# Powergen International 2003

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## 9. – 11. December 2003

# Advantages of Combined Wind-Biogas Energy Utilization for Distributed Power Generation


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**Peter Luby**

**IMTE AG**
**Switzerland**

**Power Consulting Engineers**

# REFERENCES

## IMTE AG PAPERS

**Opportunities for Biomass Power Plants in Southeast Asia Region**

**Presented at Powergen Asia 2002 in Singapore**

**Biomass Energy Utilization & Environment Protection - Commercial Reality and Outlook**

**Presented at Powergen Asia 2003 in Vietnam**

# WORLDWIDE SITUATION

**MORE THAN 2 BILLION PEOPLE AROUND THE WORLD LIVE WITHOUT CONNECTION TO THE POWER NETWORK**

# WORLDWIDE TREND

## STAND ALONE (DISTRIBUTED) POWER SYSTEMS WILL EXPERIENCE THE HIGHEST GROWTH RATES

GROWING HIGH QUALITY ELECTRICITY DEMAND

GRID-COUPLED SYSTEMS WILL CLEARLY DECREASE AFTER 2010

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# WORLDWIDE PROSPECTS

## EU TO RAISE THE SHARE OF RENEWABLE ENERGIES FROM 13% TO 15% BY 2010

INDIA IS TO ACHIEVE 10% SHARE FROM RENEWABLES BY 2012

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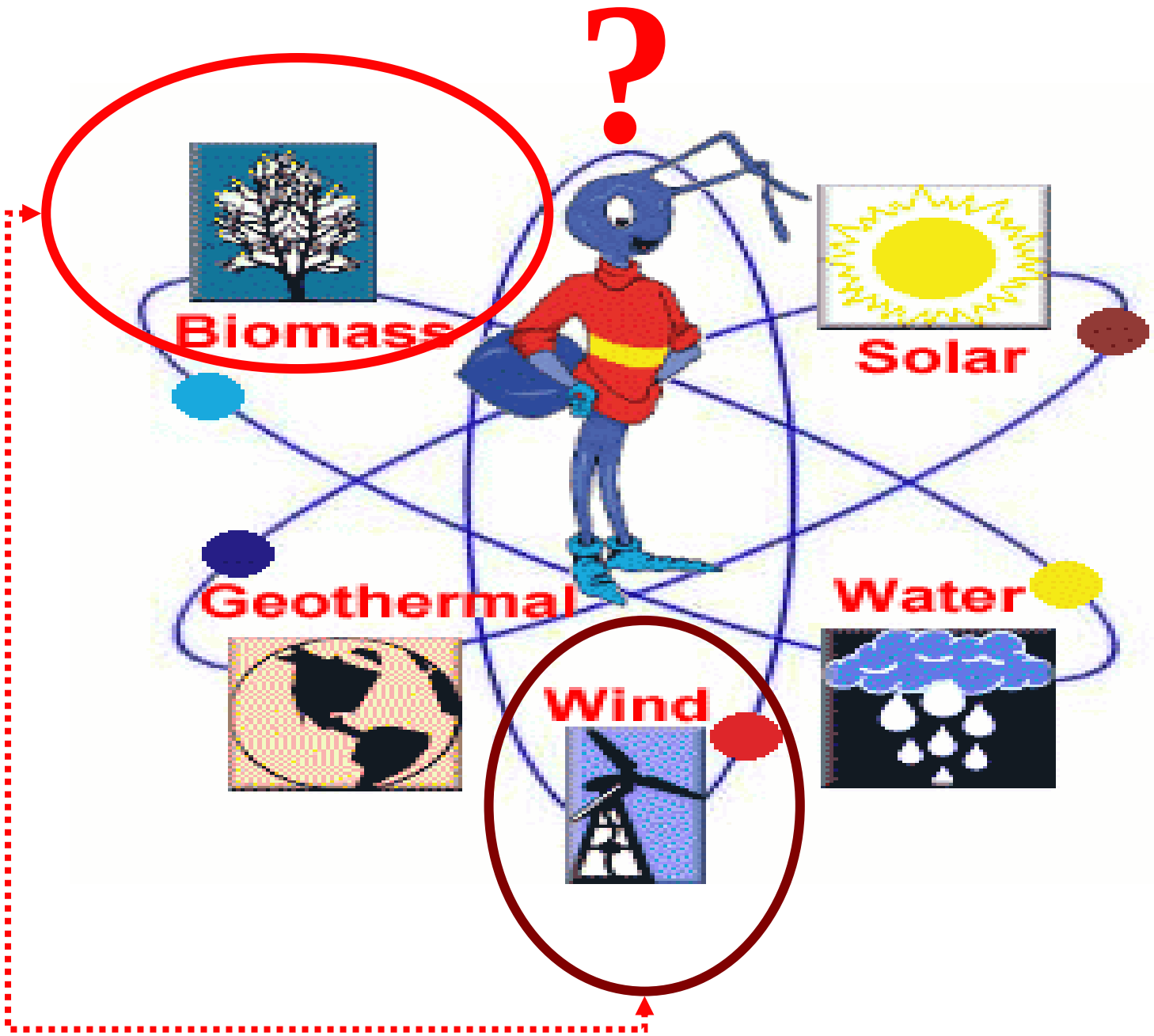
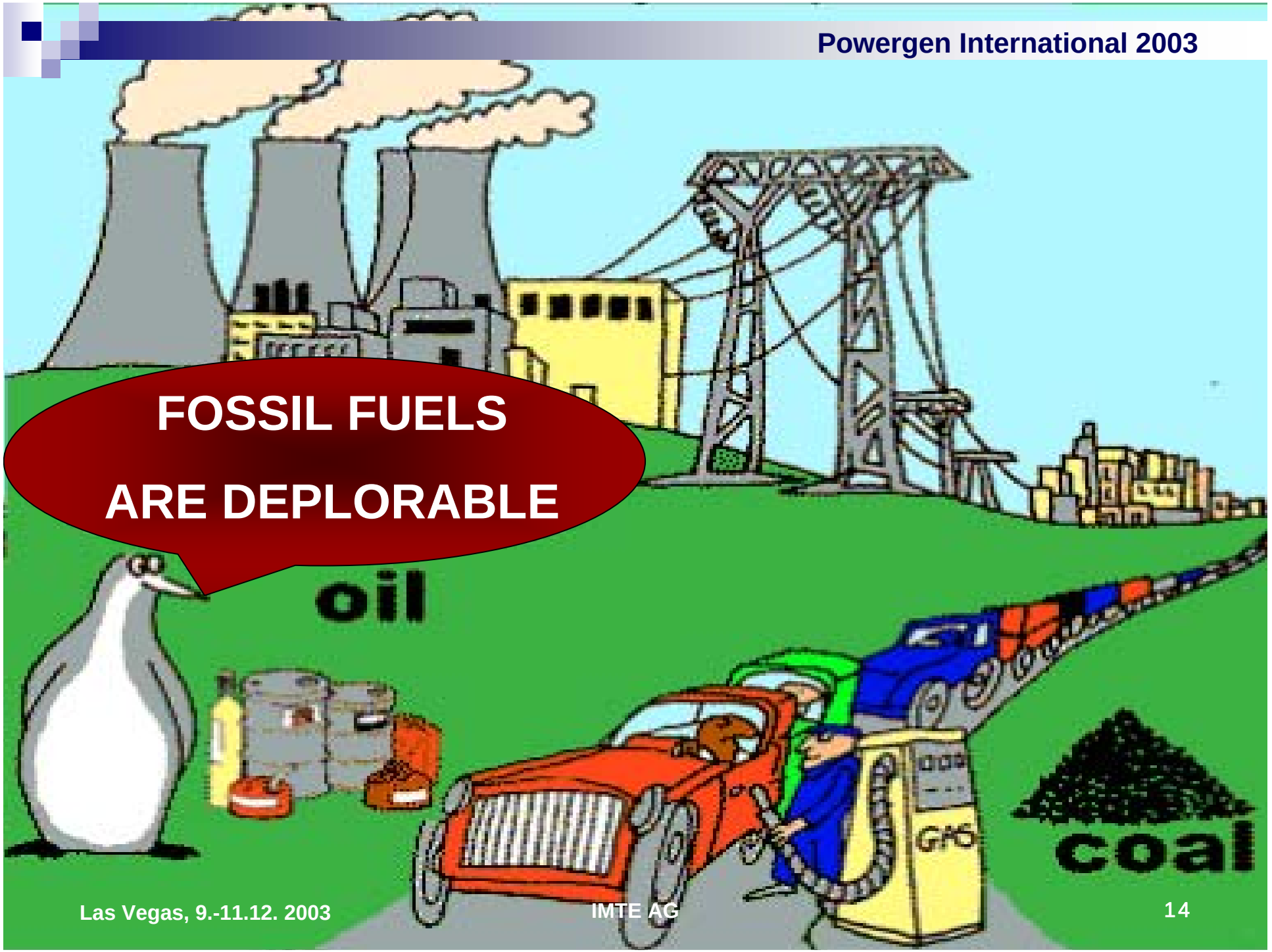
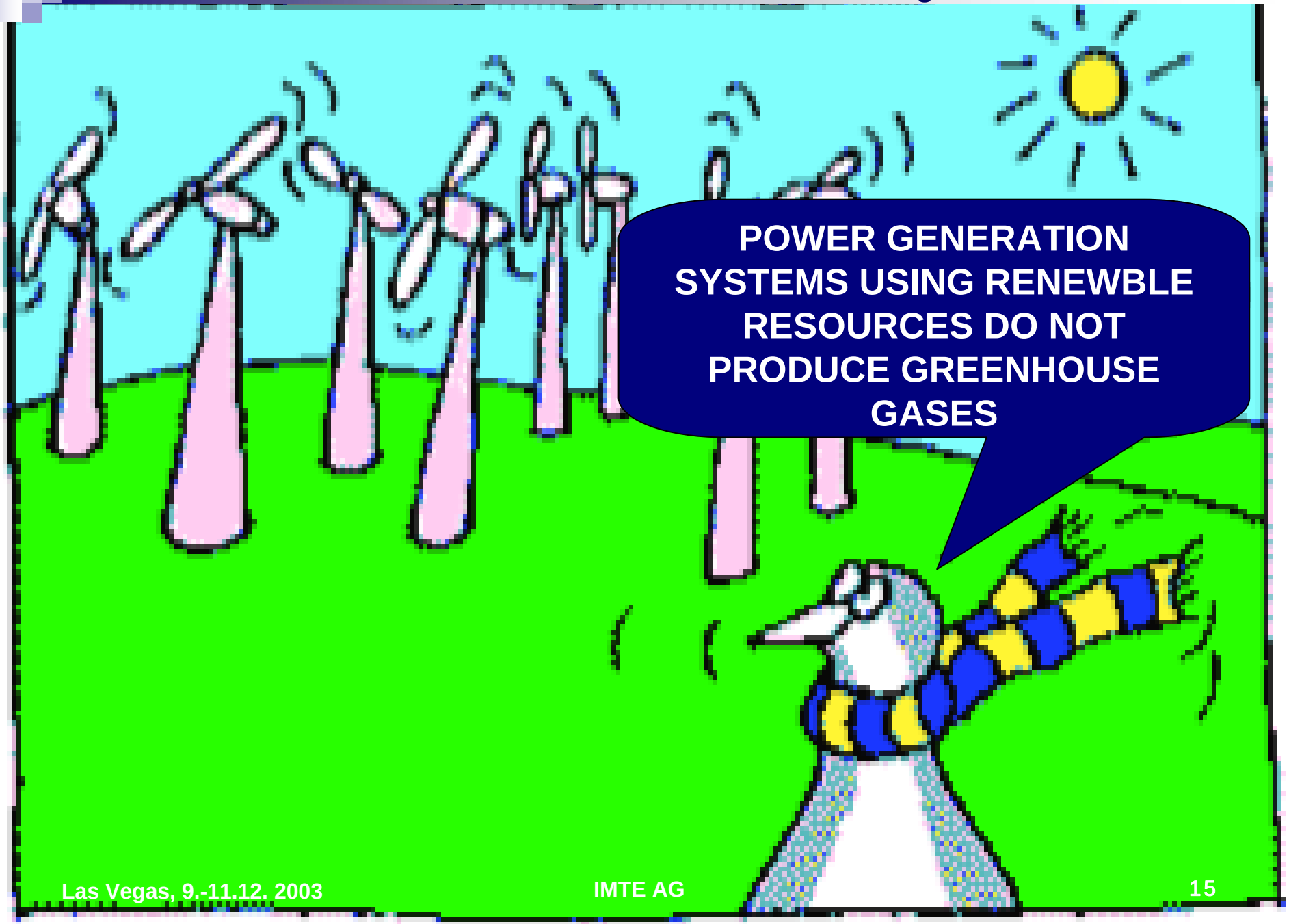

?
Biomass
Solar
Geothermal
Water
Wind

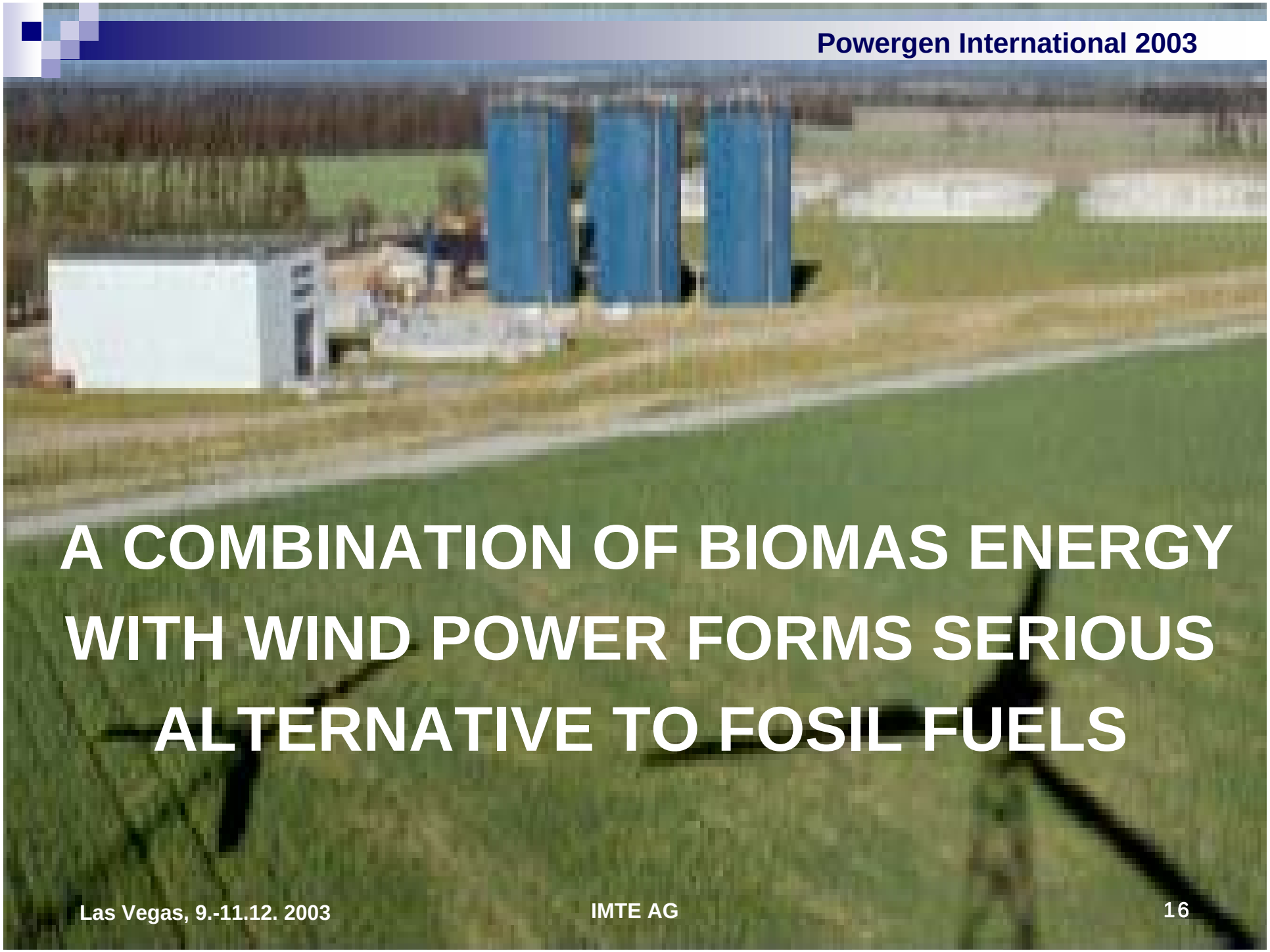
# THE KYOTO PROTOCOL, ALTHOUGH NOT RATIFIED TO THE EXTENT INTENDED, HAS BECOME A MAJOR ISSUE FOR GOVERNMENTS WORLWIDE


FOSSIL FUELS
$CO_2$


GLOBAL
WARMING!


FOSSIL FUELS
ARE DEPLORABLE
oil
GAS
coal


POWER GENERATION SYSTEMS USING RENEWBLE RESOURCES DO NOT PRODUCE GREENHOUSE GASES



# A COMBINATION OF BIOMAS ENERGY WITH WIND POWER FORMS SERIOUS ALTERNATIVE TO FOSIL FUELS

Introduction

# Distributed Power Generation

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# Distributed Power Generation refers to-

**ELECTRICAL POWER THAT IS GENERATED AT OR NEAR THE LOCATION WHERE THE ENERGY IS NEEDED**

INDEPENDENT ELECTRICTY SUPPLY ACORDING TO LOCAL AREA DEMAND

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**ELECTRICAL POWER THAT IS GENERATED AT OR NEAR THE LOCATION WHERE THE ENERGY IS NEEDED**

**INDEPENDENT ELECTRICTY SUPPLY ACORDING TO LOCAL AREA DEMAND**

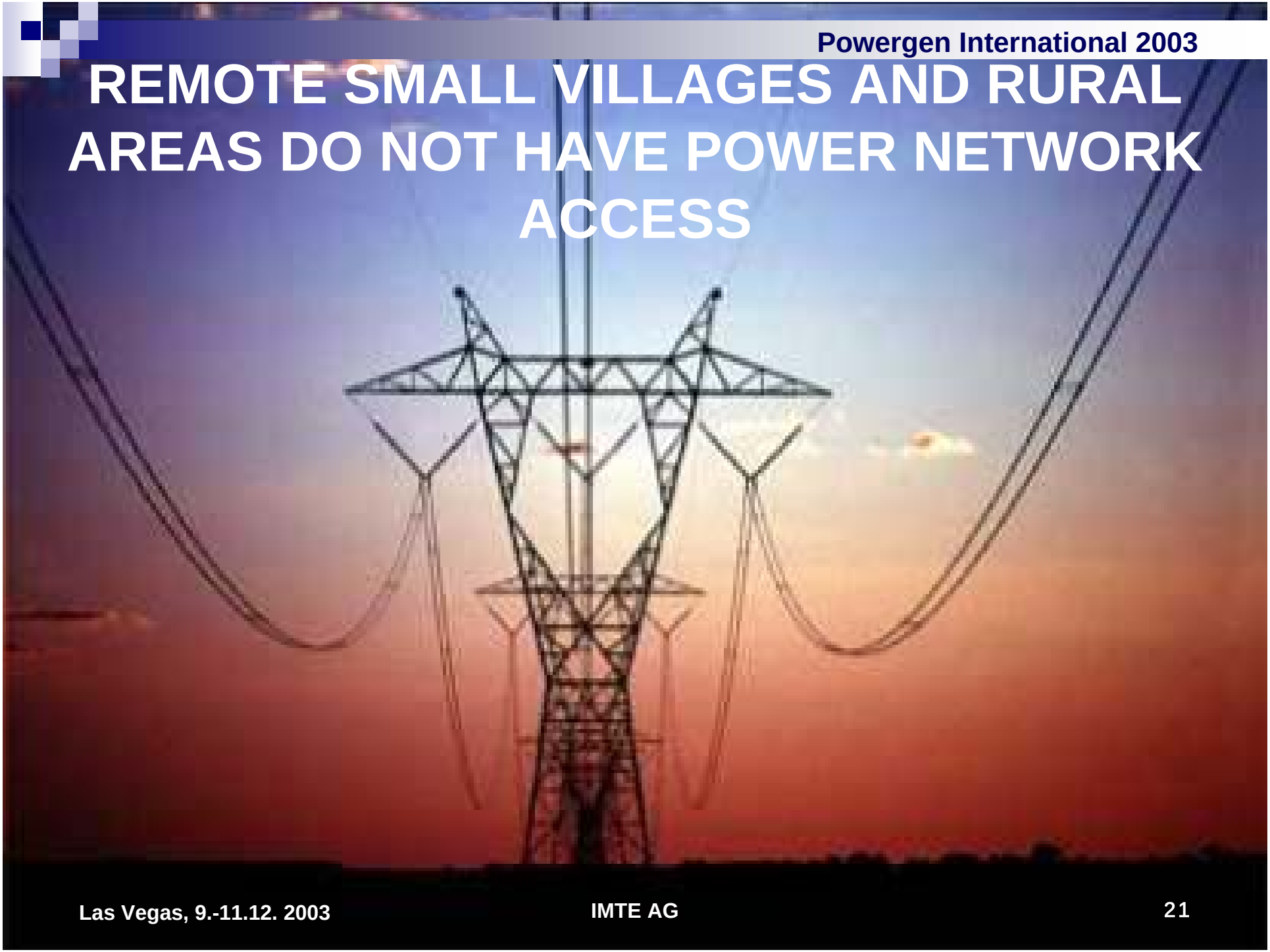
# Distributed Power Generators

# up to 60 MW

## Main Limitations:

## Power Demand at selected Location

# REMOTE SMALL VILLAGES AND RURAL AREAS DO NOT HAVE POWER NETWORK ACCESS



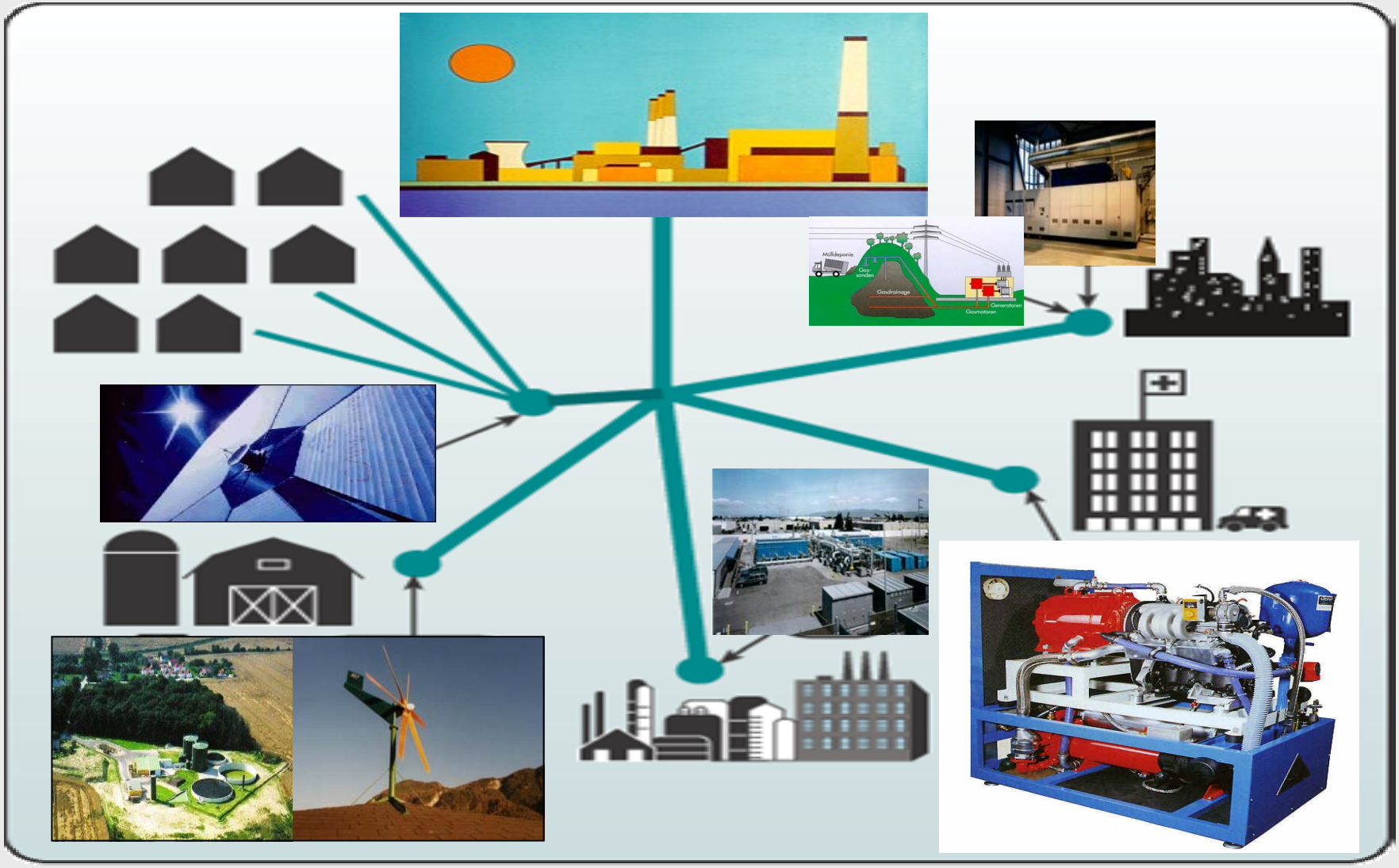
# AROUND 30% (54 MILLIONS) OF BRASIL‘s POPULATION LIVES IN RURAL AREAS

# AROUND 50% OF THEM HAVE NOT ACCESS TO ELECTRICITY

Courtesy NREL

# MORE THAN 90% (18 Mio) OF TANZANIAN POPULATION HAVE NOT ACCESS TO ELECTRICITY

# DISTRIBUTED POWER GENERATION SYSTEMS ARE GRID-CONNECTED OR STAND ALONE TECHNOLOGY SYSTEMS THAT CAN BE INTEGRATED INTO SMALL TOWNSHIPS, COMMERCIAL OR INSTITUTIONAL BUILDINGS, INDUSTRIAL FACILITIES AND OTHER GROUP OF POWER CONSUMERS


Mülldeponie
Gas-sonden
Gasdrainage
Generatoren
Gasmotoren

# Distributed Generation for-

- Base Load -
- Peak Load -
- Back-up -
- Remote -
- High Quality

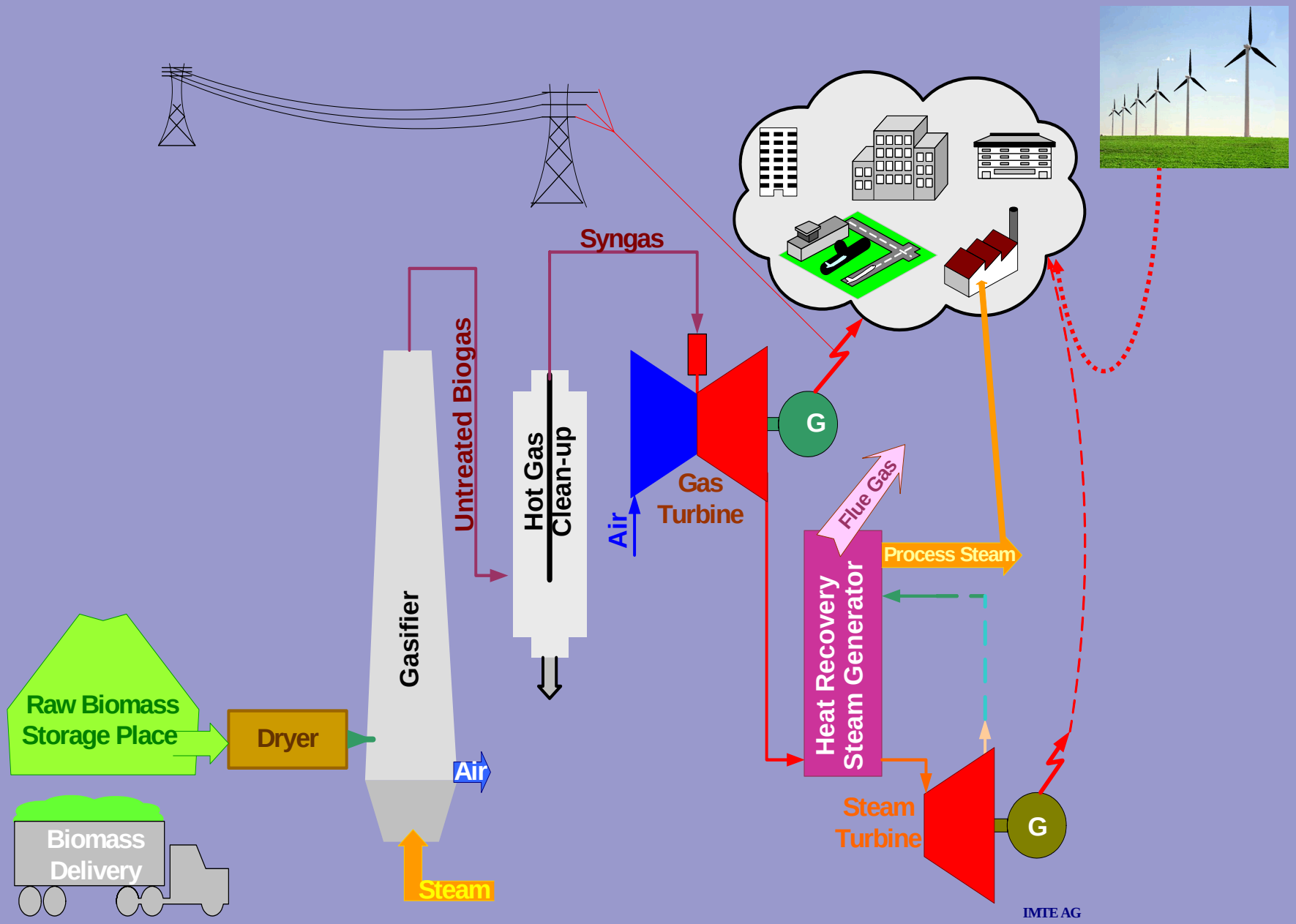
Power Production.

# Benefits

- SMALLER, MODULAR POWER GENERATING UNITS
- CLEANER & EFFICIENT
- INDIVIDUAL POWER CHOICE SATISFACTION
- MORE POWER OPTIONS
- INCREASED AVAILABILITY & RELIABILITY
- LOWER POWER GENERATION PRICE
- MORE COMPETITION

# Distributed Energy Solutions Applications

- Uninterruptible Power Supplies
- Power Supplies for Wireless Communications and Emergency Management Systems
- Network Load Management
- Generation Load Management
- Energy Production Efficiency


Syngas
Untreated Biogas
Hot Gas Clean-up
Gasifier
Air
Gas Turbine
G
Flue Gas
Process Steam
Heat Recovery Steam Generator
Steam Turbine
G
Raw Biomass Storage Place
Dryer
Air
Biomass Delivery
Steam
IMTE AG

Introduction

Distributed Power Generation

# Hybrid Power Plants - Introduction

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Biogas Power Plants

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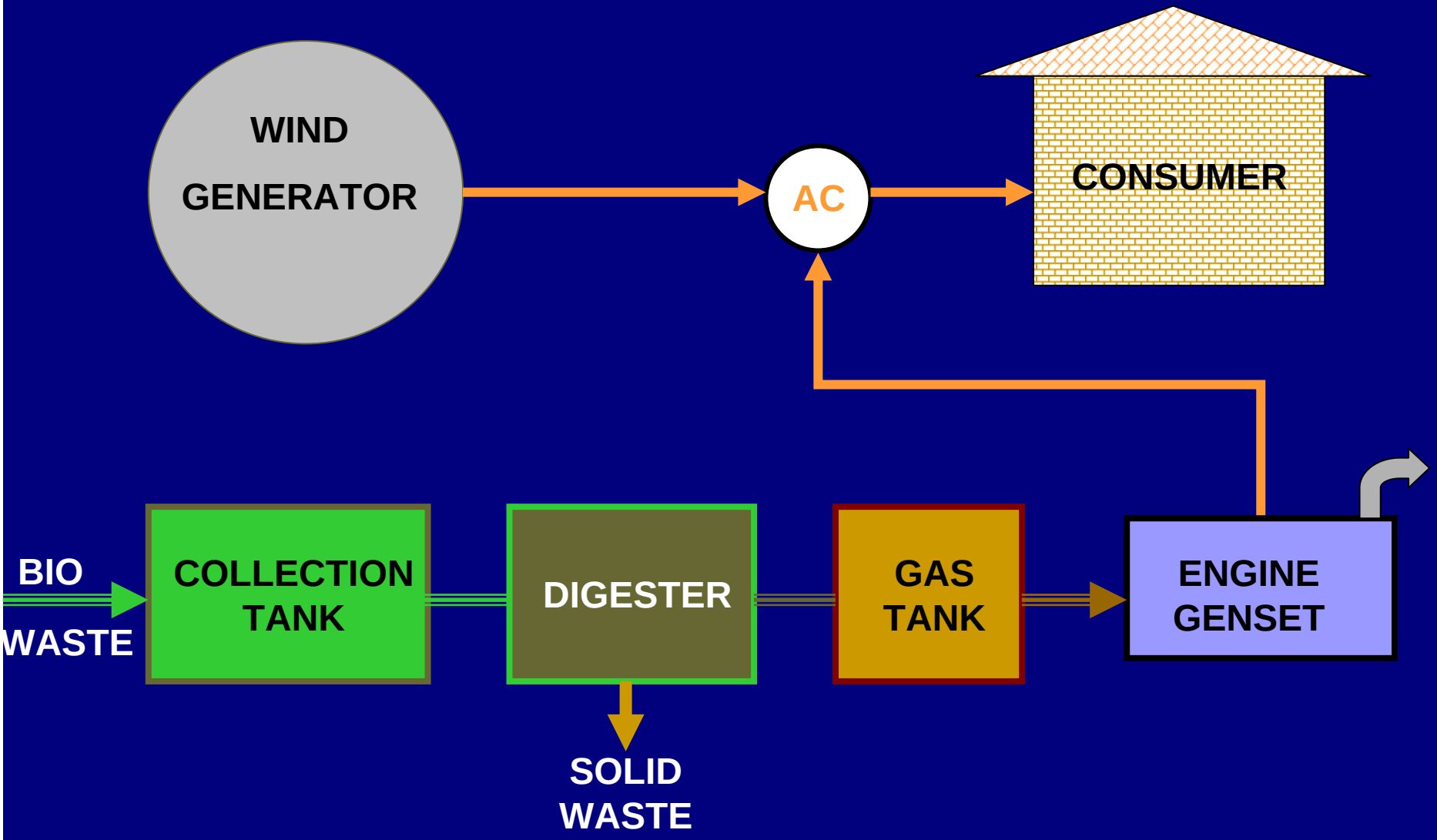
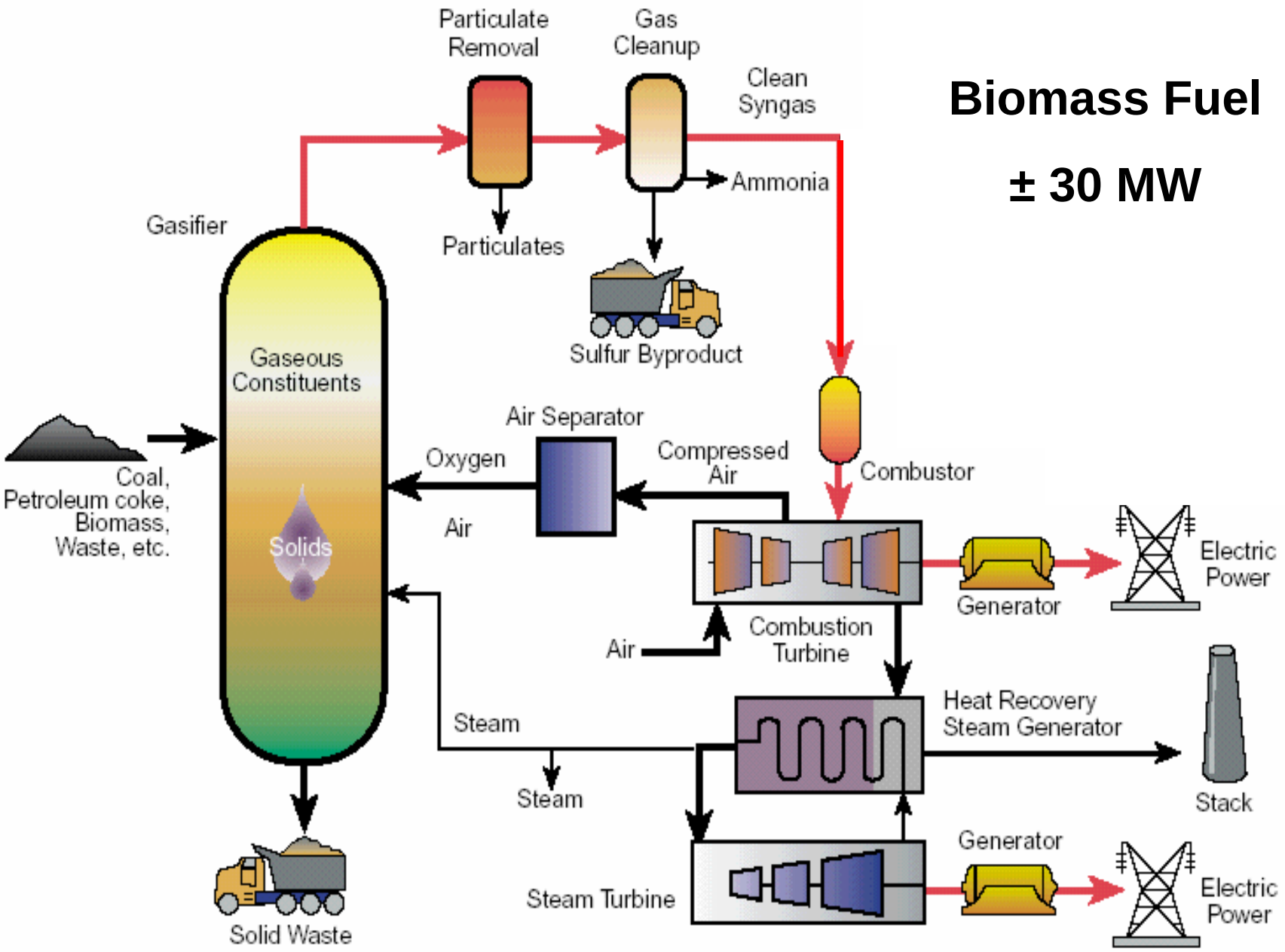
- Hybrid energy systems combine two or more different power generation applications.

- Hybrid energy systems combine two or more different power generation applications.
- When integrated, these systems overcome limitations inhered in either one.

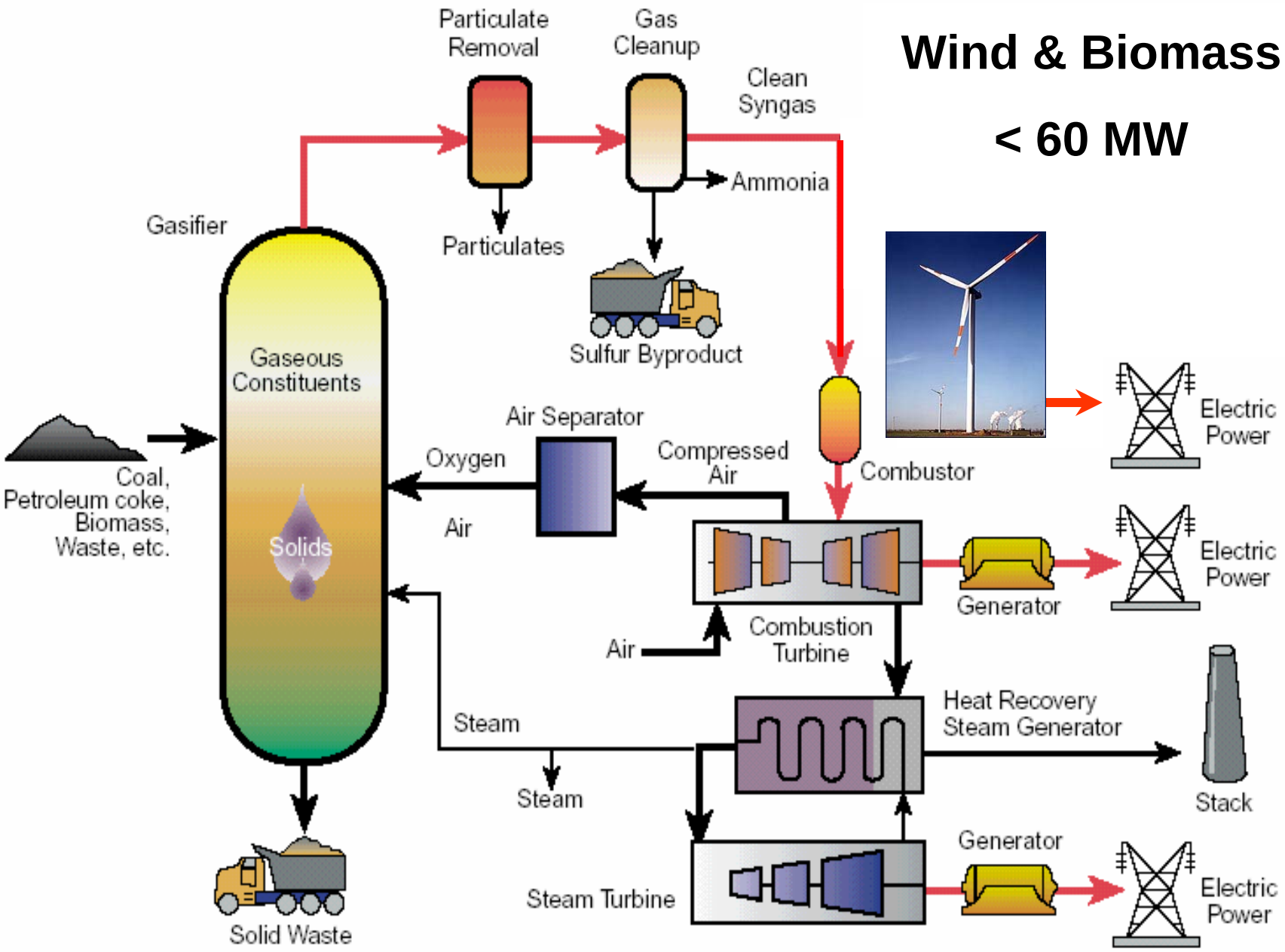
# < 1000 kW


WIND
GENERATOR
AC
CONSUMER
BIO
WASTE
COLLECTION
TANK
DIGESTER
GAS
TANK
ENGINE
GENSET
SOLID
WASTE


Particulate Removal
Gas Cleanup
Clean Syngas
Ammonia
Particulates
Sulfur Byproduct
Gasifier
Gaseous Constituents
Solids
Coal, Petroleum coke, Biomass, Waste, etc.
Air Separator
Oxygen
Air
Compressed Air
Combustor
Combustion Turbine
Generator
Electric Power
Air
Steam
Steam
Heat Recovery Steam Generator
Stack
Solid Waste
Steam Turbine
Generator
Electric Power
Biomass Fuel
± 30 MW

# Wind & Biomass

## < 60 MW



# Biogas - Wind

# 10 kW – 1 MW

**Main Limitation:**

**Balance betwen Windpower & Biopower**

# Biomas/Syngas - Wind

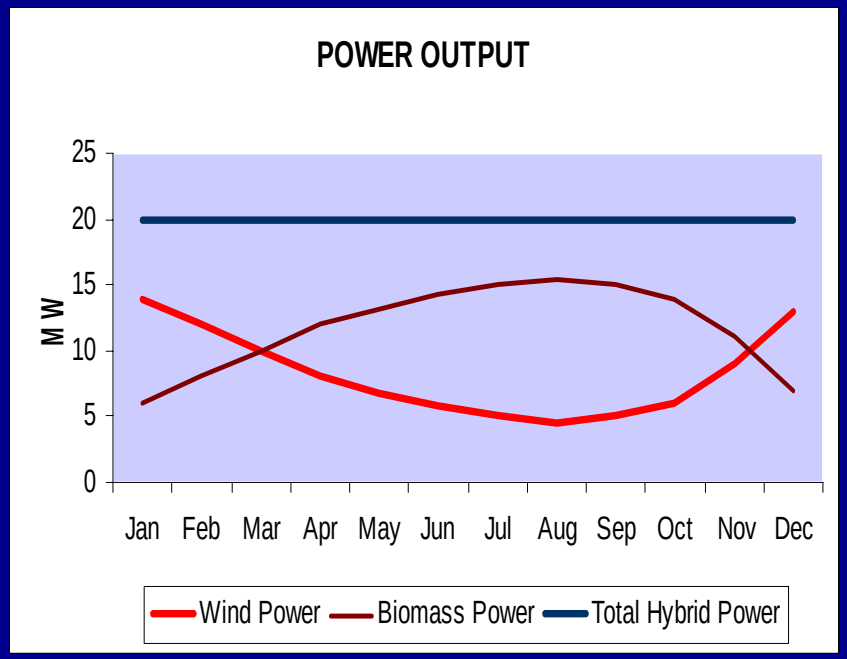
# 20 – 60 MW

**Main Limitations:**

**Biomass Suply**

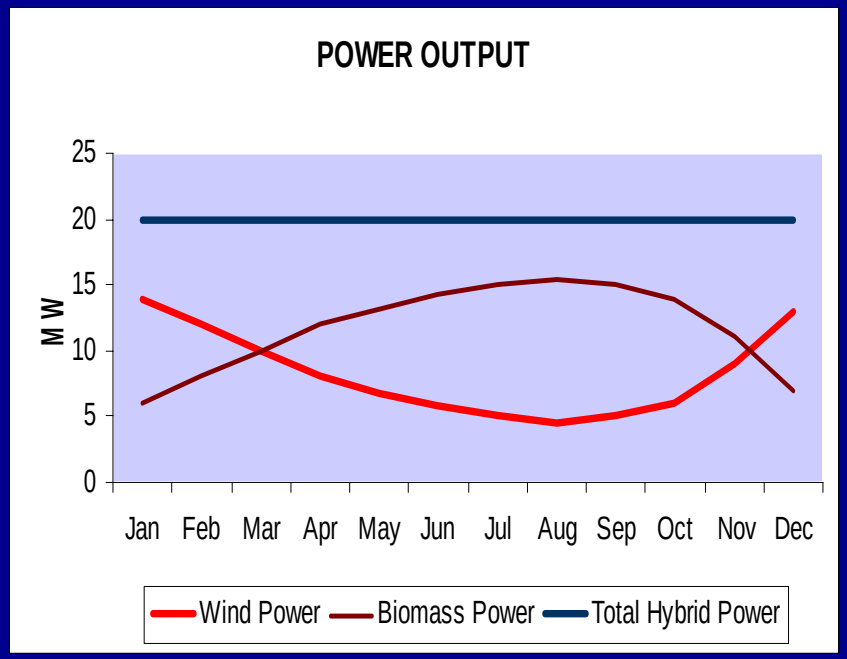
**Balance between Windpower & Biopower**

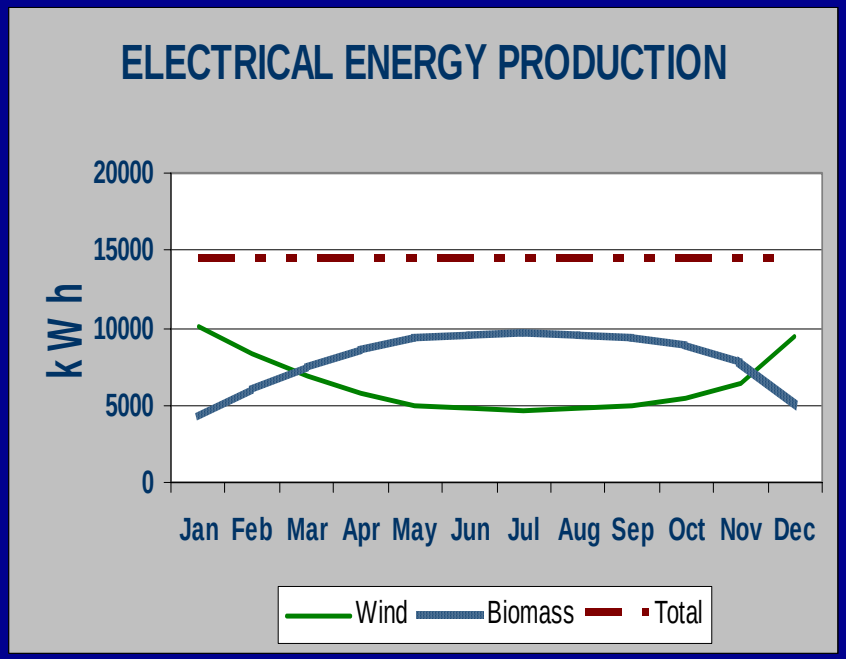
# HYBRID POWER PLANTS



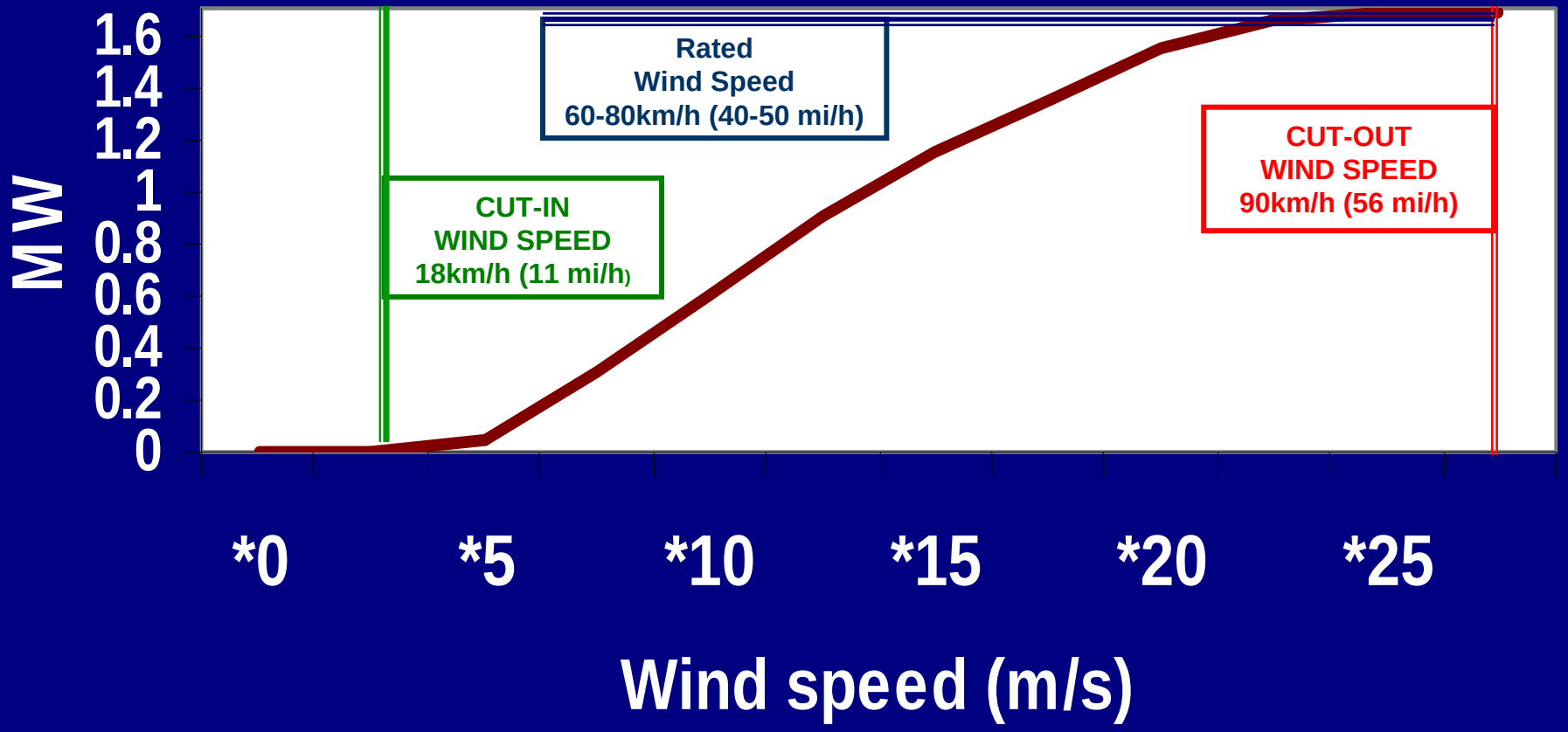
# HYBRID POWER PLANTS

## 12x1.6 $MW_{WIND}$ +15 $MW_{BIOMASS}$



# Wind Speed vs. Power Generation



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# Syngas Power Plants

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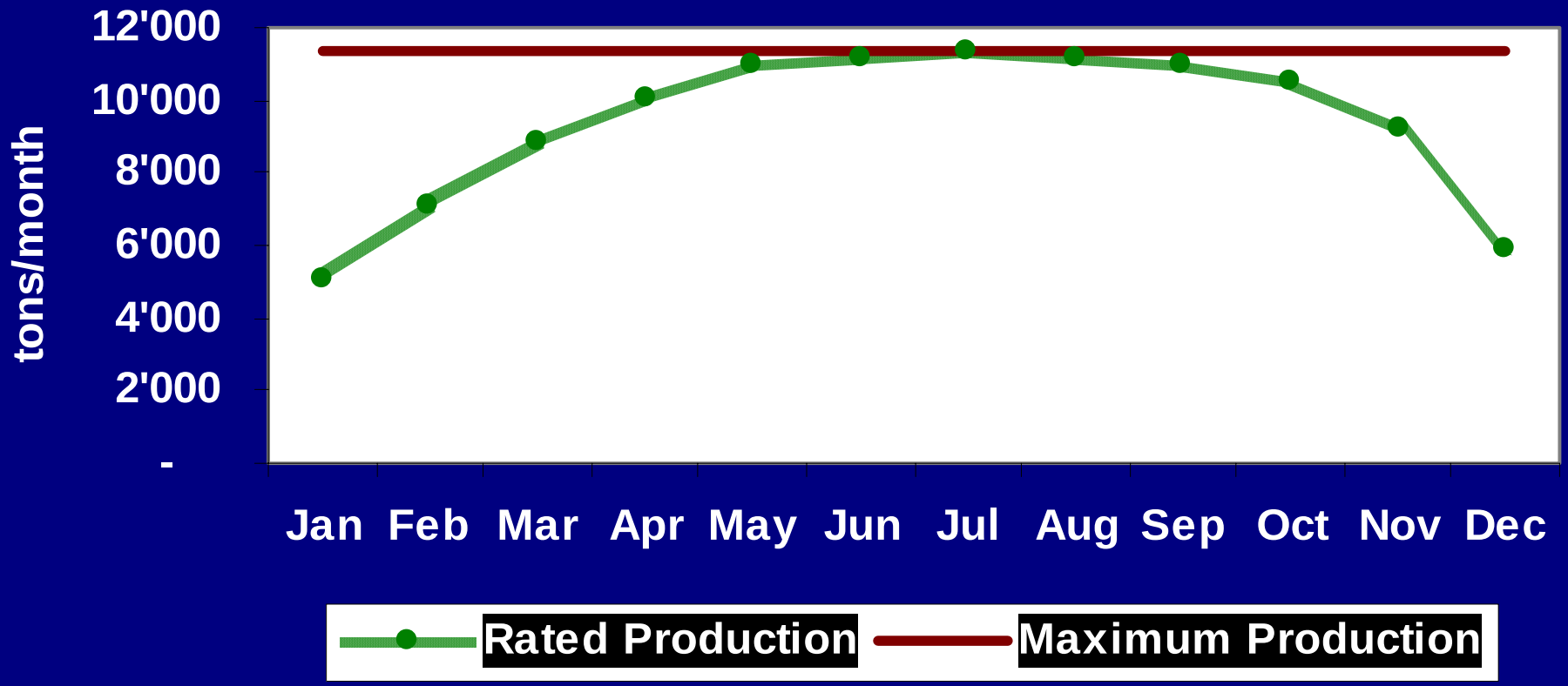
# 5 – 30 MW

**Main Limitation:**
**Biomass Supply**

# 15 MW SYNGAS PLANT

## Biomass Consumption



# Solid fuel gasification is enjoying a steeply growing market share.

**Solid fuel gasification is enjoying a steeply growing market share.**

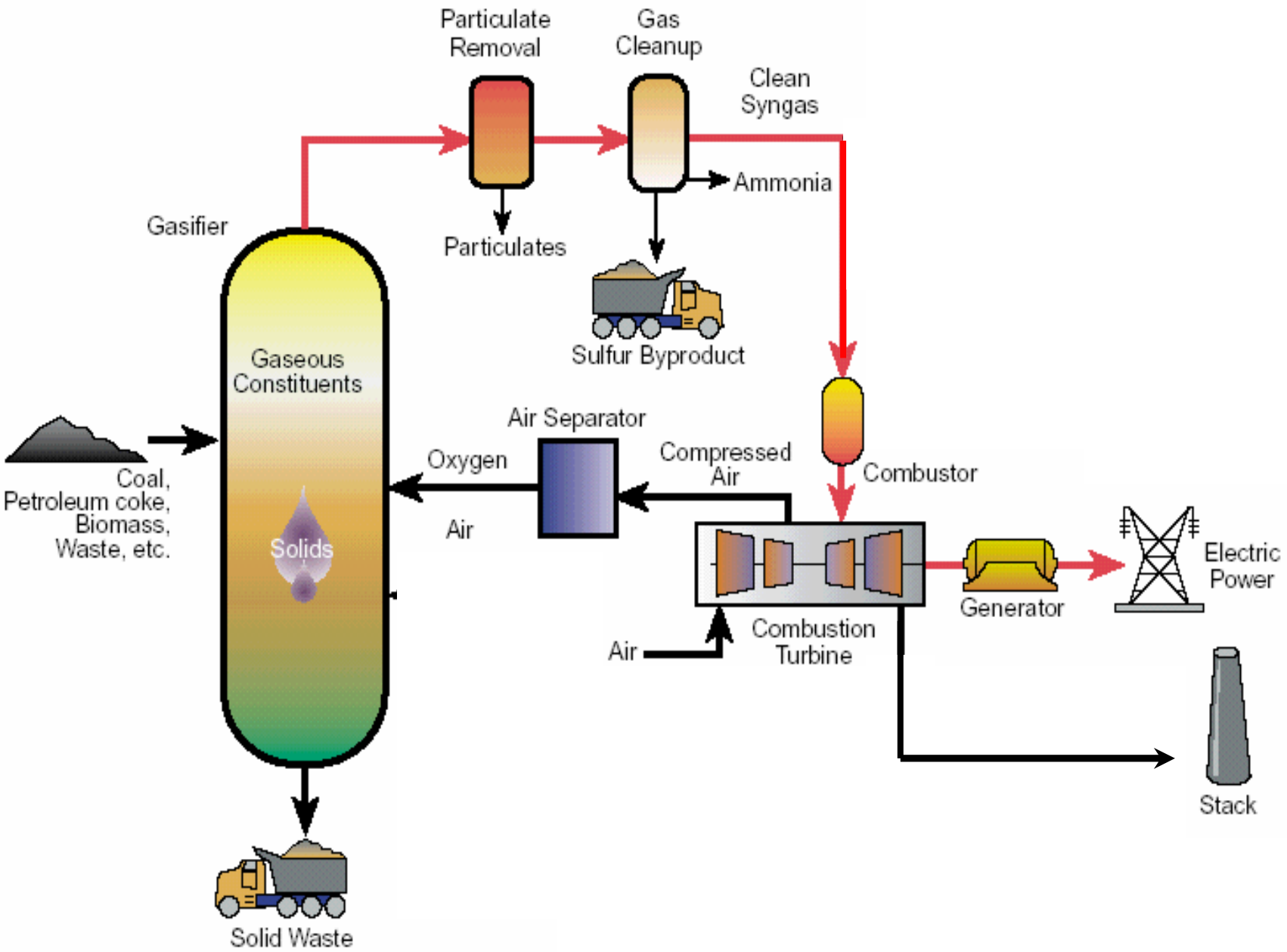
**Due to high investment costs the biomass gasification market is not following this trend yet.**

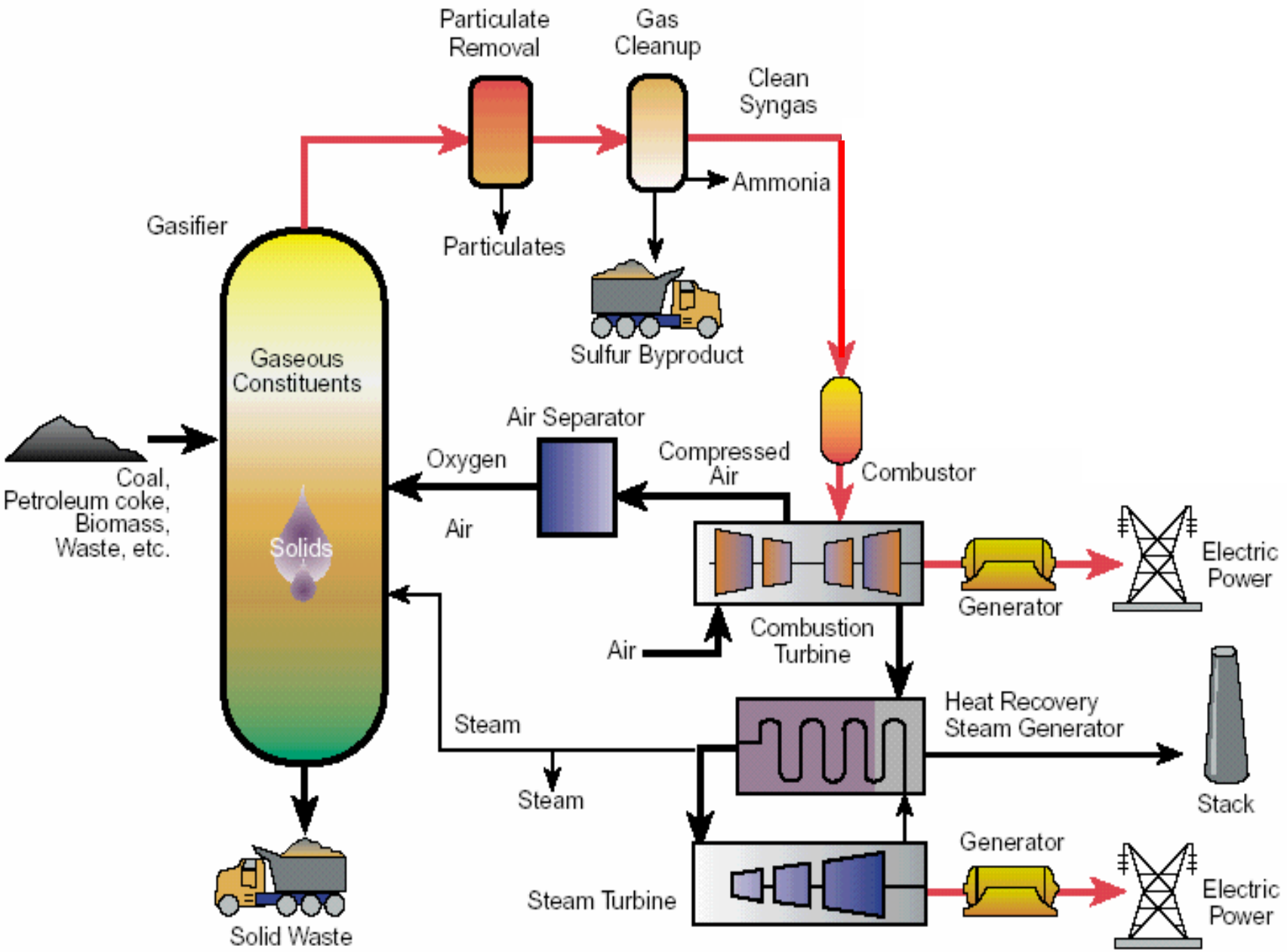
# Strong growth of biomass gasification can be expected

# in

# 5-10 years' time

# when the costs are further decreased, and commercial risks reduced


Particulate Removal
Gas Cleanup
Clean Syngas
Ammonia
Particulates
Gasifier
Sulfur Byproduct
Gaseous Constituents
Air Separator
Oxygen
Compressed Air
Combustor
Coal, Petroleum coke, Biomass, Waste, etc.
Solids
Air
Generator
Electric Power
Air
Combustion Turbine
Stack
Solid Waste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Gas Cleanup
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Sulfur Byproduct
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Oxygen
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Solids
Air
Generator
Electric Power
Air
Combustion Turbine
Heat Recovery Steam Generator
Steam
Steam
Stack
Generator
Steam Turbine
Electric Power
Solid Waste

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# <500 kW

## Main Limitation:

## Digester Size

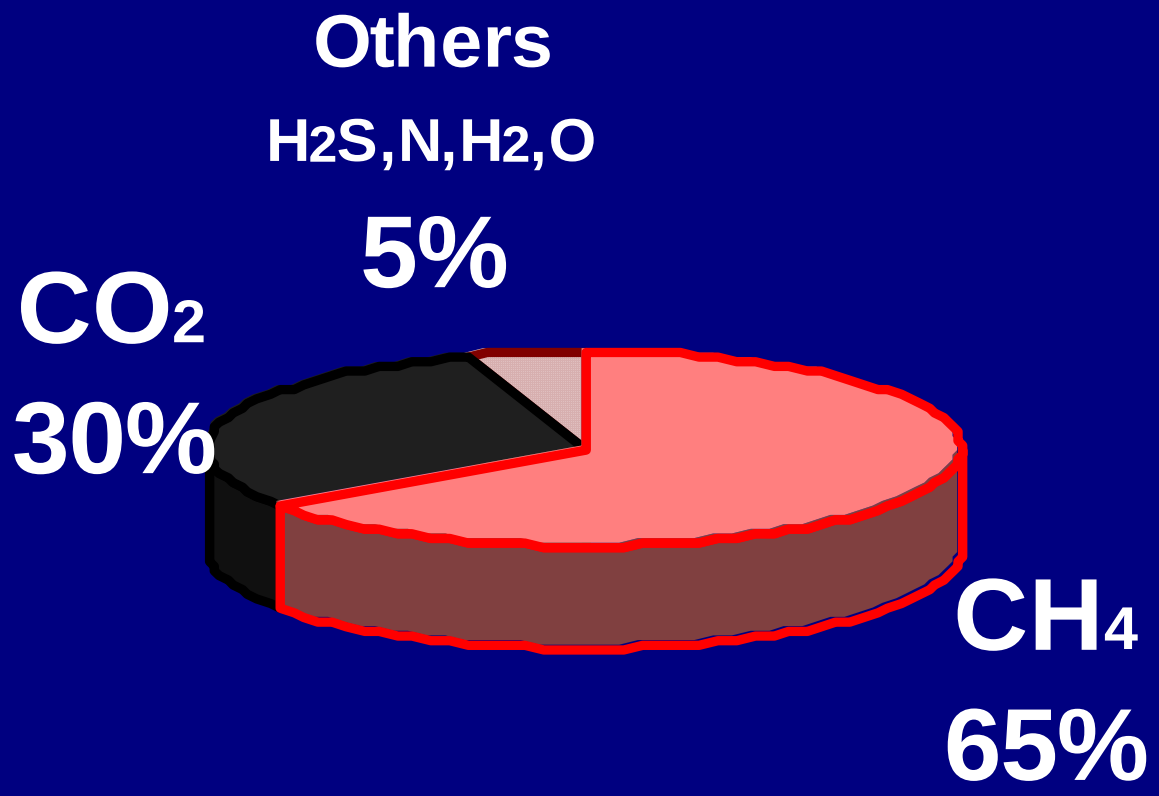
# Typical Parameters

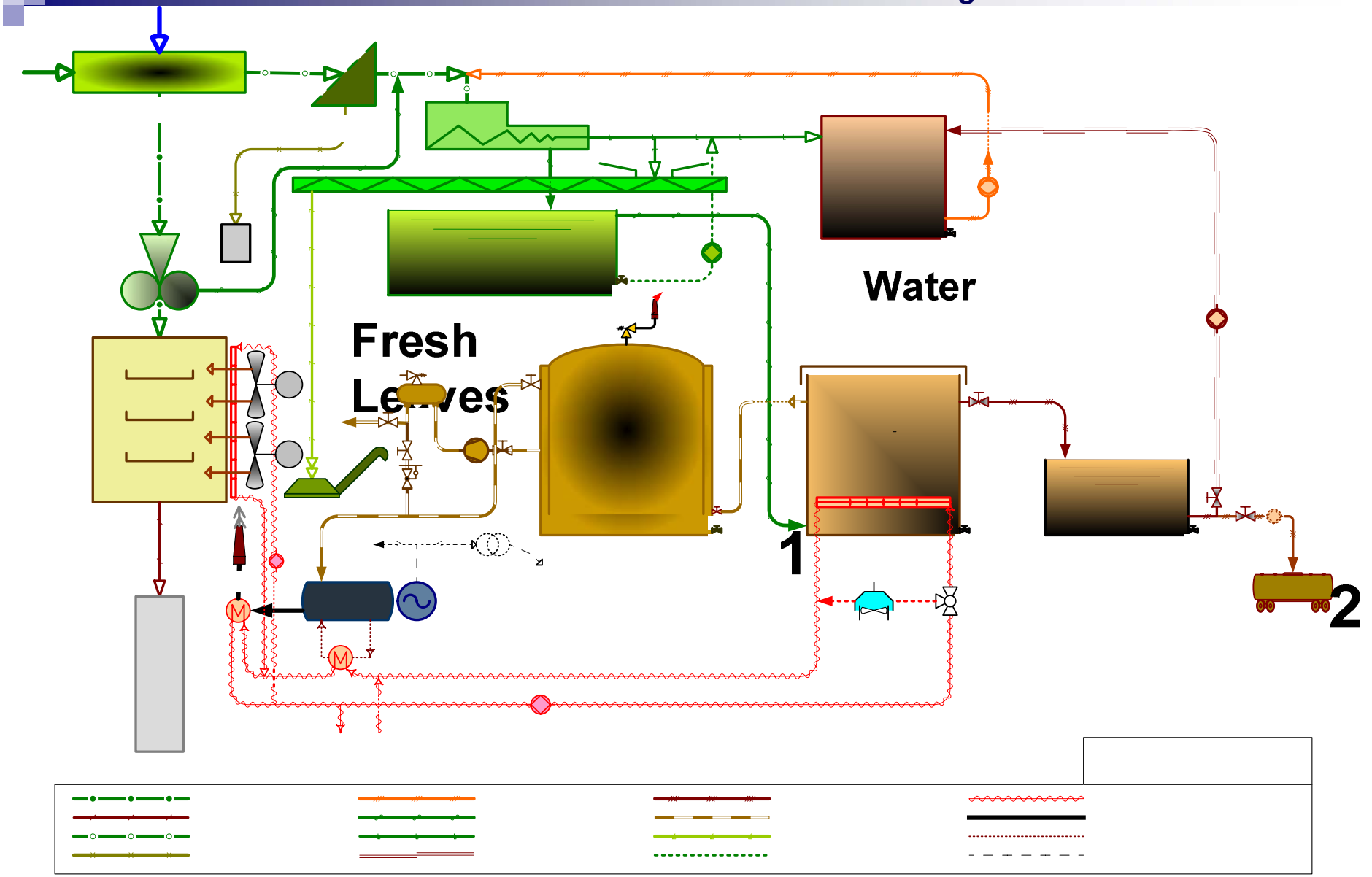
**Biogas-production**
**~ 0.3 - 0.45 $m^3$ / kg TS**

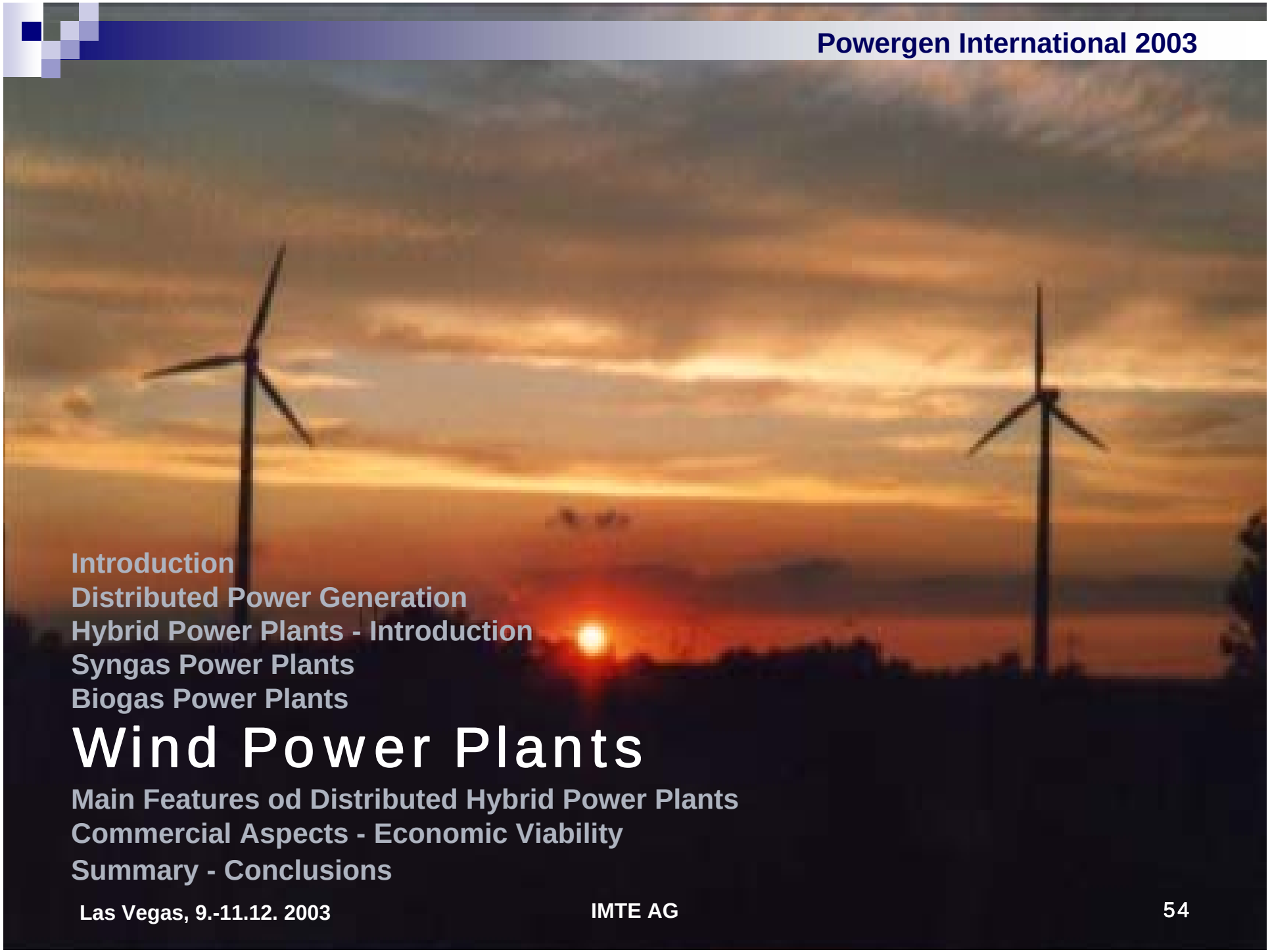
**Retention time**
**15-30 days**

**Average lower heating value**
**~ 22 $MJ/m^3$**

# Typical Biogas Composition




Water
Fresh
Leaves
1
2



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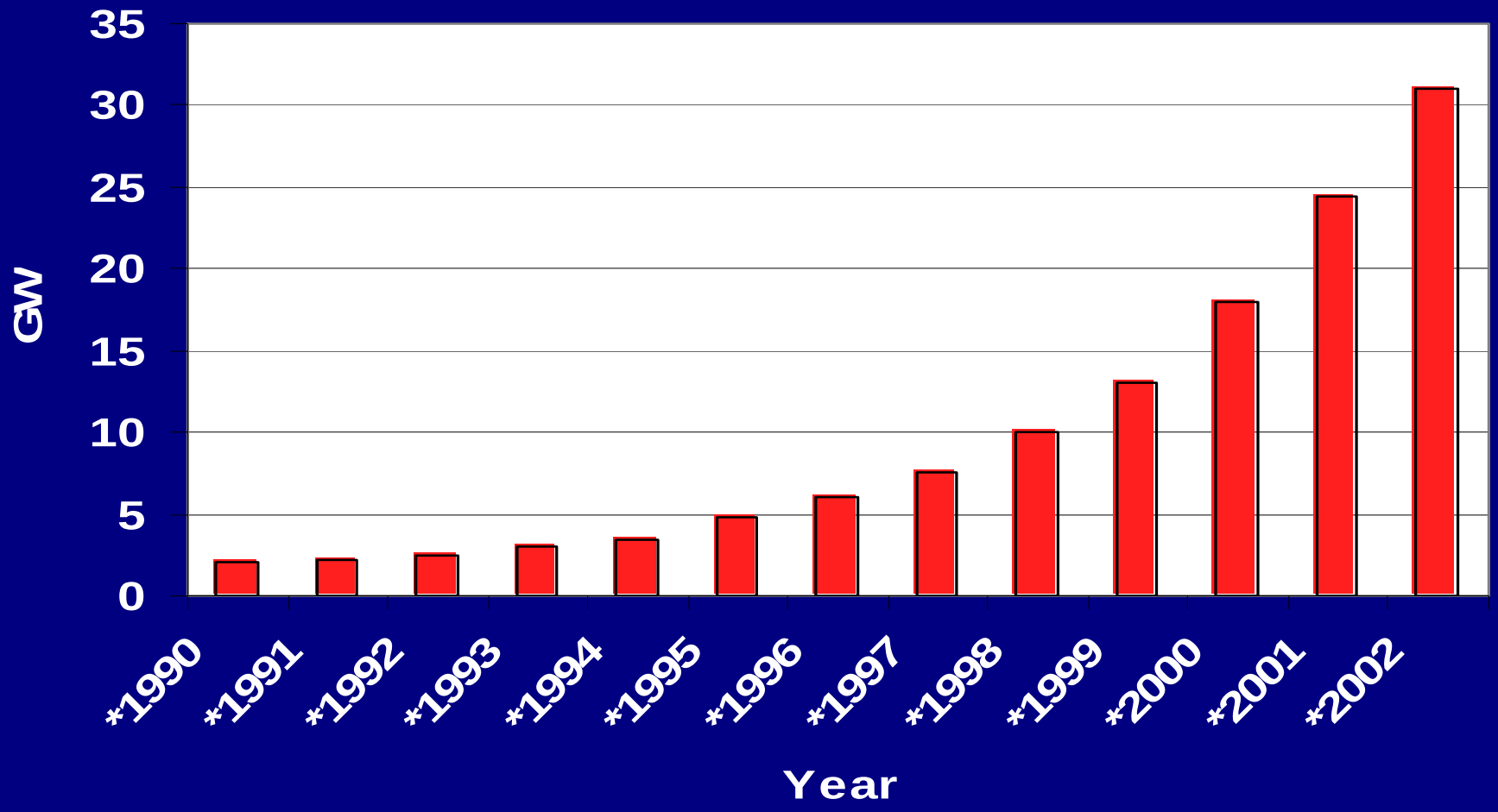
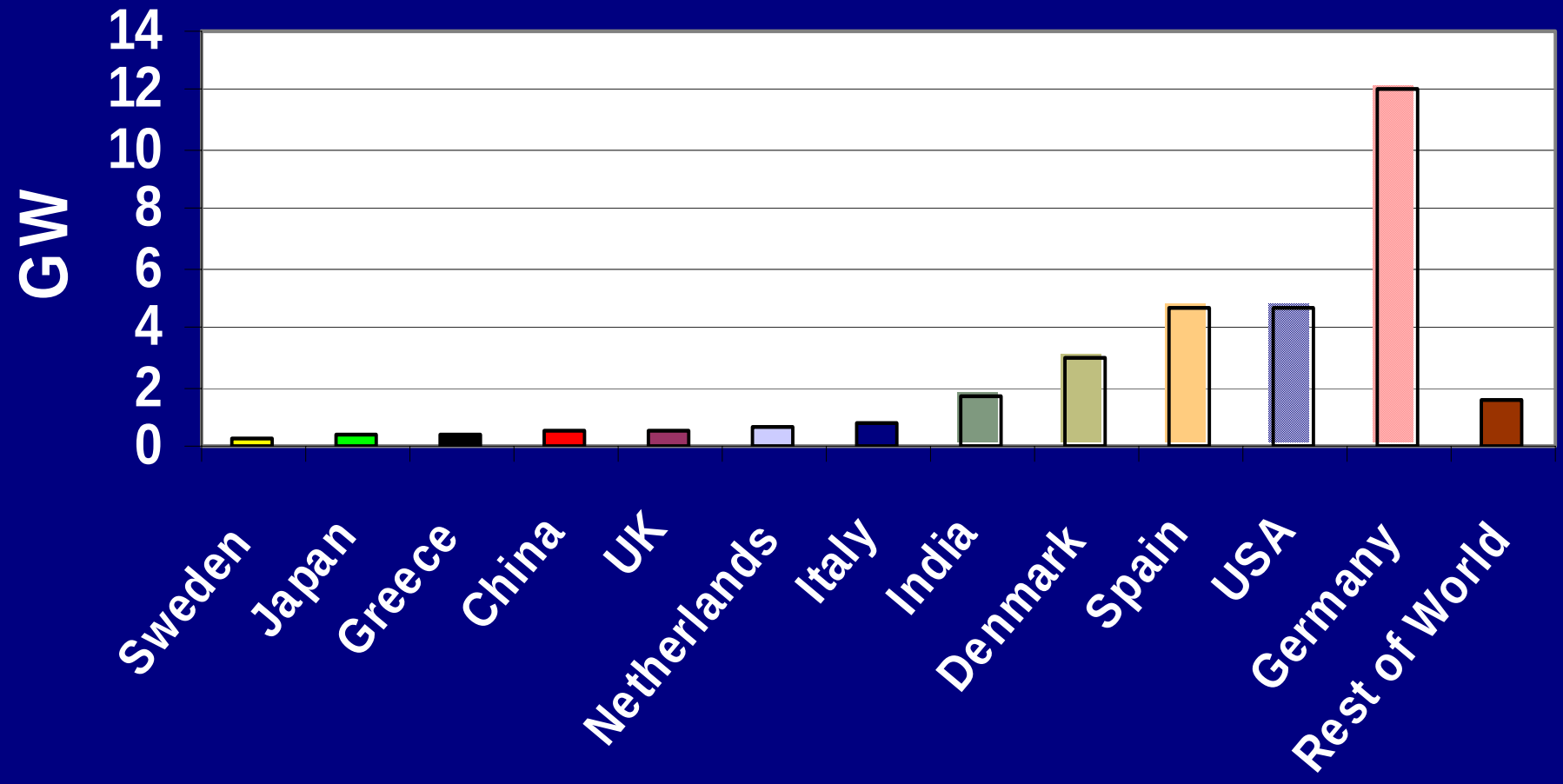
# PLANT OUTPUT DEPENDS ON AVAILABLE LAND AREA AND SELECTED UNIT SIZE

## Unit Size
## 1 kW and 4.5 MW

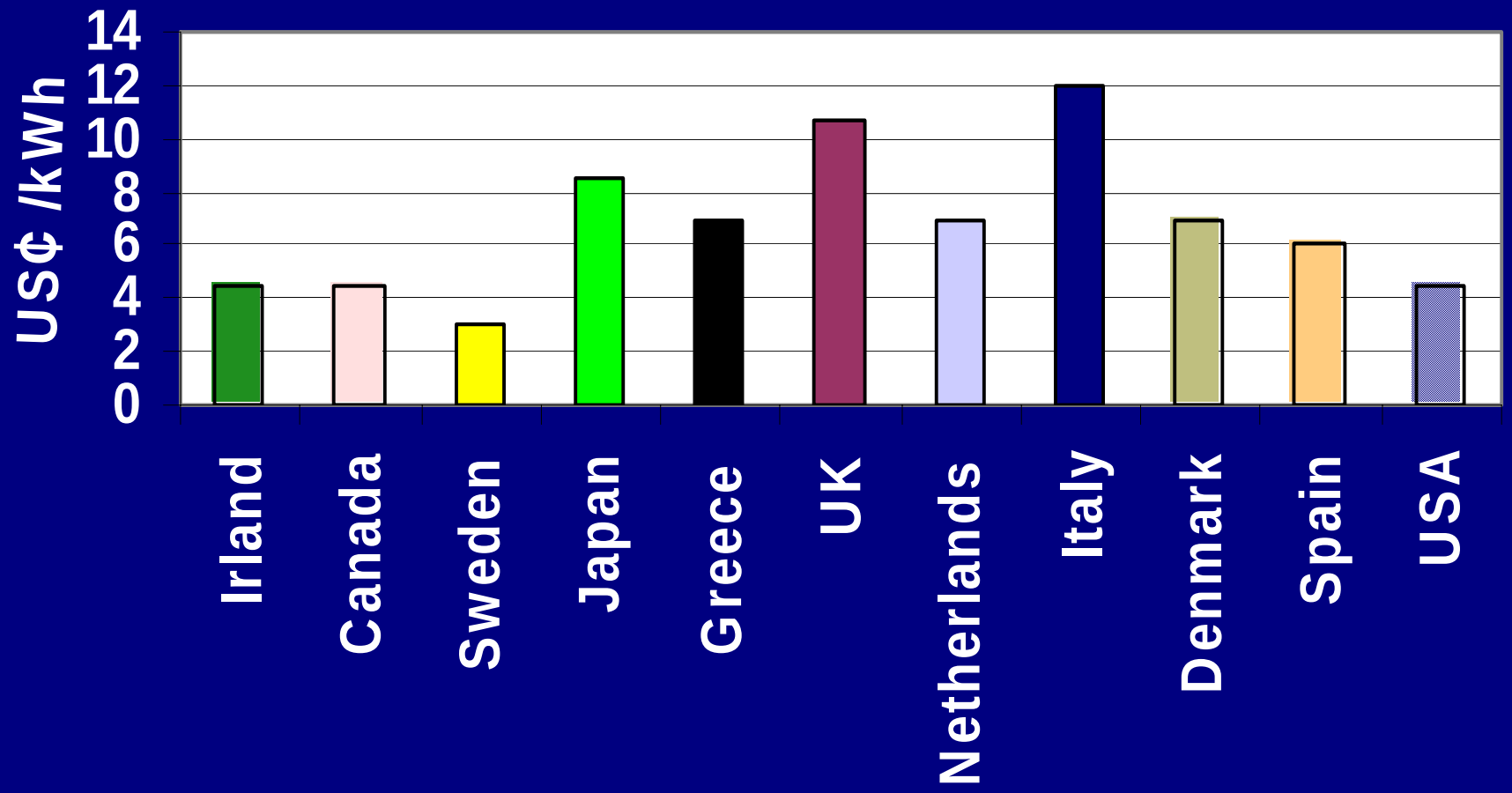
# WORLDWIDE WIND POWER GENERATION CAPACITY



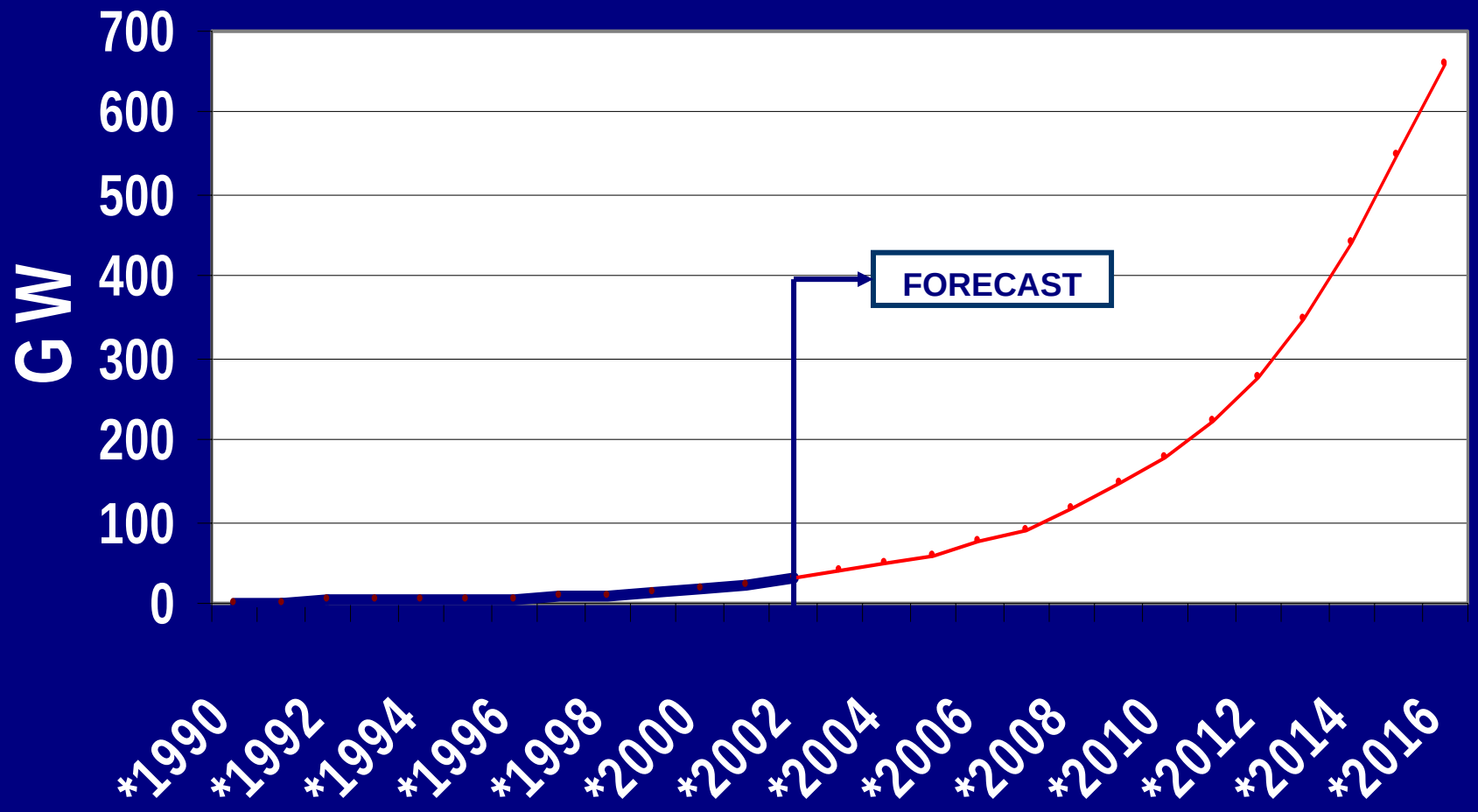
# MAJOR WIND GENERATORS - 2002

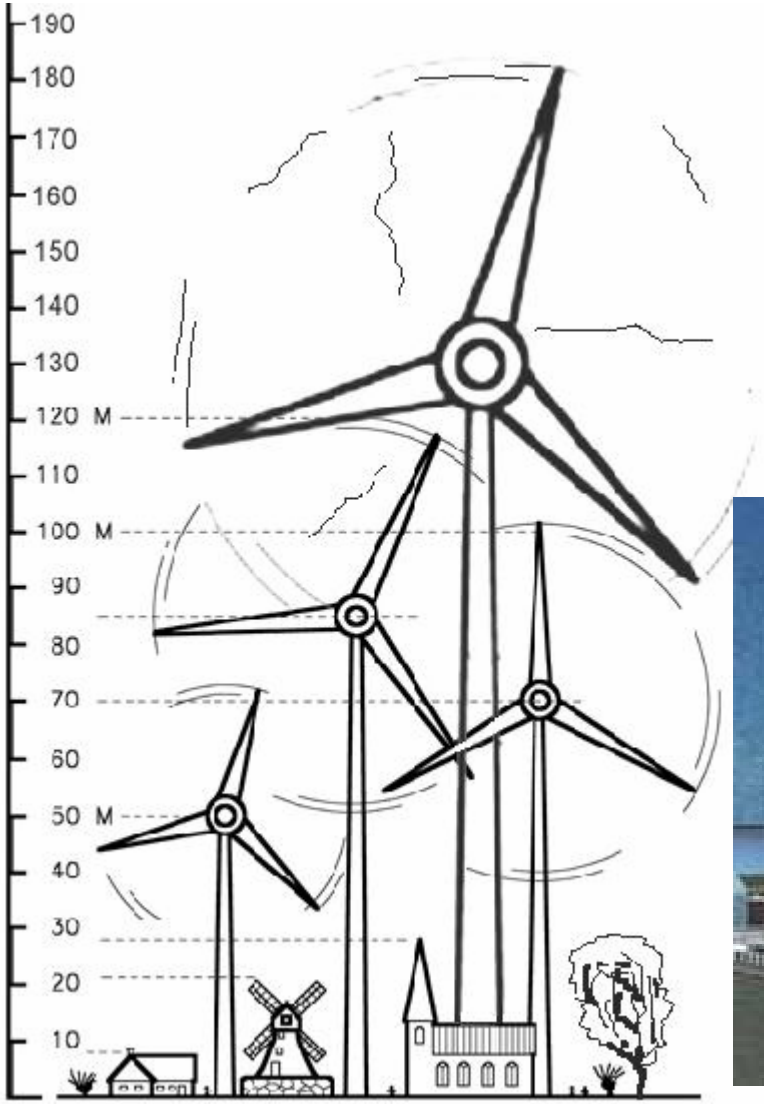


# kWh PAID TO WIND GENERATORS - 2002



# WIND POWER CAPACITY GROWTH FORECAST




190
180
170
160
150
140
130
120 M
110
100 M
90
80
70
60
50 M
40
30
20
10

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# Distributed Energy

## PROVIDES REMOTE COMMUNITIES WITH COST EFFECTIVE ENERGY GENERATION AND SUPPLY OPTIONS

# Distributed Energy

**PROVIDES REMOTE COMMUNITIES WITH COST EFFECTIVE ENERGY GENERATION AND SUPPLY OPTIONS**

**DRIVES INVESTMENT IN LOCAL INDUSTRY AND BUSINESSES**

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**PROVIDES REMOTE COMMUNITIES WITH COST EFFECTIVE ENERGY GENERATION AND SUPPLY OPTIONS**

**DRIVES INVESTMENT IN LOCAL INDUSTRY AND BUSINESSES**

**MOVES REMOTE REGIONS TOWARD MORE SUSTAINABLE ENERGY MANAGEMENT**

# Distributed Energy

**PROVIDES REMOTE COMMUNITIES WITH COST EFFECTIVE ENERGY GENERATION AND SUPPLY OPTIONS**

**DRIVES INVESTMENT IN LOCAL INDUSTRY AND BUSINESSES**

**MOVES REMOTE REGIONS TOWARD MORE SUSTAINABLE ENERGY MANAGEMENT**

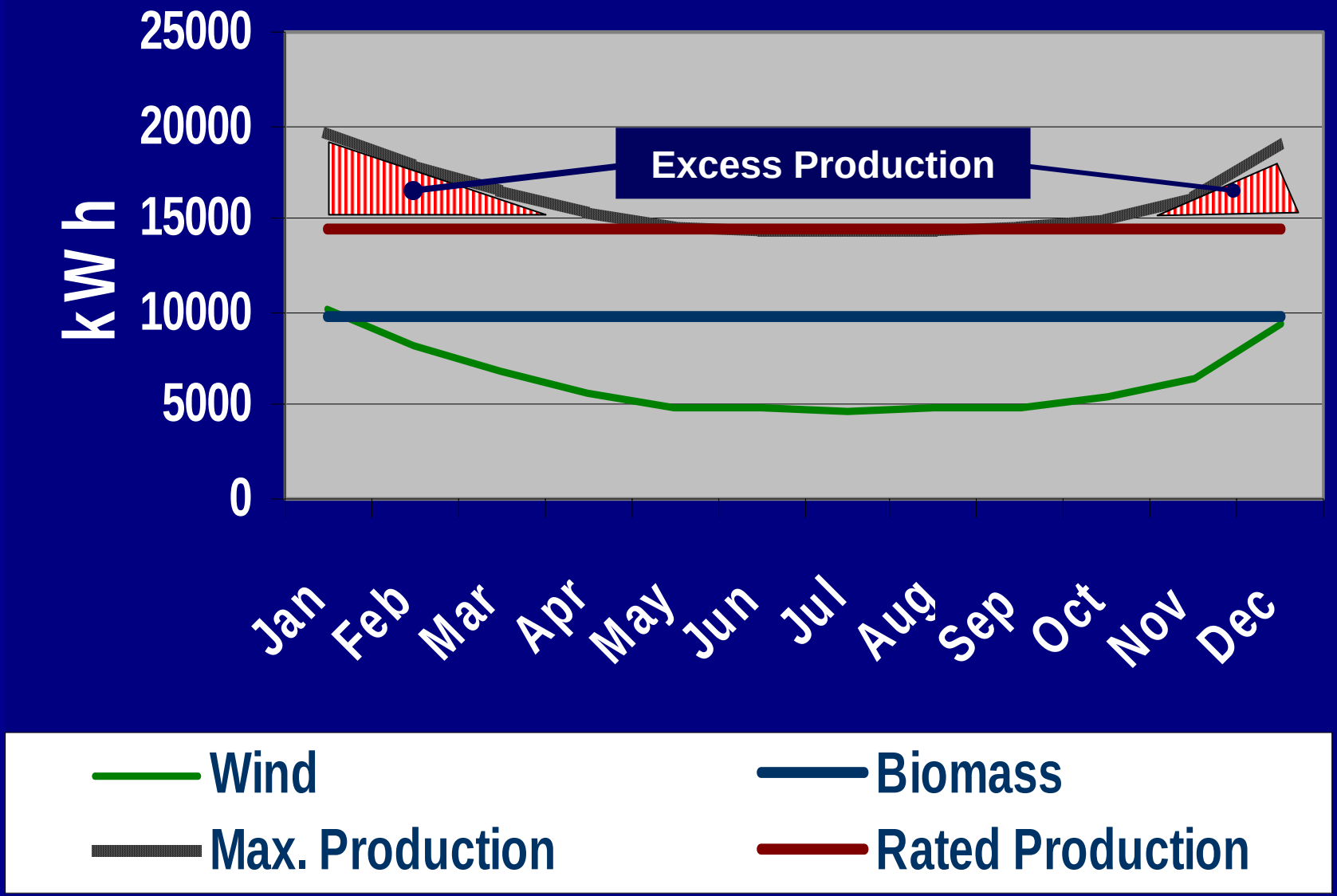
**PROVIDES OPPORTUNITIES FOR GREATER LOCAL CONTROL OF ELECTRICITY DELIVERY AND CONSUMPTION**

# Distributed Power Generation

**CAN PROVIDE INDEPENDENT FUL AND/OR BACKUP POWER AT CONSUMER's SITE**

**or**

**CAN BE HIGHLY INTEGRATED WITH ELECTRICITY NETWORK**


25000
20000
15000
10000
5000
0
kW h
Excess Production
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Wind
Biomass
Max. Production
Rated Production

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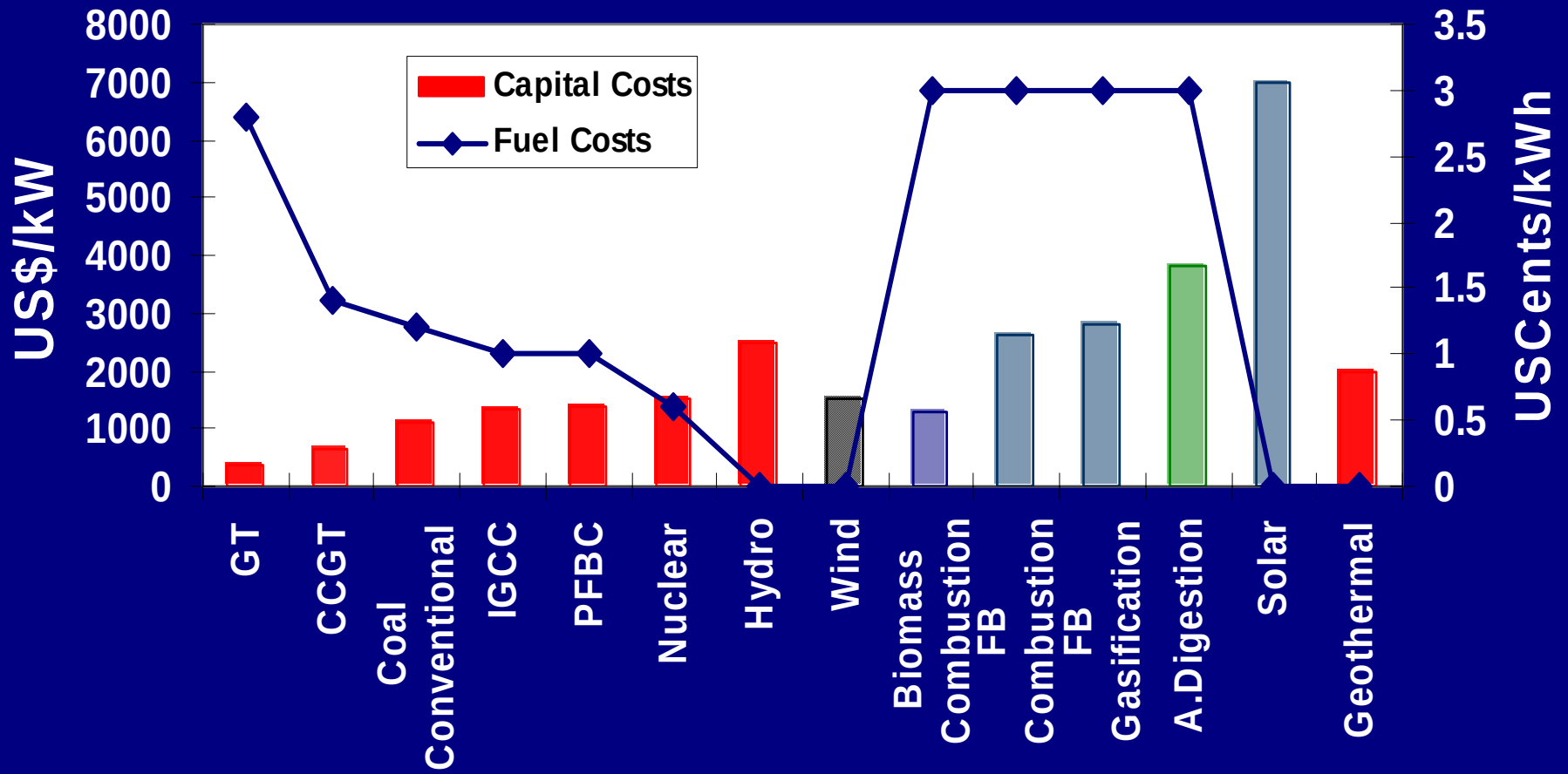
.

# Specific Capital Costs vs. Fuel Costs for Miscellaneous Power Generation Systems



# Price Estimation

**20 - 35 MW**

**Syngas – Windpower Plant**

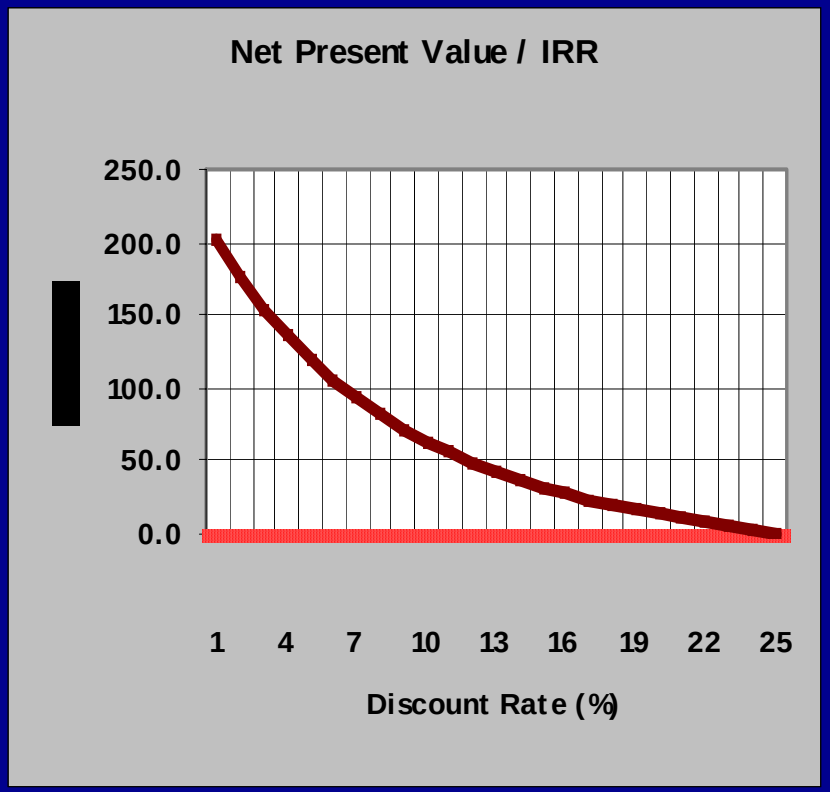
**1500 – 2000 USD / kW**

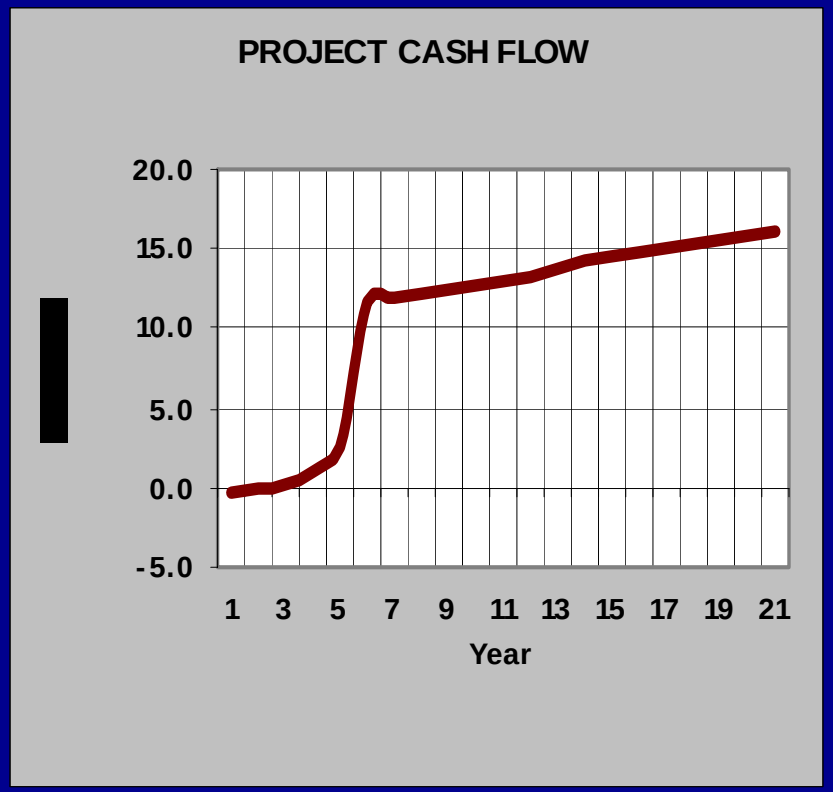
| Pos | Item | Unit | Price |
|---|---|---|---|
| 1 | Turnkey Price (EPC) | mio US$ | 44.00 |
| 2 | Site Preparation | mio US$ | 0.60 |
| 3 | O & M Mobilization | mio US$ | 0.50 |
| 4 | Contingency | mio US$ | 1.50 |
| 5 | Land Costs | mio US$ | 1.00 |
| 8 | Reimbursed Development | mio US$ | 1.80 |
| 9 | Insurance | mio US$ | 0.60 |
| 10 | Consultants' and Advisors' Fees | mio US$ | 1.00 |
| 13 | Financing Fees | mio US$ | 0.50 |
| 14 | Interest during Construction | mio US$ | 1.50 |
| 15 | TOTAL | mio US$ | 53.00 |

- Changes in interest rates and fees;
- Variation in exchange rates;
- Changes in applicable laws;
- Changes in imposition of any taxes;
- Project delay beyond the control of the Investor;
- Changes in financing draw-down schedule;
- Variations in scope of supply;
- Events or circumstances not within reasonable control of the Investor.

| Pos | Item | Unit | Worst Case | Best Case |
|---|---|---|---|---|
| 1 | Gross Power Output | MW | 20 | 35 |
| 2 | Degradation factor | % | 2 | 2 |
| 3 | Power Plant Availability | % | 88 | 92 |
| 4 | Capacity Factor | % | 55 | 90 |
| 5 | Expected PPA Tariff | US$/kWh | 0.165 | 0.168 |
| 6 | Fixed O & M Escalation | %/Year | 1.00 | 0.75 |
| 7 | Variable O&M Escalation | %/Year | 1.50 | 1.00 |
| 8 | PPA Tariff & Capacity Escalation | %/Year | 0.00 | 0.25 |
| 8 | Biomass Price Escalation | %/Year | 0.25 | 0.12 |
| 9 | Auxiliary Consumption | % | 1.8 | 1.8 |
| 10 | Hybrid Plant Efficiency | % | 45 | 80 |
| 11 | Operational Months | No. | 12 | 12 |
| 12 | Biogas/syngas LHV | $MJ/m^3$ | 20 | 22 |
| 13 | Biogas/syngas production | $m^3$/kg SW | 0.35 | 0.45 |
| 14 | Assumed Solid waste Price | US$/ton | 3 | 2 |

# IRR & Casfflow
## (0.225 USD/kWh)



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# DISTRIBUTED HYBRID POWER SYSTEMS ARE EXCELLENT CHOISE FOR-

# COUNTRIES WITH LIMITED POWER NETWORK

**AND**

# RURAL HOMES, FARMS, RANCHES, SMALL FCTORIES, OR INDUSTRIES LIKELY TO PRODUCE AND USE RENEWABLE POWER

- Worldwide renewable energy portfolio standards;
- Energy tax credits tax incentives for development of renewable energy projects;
- Utilities should be encouraged to enter into long-term power purchase agreements with renewable energy power producers;
- Dissemination of distributed hybrid power systems advantages to the public;

**DISTRIBUTED POWER GENERATING SYSTEMS ENTAIL A SIGNIFICANT FIRST-COST EXPENDITURE……..**

**……..BUT BUSINESS THAT SUFFERS A POWER INTERRUPTION OR WHOSE POWER QUALITY DETERIORATES TO THE POINT THAT COMPUTER-RELATED OPERATIONS ARE COMPROMISED WILL LIKELY VIEW THAT COST AS JUSTIFIED.**

# THANK YOU

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