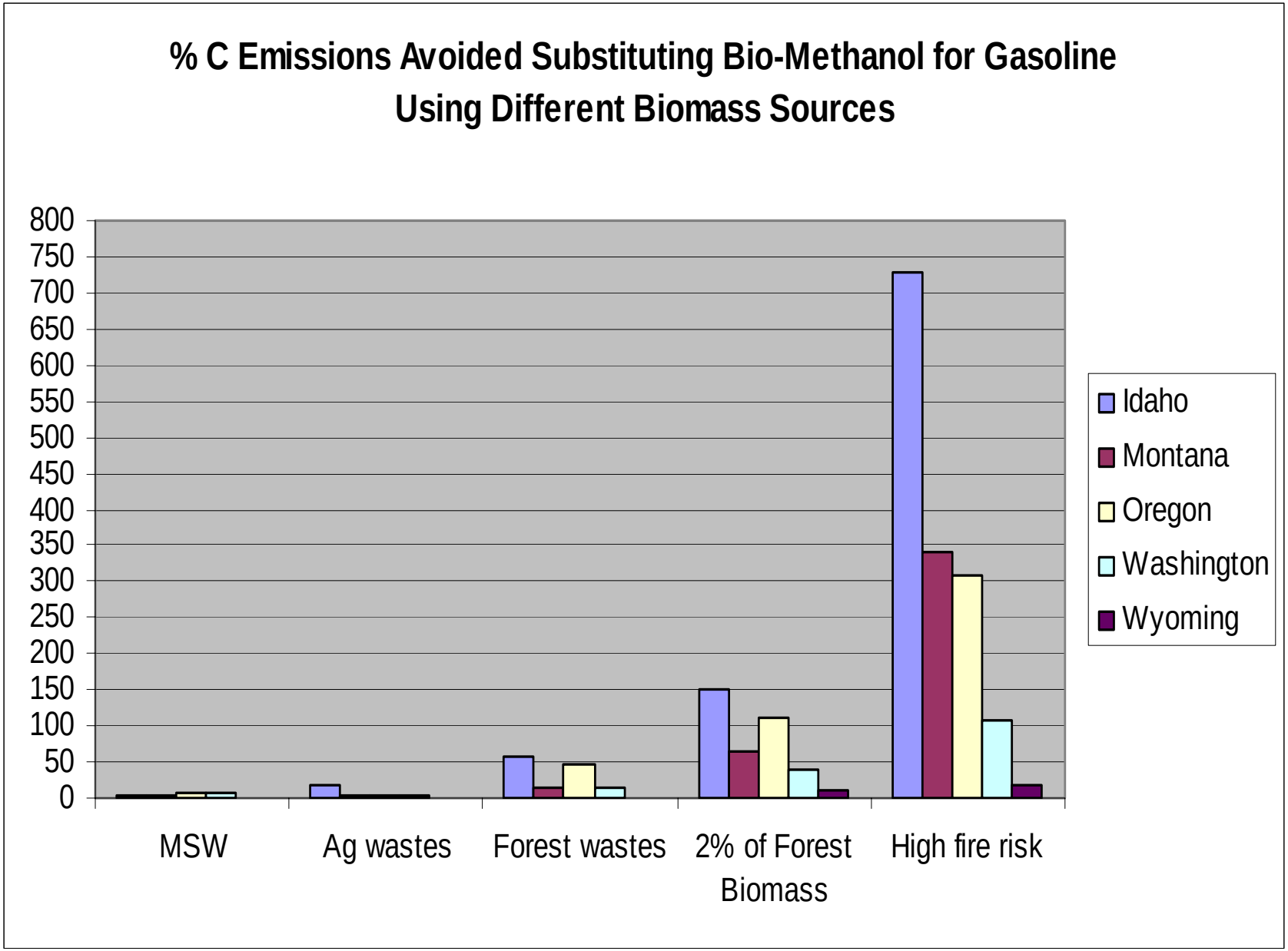
Avoid emissions of 420 kg C or 924 pounds of C



% Total State Gasoline substituted by Bio-methanol – annual except high fire risk woody materials

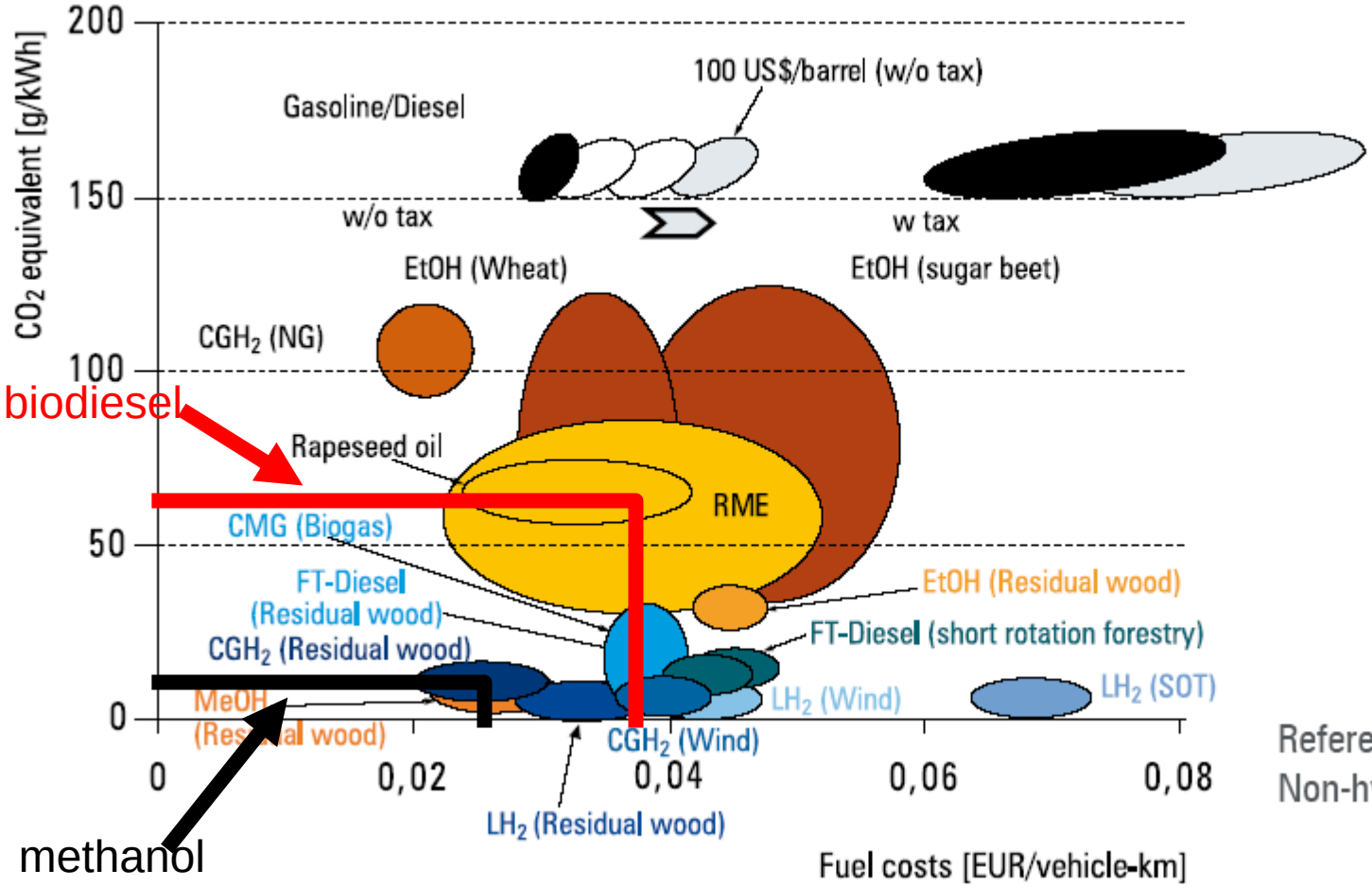
	MSW	Ag Waste (use 25%)	Forest Waste	2% of all forest lands	Forests with High Fire Risk 2-7 inch
Montana	**13**	**23**	**68**	**343**	**1808**
Idaho	**11**	**42**	**145**	**345**	**1796**
Montana	**13**	**23**	**68**	**343**	**1808**
New Mexico	**3**	**1**	**4**	**49**	**513**
Oregon	**18**	**10**	**136**	**317**	**886**
Washington	**20**	**12**	**48**	**124**	**337**
Wyoming	**3**	**1**	**16**	**180**	**340**

Primary Power: **coal = blue/white**; **hydroelectric = tan/green**; **gas = red**


% C Emissions Avoided Substituting Bio-Methanol for Gasoline Using Different Biomass Sources
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
MSW
Ag wastes
Forest wastes
2% of Forest Biomass
High fire risk
Idaho
Montana
Oregon
Washington
Wyoming

	Fuel costs [US$/vehicle mile]	CO2 equivalent [g/kWh]
EtOH (wheat)	0.03	110
EtOH (sugar beet)	0.06	80
EtOH (residual wood)	0.06	35
MEOH (residual wood)	0.03	5
Solarthermal Power Production	0.09	8
Biogas	0.05	20
Gasoline/Diesel	0.05	160

Ref: Where will the energy for hydrogen production come from - Status and Alternatives. 2006. European Hydrogen Association, Germany
Schindler J, Wurster R, Zerta M, Blandow V and W Zittel, Ludwig-Bolkow-Systemtechnik GmbH



RME = Raps-methyl-ester (biodiesel)

LH2 = liquid H

CGH2 = compressed H

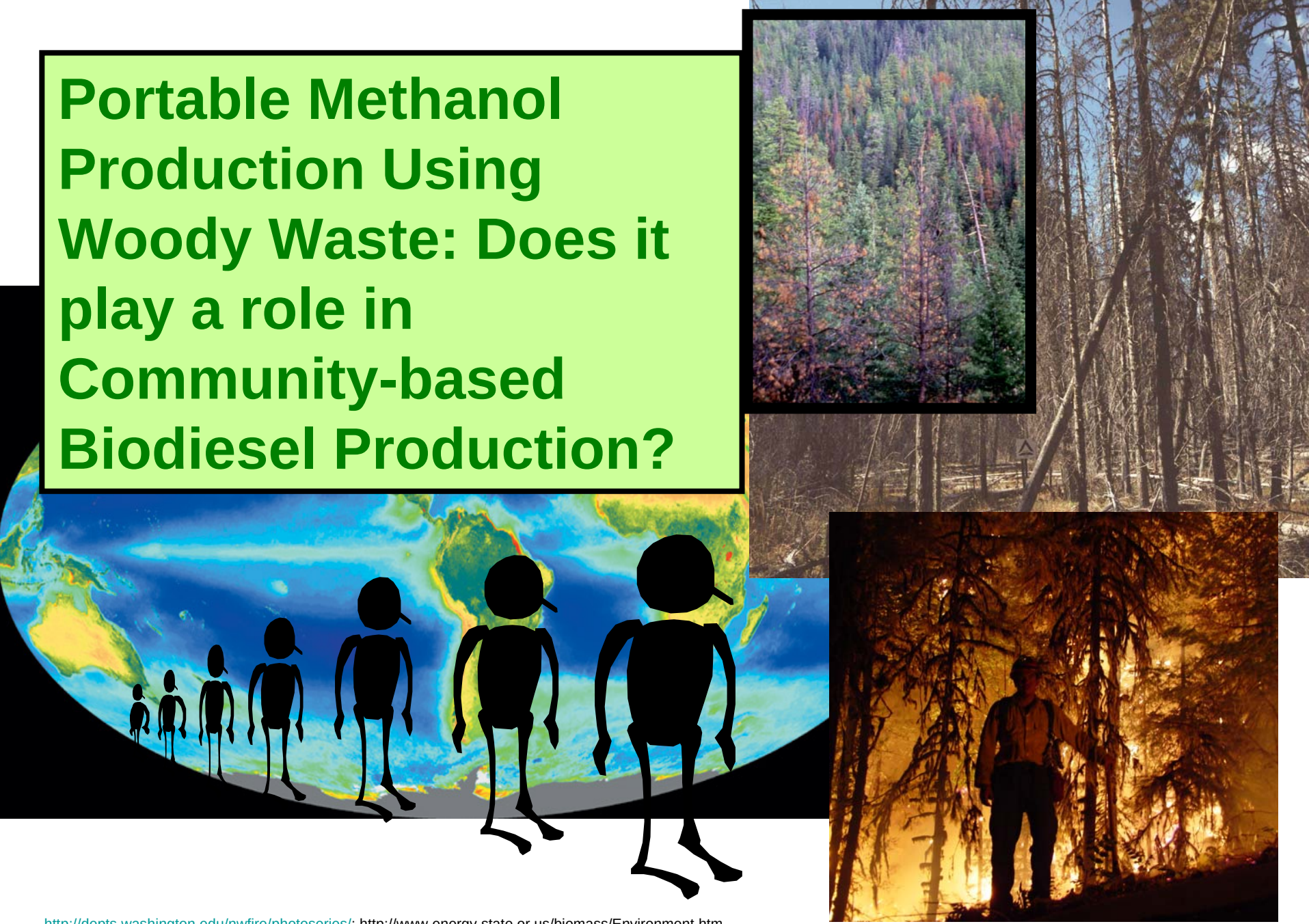
SOT = solarthermal power production

Reference vehicle: VW Golf Non-hybrid

Compares costs of various fuels "Well to Wheel" for vehicle km traveled and the greenhouse gas emissions of the fuels

Schindler J, R Wurster, M Zerta, V Blandow and W Zittel. 2006. Where will the energy for hydrogen production come from? – Status and alternatives. European Hydrogen Association, Ludwig-Bolkow-Systemtechnik GmbH (LBST), Ottobrunn, Germany

Portable Methanol Production Using Woody Waste: Does it play a role in Community-based Biodiesel Production?



http://depts.washington.edu/nwfire/photoseries/; http://www.energy.state.or.us/biomass/Environment.htm

USFS 2003 A strategic assessment of forest biomass and fuel reduction treatments in western states

WESTERN BARK BEETLE REPORT April 22, 2002

Asep Suntana

Indonesia – Palm oil-Based Biodiesel

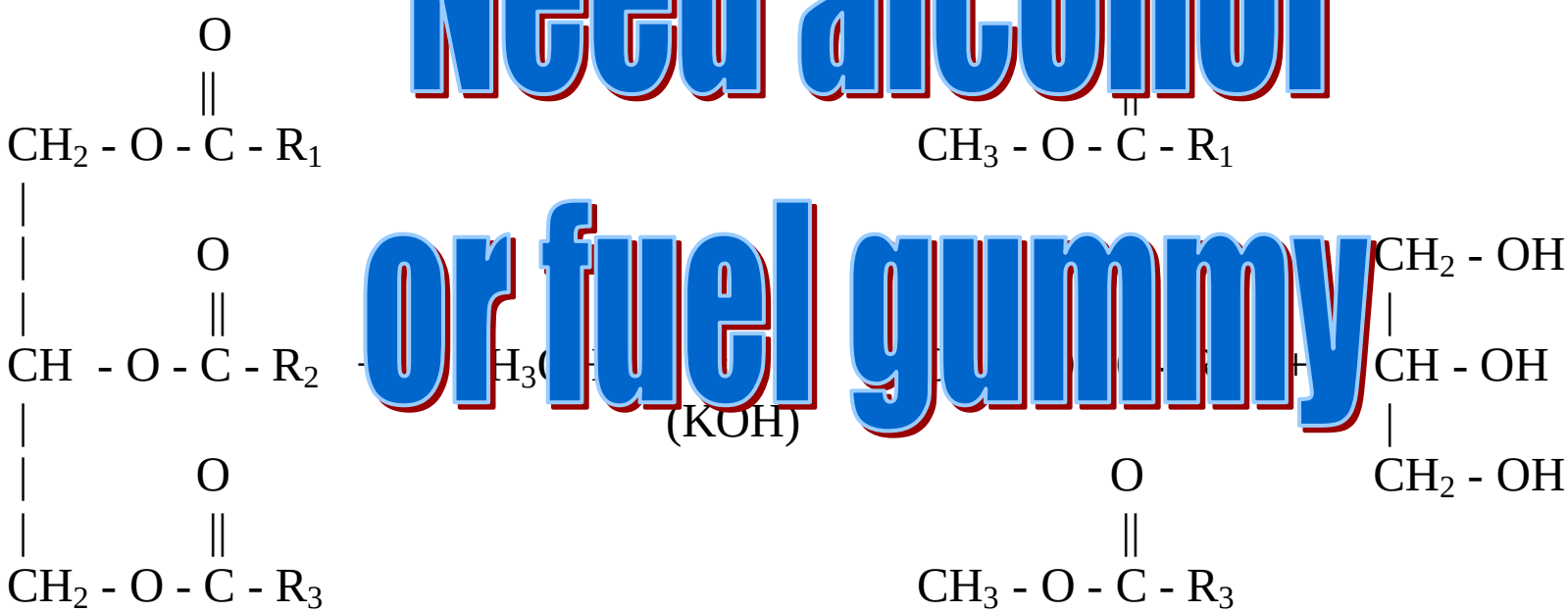
Feedstocks Used in Biodiesel Production

- Triglygeride or fats and oils (e.g. **100 kg soybean oil**) – vegetable oils, animal fats, greases, soapstock, etc.
- **Primary alcohol (e.g. 10 kg methanol) – methanol or ethanol (44% more ethanol is required for reaction)**
- Catalyst (e.g. 0.3–1.0 kg sodium hydroxide)
- Neutralizer (e.g. 0.25 kg sulfuric or hydrochloric acid)

http://www.cisat.jmu.edu/biodiesel/presentations/Biodiesel%20Production%20Technologies-VanGerpen%202p%20presentation.ppt#319,7,Standard Recipe

Transesterification

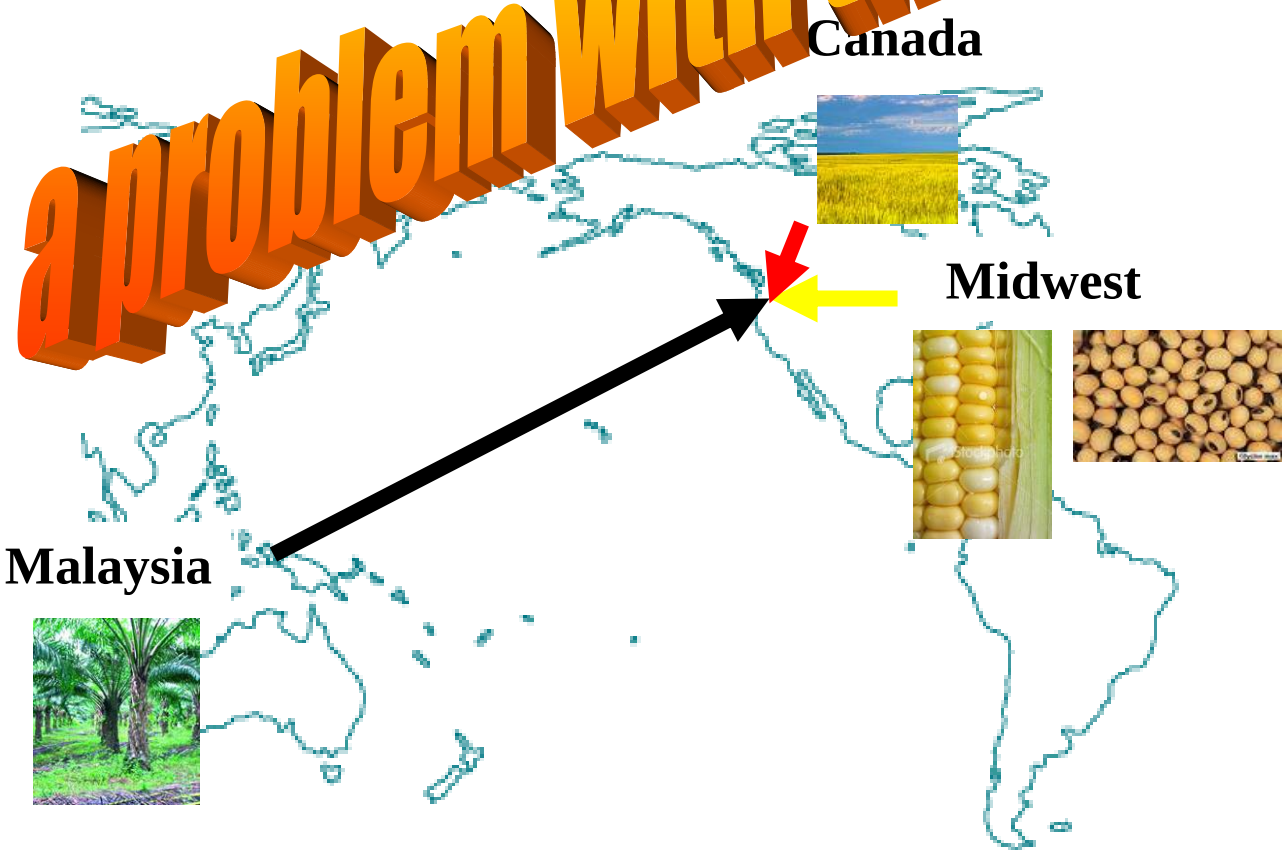
Need alcohol or fuel gummy



Triglyceride methanol mixture of fatty esters glycerin

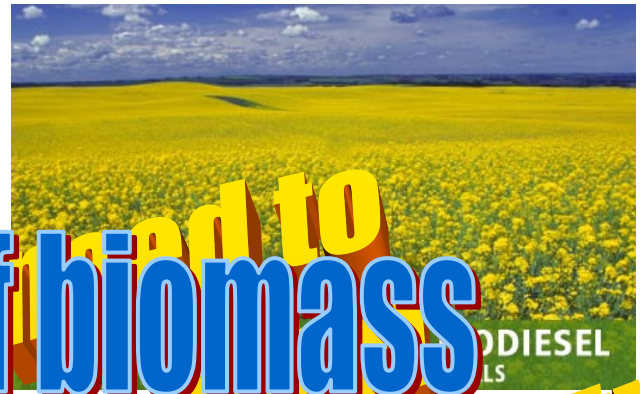
Biomass Availability: Ethanol and Biodiesel

Do you see a problem with this?



Evaluating both the forest stand and Washington state level feasibility of methanol production from woody biomass, **Carrie Lee,** M.S. Thesis Defense, College of Forest Resources, January 19, 2007

BIOFUELS: RENEWABLE ENERGY OR ENVIRONMENTAL DISASTER IN THE MAKING?



These will drive whether biomass is u
produce biot

SOURCE of biomass

significant ISSUE

to be accepted by

'In the absence of government ... s, the rising ...
could quickly become the leadin threat to ... w under way
does indeed become the six
Lester Brown (Director of the Worldwatc ... /banner.jpg

Peat and forest fires on Borneo-mostly set by oil plantation owners
http://earthhopenetwork.net/brazil_deforestation.jpg
http://www.esa.int/images/Fire72_M.jpg

Amazon destruction to grow soya

Some conversion efficiencies to alcohols

Material	Ethanol (gallons / 1 Mg biomass)	Methanol (gallons/ 1 Mg biomass)
Sugar cane www.itdg.org/docs/technical_information_service/sugar_production_from_cane.pdf, K Vogt estimate	**24 – 36 gallons** (6 - 9%)	Chemistry determines how much liquid by-product produced
Corner stover Kheshgi et al. 2000, www.ctic.purdue.edu/Core4/StoverNCNU.pdf	**79 – 119 gallons**	
Wood www.cfr.washington.edu/research.Forest_Energy/, Kheshgi et al. 2000, K Vogt estimate	**99 – 142 gallons**	**165 – 186 gallons**

Starch or Cellulose being converted

Cellulose and lignin being converted

NOTE: Ethanol cannot currently be made from lignin, a major component of waste biomass

CELLULOSE = 35 – 50% of biomass

LIGNIN = 15 – 30% of biomass

Cost & Revenue: Green wood biomass ME

(WA - 12.8 T/ac green high fire risk (*Class 3 Timberlands, 2-9 inch diameter*)

COSTS -

- Harvest Cost to Thin: ***$300/ac***
- Tipping Fee at Landfill: ***$384/a*** [illegible]
- Fire fighting costs average: **$21**[illegible]

  Stumpage value for Pulp: ***$128/ac*** ($10/T)
- ME Conversion System Costs: ***$1,229/ac*** ($96/T)

Sell Methanol to Chemical Industry, [illegible]s Transportation [illegible]uel, Supply Small [illegible]ppliances based on ME-fuel cells

Sell extra Methanol produced

REVENUE SEL[illegible]

- 4 ME prices/[illegible] [illegible] gals/Bone Dry T)

  Wh[illegible] **[illegible]c]**

  Mid Price ($1.90/gal) = ***$2,262/ac*** ($177/T); **[RB = $1,117/ac]**

  Green 35% Premium ($2.57/gal) = ***$3,059/ac*** ($239/T); **[RB = $1,914/ac]**

  High ($3.00/gal) = ***$3,571/ac*** ($279/T); **[RB = $2,426/ac]**

[REVENUE BALANCE (RB) = (selling ME) - (thin + produce ME - landfill)]

In western US, 30% forests are overstocked, have insect (bark beetle) and fire risk problems; Washington, 20% forests have high fire risk

Restoration

Fire control

AT YOUR PERIL

On Fringe of For[illegible] Homes and Fires Meet

In the Bitterroot Valle[illegible] Montana, a house[illegible] construction in a [illegible] increasingly desir[illegible] homeowners and [illegible]strating to firefighters.

By JESSE McKINLEY and KIRK JOHNSON
Published: June 26, 2007 The New York Times A1, A14-A15

Why are we talking about biomass?

Characteristics of Biomass Energy

Biofuels has to be part of solution or energy use not ENVIRONMENTAL

- **Carbon neutral** – zero CO_2 emissions [not increase atmosphere CO_2 since growing plants take up CO_2]
- **Energy [illegible]** [illegible] ch region, available every climate zone except polar deserts
- Renewa[illegible] fossil fuels
- TODAY **highly efficient conversion** to by-products
- By-produc[illegible] **ort**, not toxic
- By-products **substitute/supplement fossil fuels** in transportation and electricity