Rice straw for Electricity & Heat Production

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Overview presentation

- Introduction
- Technologies available
- Experiences in other regions
- Conclusion, Recommendations

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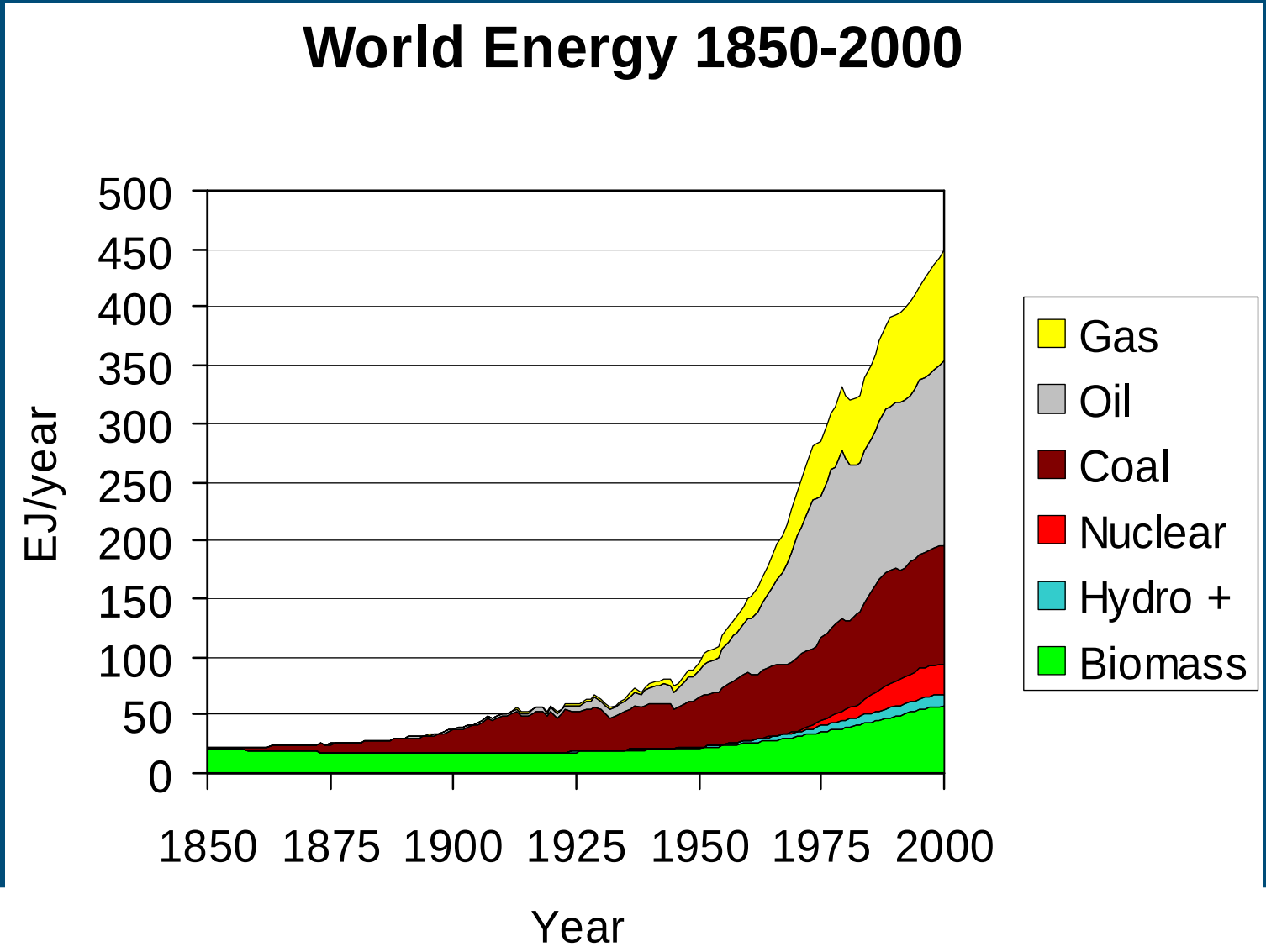
Introduction

Why produce energy from rice straw?

- Energy demand is increasing!
- Potential energy production from rice straw !!
- Potential environmental savings !!!

Energy demand



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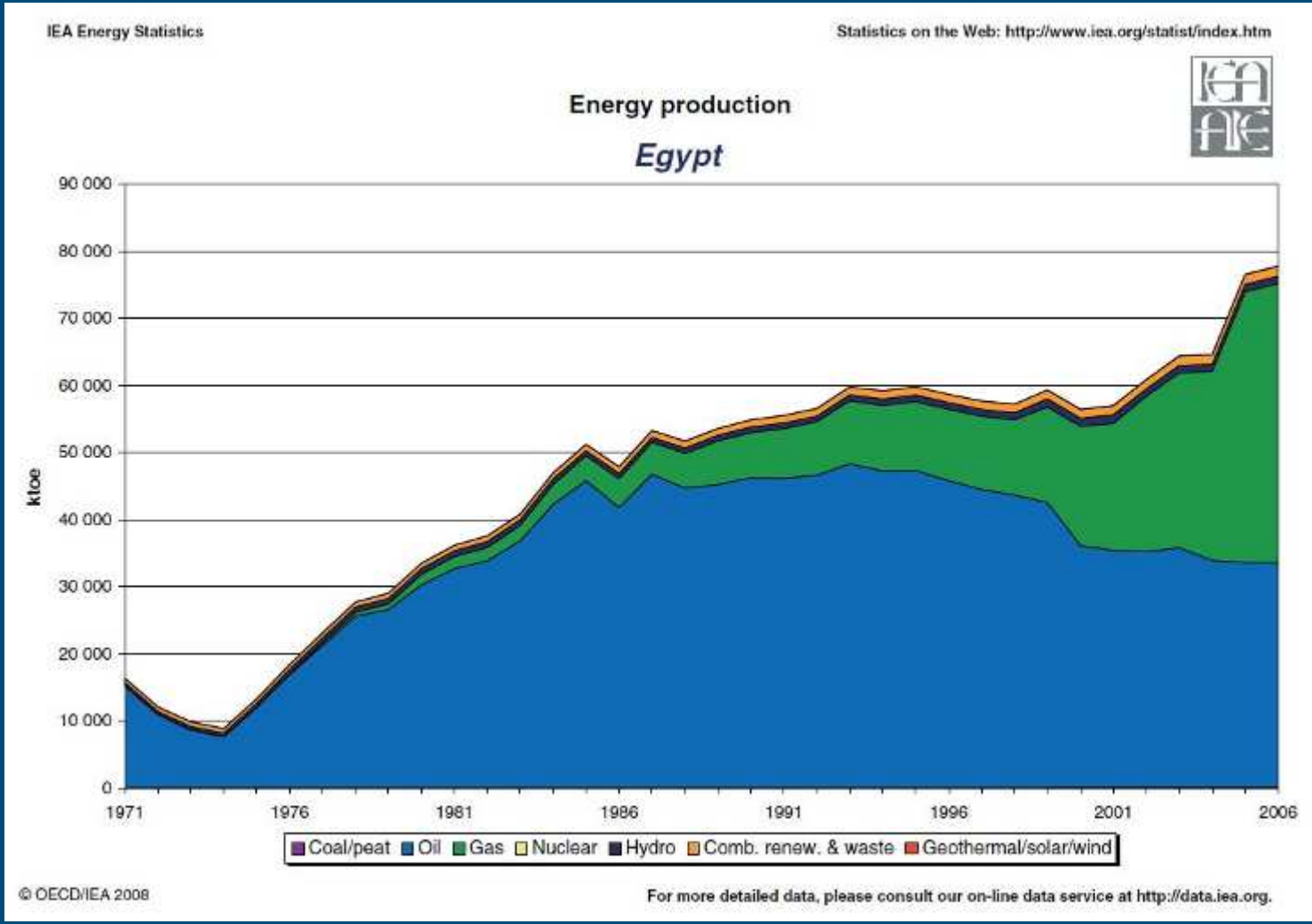
Oil consumption in selected countries

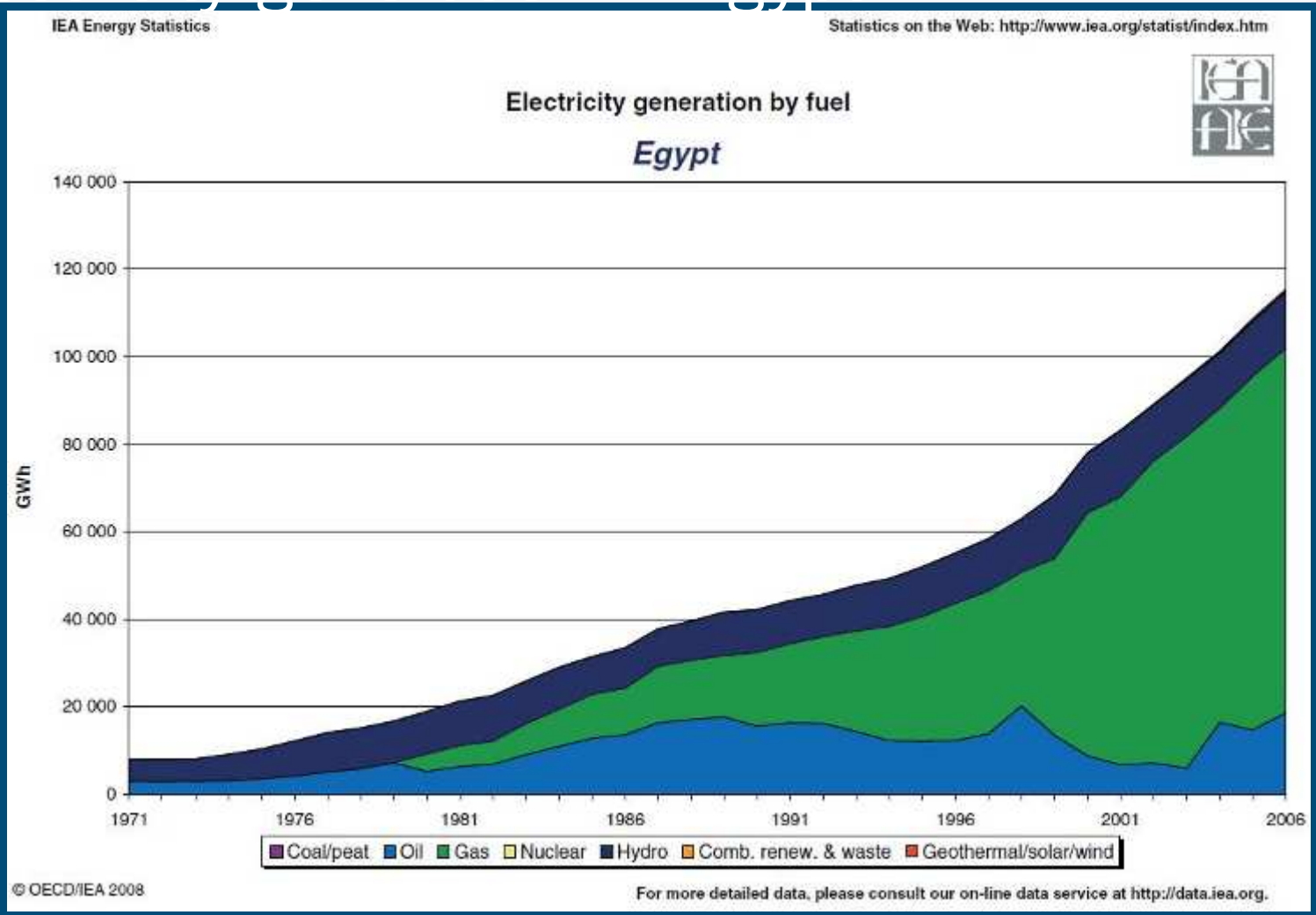
Country	2003 total 1000 barrels/d	10-yr change %	Per capita barrels/yr
USA			6
Cana			5
Aust			8
Japa			0
Fran			5
Gerr			9
U.K.	1722	-6	10.5
Brazil	2132	31	4.5
Indonesia	1155	51	2.0
China	5550	88	1.6
India	2320	77	0.8

World energy demand is projected to increase by 50% by 2030.

Energy production in Egypt



Electricity generation in Egypt



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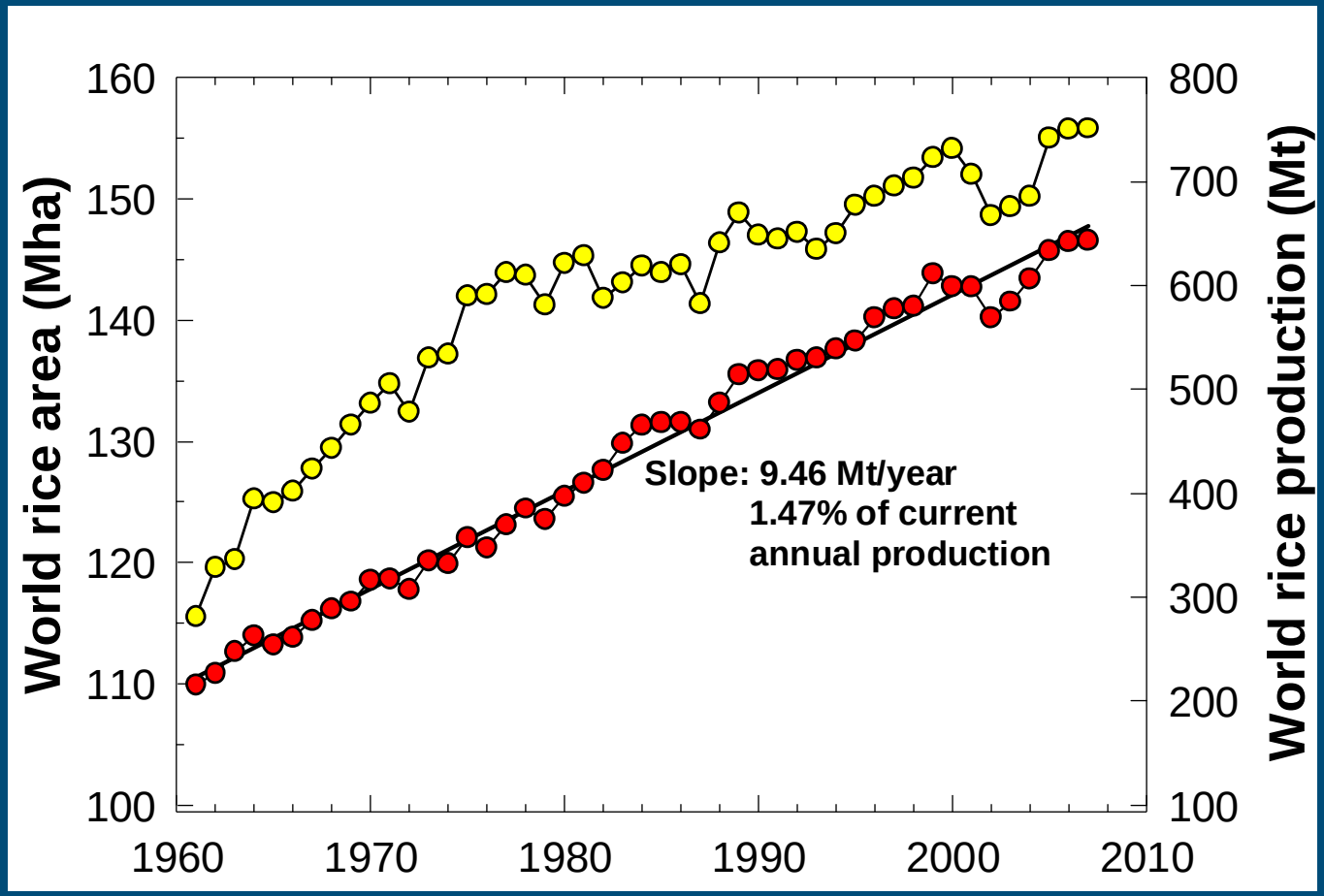
Rice Production



Source: International Rice Research Institute IRRI

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More rice means: more by-products

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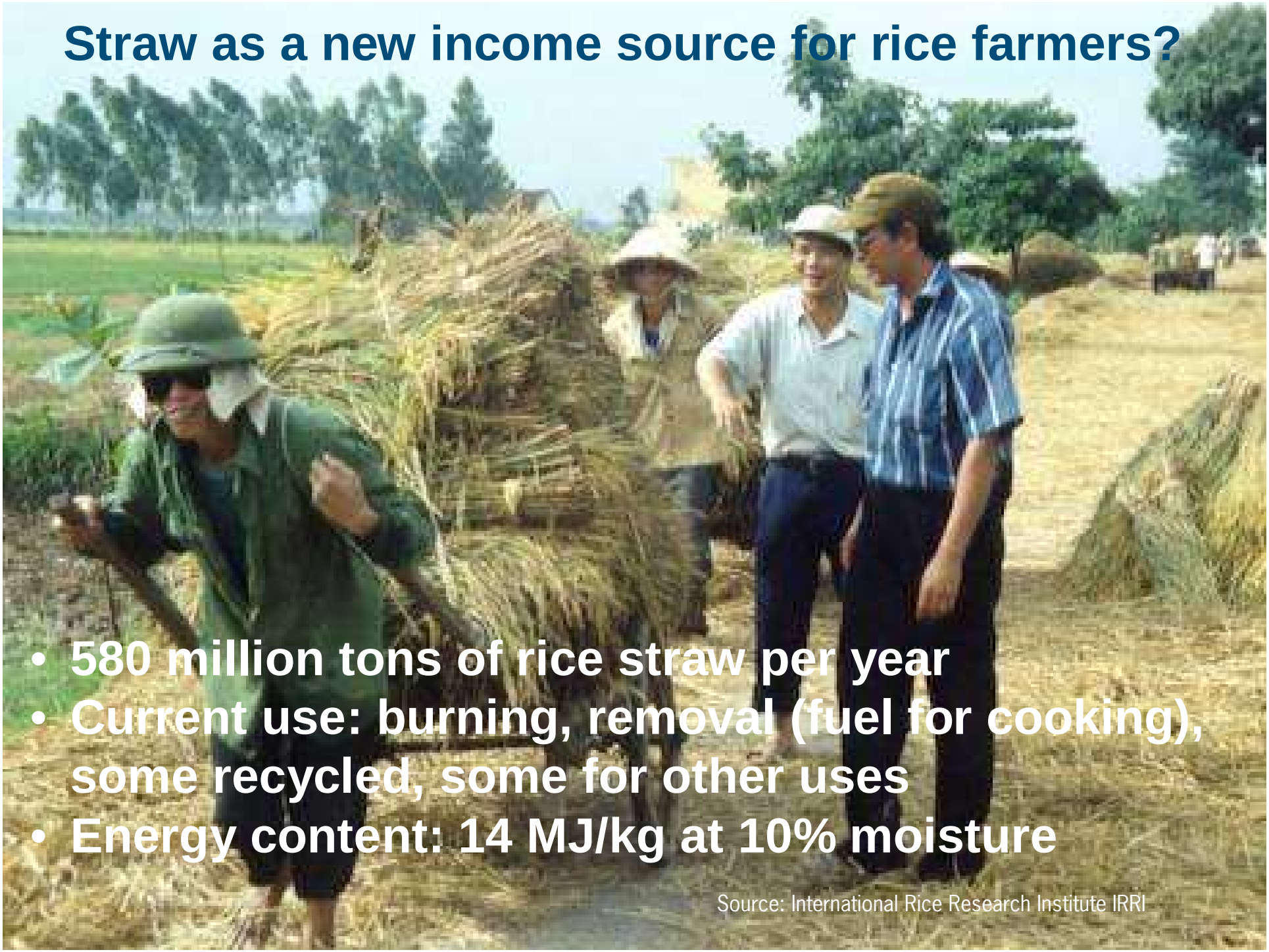
Straw as a new income source for rice farmers?



- 580 million tons of rice straw per year
- Current use: burning, removal (fuel for cooking), some recycled, some for other uses
- Energy content: 14 MJ/kg at 10% moisture

Source: International Rice Research Institute IRRI

Estimates of air emissions from rice straw field burning in Egypt

Pollutant	Unit	Emission factor	Combustion factor	Emissions (Mg /year)	GWP source: IPCC,2006	Emissions in CO_2 Eq. (metric tonnes)
CO_2	g/kg_{dm}	1460	0.8	4495538560	1	4,495,500
CH_4	g/kg_{dm}	0.74	0.8	2278561	21	47,850
N_2O	$g/kg_{dry\ fuel}$	0.79	0.8	2432517	310	754,080
CO	g/kg_{dm}	72.4	0.8	222929446	-	
NO_X	g/kg_{dm}	3.52	0.8	10,838	-	
SO_2	g/kg_{dm}	0.147	0.8	452	-	
$PM_{2.5}$ (fine particulate matter)	g/kg_{dm}	12.95	0.8	39,874	-	
PM_{10}	g/kg_{dm}	3.7	0.8	11,392	-	
PAHs*	$g/kg_{dry\ fuel}$	18.62	0.8	57,335	-	

***PAHs**: polycyclic aromatic hydrocarbons

Source: Ngririnshuti and Bakker et al, 2009

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Technologies of producing electric power and heat from rice straw

- Combustion (electricity, and heat)
- Anaerobic digestion (biogas)
- Pyrolysis (bio-oil) *
- Gasification (syngas) *

* In development

Combustion

- Most well-known conversion method
  - Boiler coupled to heat exchanger, steam turbine
- Options for rice straw combustion:
  - “Stand-alone” , small-scale for electricity and heat
  - Co-combustion with coal or other fuels (co-firing)
- Challenges for rice straw combustion:
  - High ash content (up to 20%)
  - Troublesome inorganic elements (K, Cl)
  - Need to densify fuel for optimal logistics

Biomass-fueled power plants

- Smaller-scale combustion systems (5 – 15MW) are well established
- Larger systems: transportation distances may become a problem!
- One major challenge for combustion of rice straw: the ash

Boiler Tube Corrosion

Corrosion of a biomass boiler superheater tube after two years of service firing high chlorine fuels. The deposit has been removed at center revealing the corroded steel surface beneath.

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Photos courtesy of Prof. Jenkins, UCDavis

Ash agglomeration

Bed agglomerate removed from a fluidized bed combustor burning a blend of 10% rice straw in wood fuel after 3.5 h of operation.

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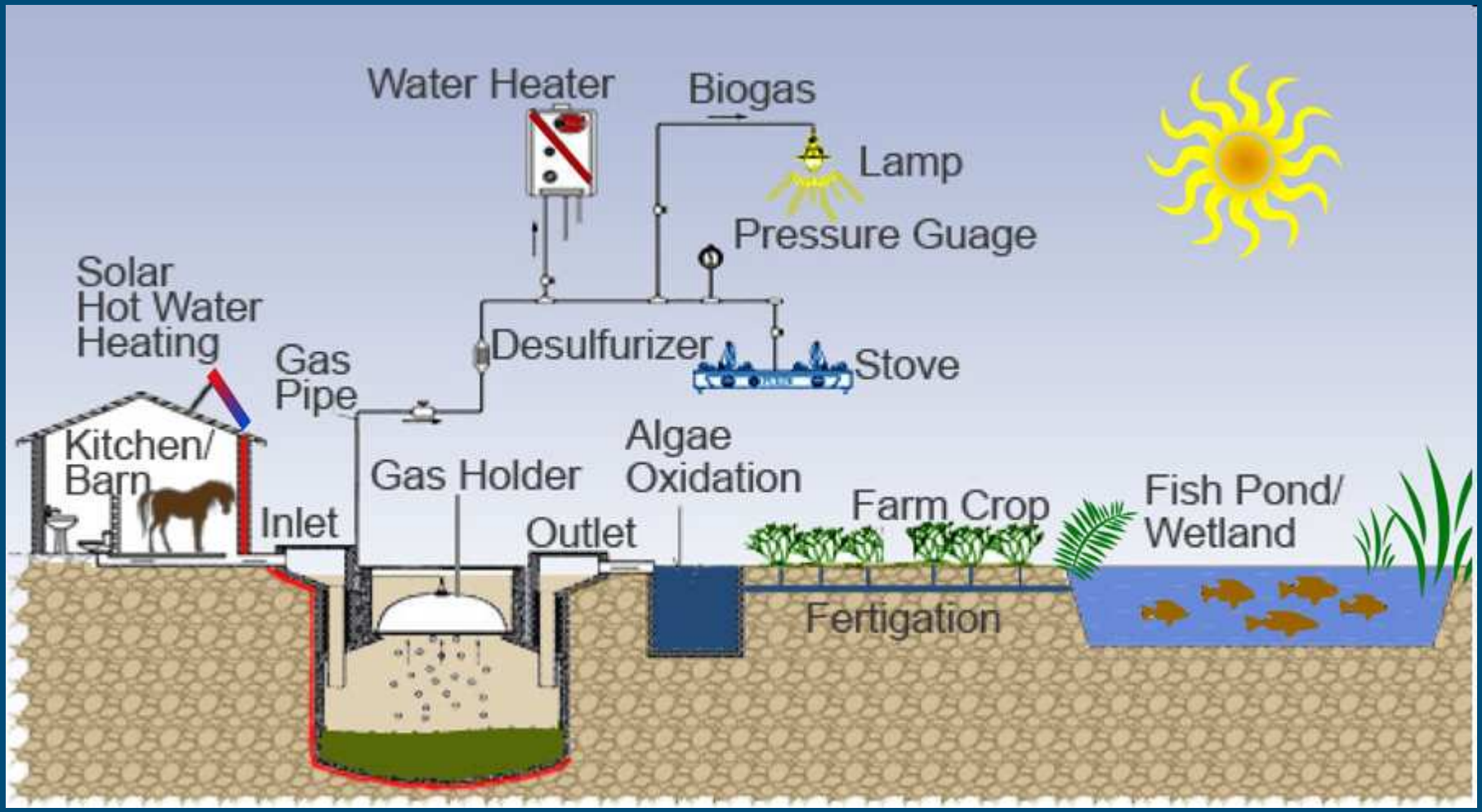
Photos courtesy of Prof. Jenkins, UCDavis

Solutions for ash-related problems of rice straw

- Combine rice straw with other fuels that are lower in alkali and chlorine
- Lower temperatures in combustion systems
- Remove troublesome components prior to combustion ("leaching")

Anaerobic digestion

- Well-proven technology for various agricultural waste
  - Low maintenance; technology not complicated
  - Small-scale: short transportation distance
- Two applications for Biogas:
  - Direct use: use biogas for cooking and heating
  - Indirect use: biogas into engine for electricity generation
- Straw is digested together with other biomass types
  - For Rice straw common substrates are Animal manure, or other organic wastes


Water Heater
Biogas
Lamp
Pressure Guage
Solar
Hot Water
Heating
Gas
Pipe
Desulfurizer
Stove
Kitchen/
Barn
Algae
Oxidation
Gas Holder
Inlet
Outlet
Farm Crop
Fish Pond/
Wetland
Fertigation

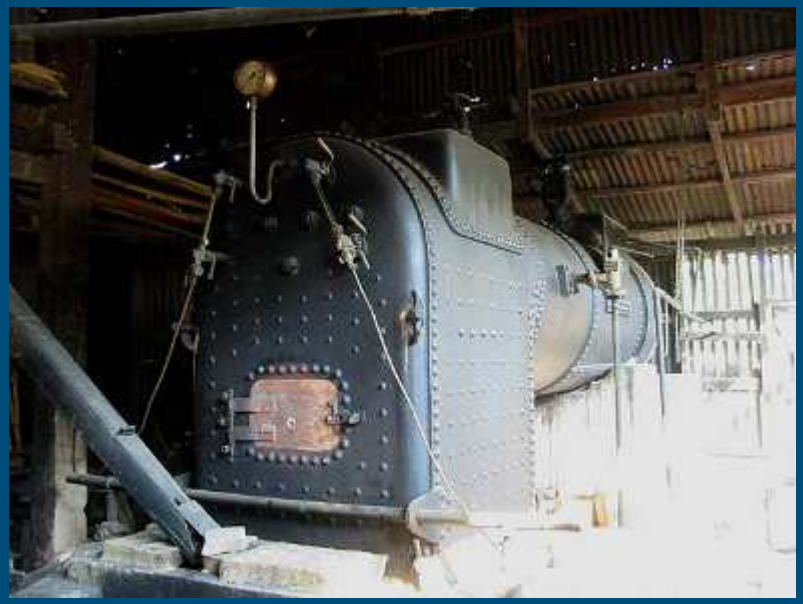
Pyrolysis, Gasification

- Products:
  - Pyrolysis: bio-oil and biochar
  - Gasification: synthetic gas for combustion, or other products
- Technologies show promise, but have not been implemented at large scale
- Main developments to date:
  - Pyrolysis: biochar for fertilization; bio-oil for energy production
  - BioCrude: Technique specifically invented for wet biomass

Related to straw: combustion of rice husk

- Most successful rice waste product used: Rice Husk
- Why?
  - Material is already collected in one site (rice mill)
  - Composition is somewhat more benign than rice straw
  - Rice husk ash = marketable product, depending on operating conditions

Small scale rice husk furnaces, gasifiers, pyrolysis units



Pictorial of the Continuous-Flow Rice Husk Gasifier

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Industrial scale rice husk utilisation

Cargill Rice Milling
Greenville, Mississippi
330 t rice husk+straw/day
6.5 MW electricity + steam
for parboiling facility

Riceland Foods, Inc.,
Stuttgart, Arkansas
525 t rice husk/day
15 MW electricity

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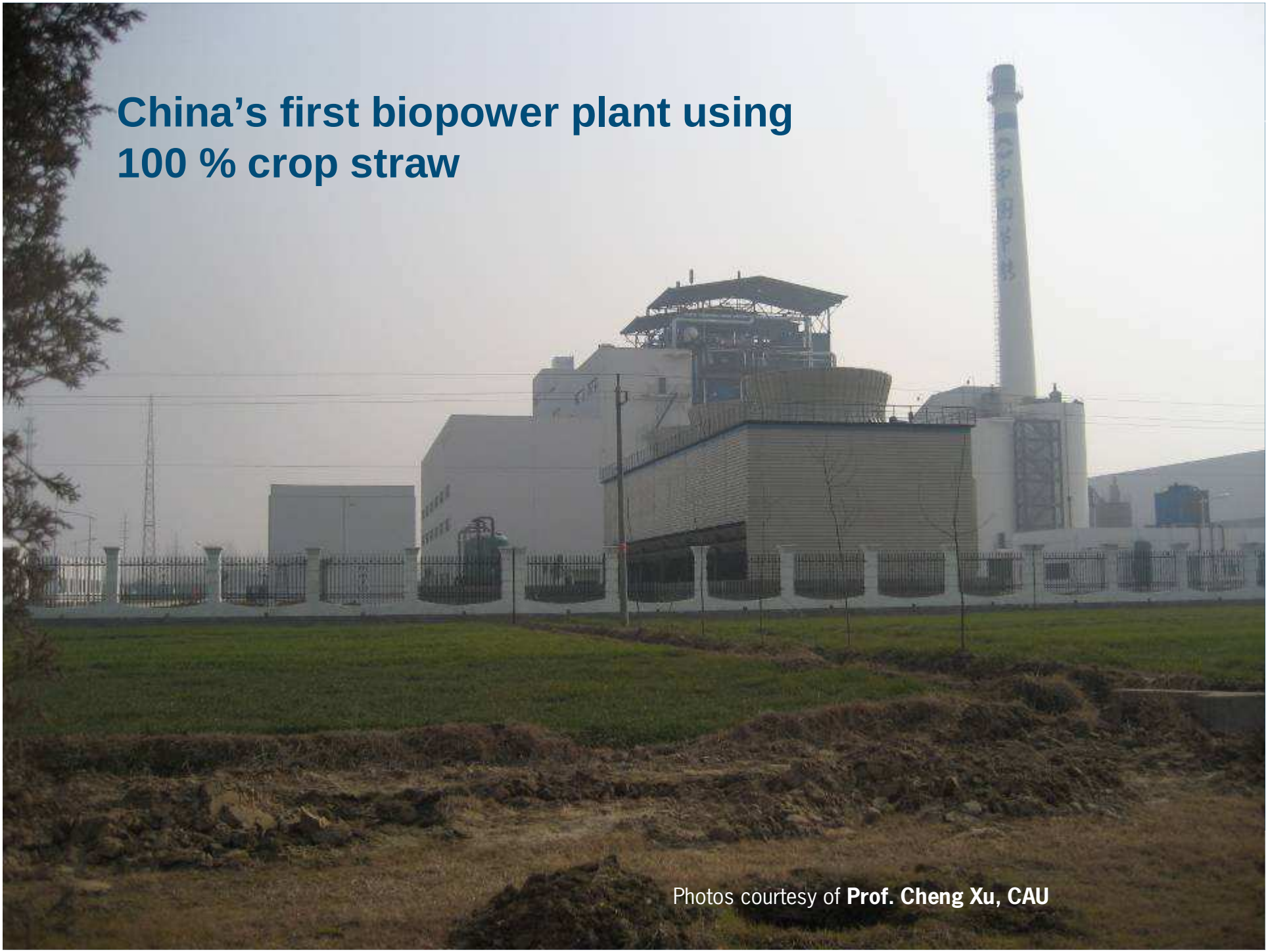
Photos courtesy of Prof. Jenkins, UCDavis

Case 1: China (Gadde et al, 2008)

- Various projects in Jiangsu Province
  - Typical size is 12 – 25 MW electricity, per powerplant
- Various raw materials are used as fuel
  - typically 50 – 60% of all fuels is rice straw
- Most projects source their raw material from a 25 to 50 km radius
- Main concern: cost of the raw material
  - *"It is assumed that collection and transportation charges will increase every year because of increasing labor and transport costs." (Gadde, 2008)*

China’s first biopower plant using 100 % crop straw



Photos courtesy of **Prof. Cheng Xu, CAU**

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Case 2: California

- Rice straw mono-cropping (no 2nd crop)
- Mandatory phase-out of field burning
  - Legislation passed by state in the 1990's
- Currently: primary disposal method is in-field recycling
  - Attempts to utilise rice straw in existing biopower industry not successfull
  - Some other uses of rice straw exist (e.g. erosion control)

Biomass Power Industry California

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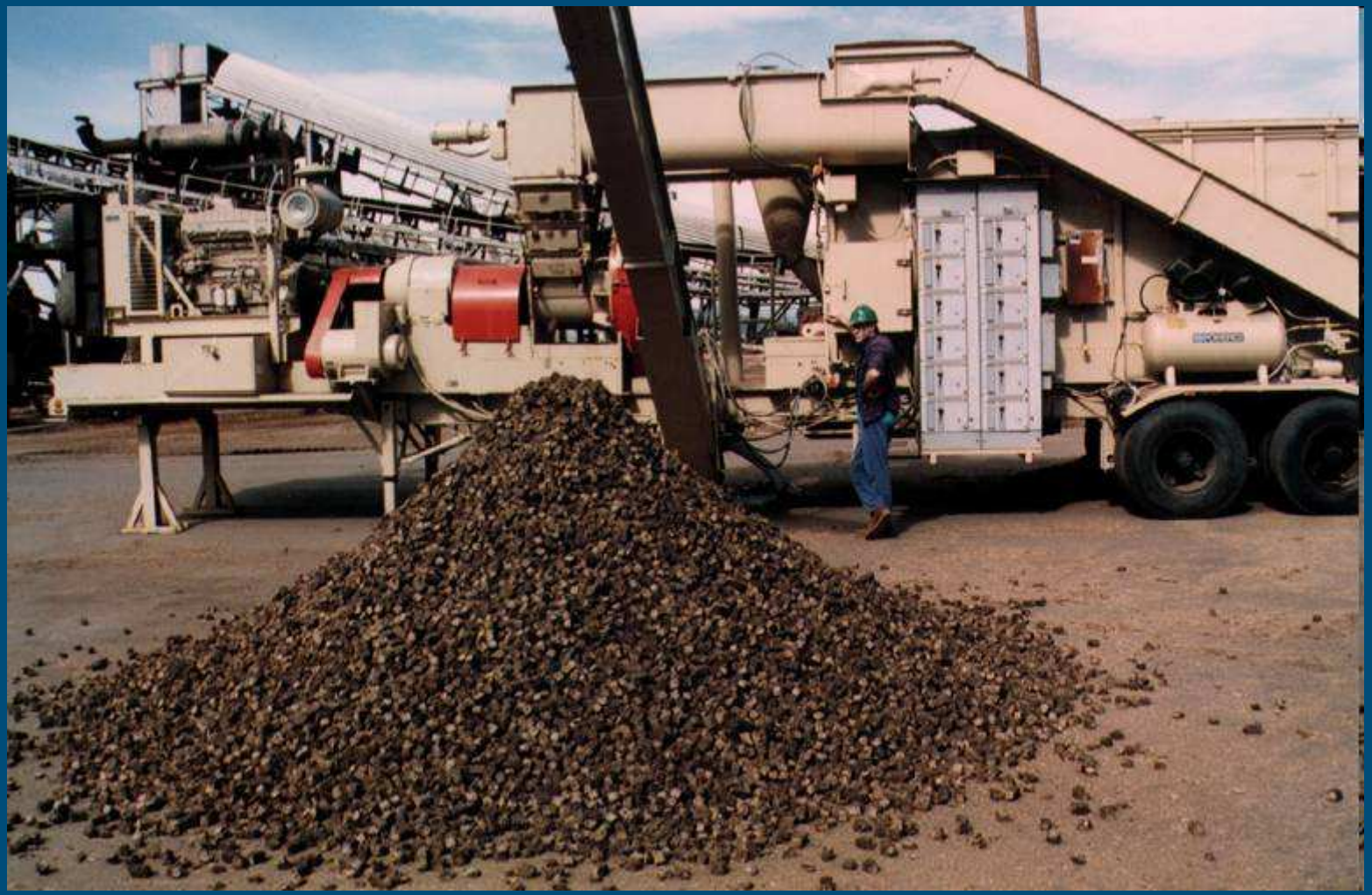
Attempts with rice straw combustion



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Other rice straw uses in California

Photos courtesy of Prof. Jenkins, UCDavis

Case 3: India (Punjab)

- Rice followed by wheat
- Majority of fields are mechanically-harvested
- Two major initiatives
  - Small 10 MW powerplants
  - Community biogas plants
- Limited success:
  - Number of biogas plants have reduced, due to increase in cost of raw material, and cheaper & abundantly available cooking gas

Conclusions

- Many technologies are available for producing electricity and heat from rice straw
- Up to now, potential of rice straw has not been realised
  - This is in contrast with energy applications from rice husks, which in general are quite successfull
- Major challenges that are encountered with straw:
  - Technological: rice straw composition
  - Organisational: logistics of straw collection
  - Economics: cost of straw versus revenue

Recommendations

- Investigate feasibility of:
  - Decentralised energy production from rice straw
    - Use rice straw near the source.
    - Use rice straw for other agricultural operations: cooling/freezing houses?
  - Couple energy production with local industry
  - Explore Opportunities for CDM projects (carbon credits)
- Assess markets outside Egypt
  - Growing international market for biomass fuels!
  - Here, ash composition will remain a concern

Thank you!

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