Ministry of Industry and Trade

Implemented by

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

Climate Protection through Sustainable Bioenergy Markets in Viet Nam (BEM)

Tobias Cossen
MOIT/GIZ Energy Support Programme

GIZ in Viet Nam

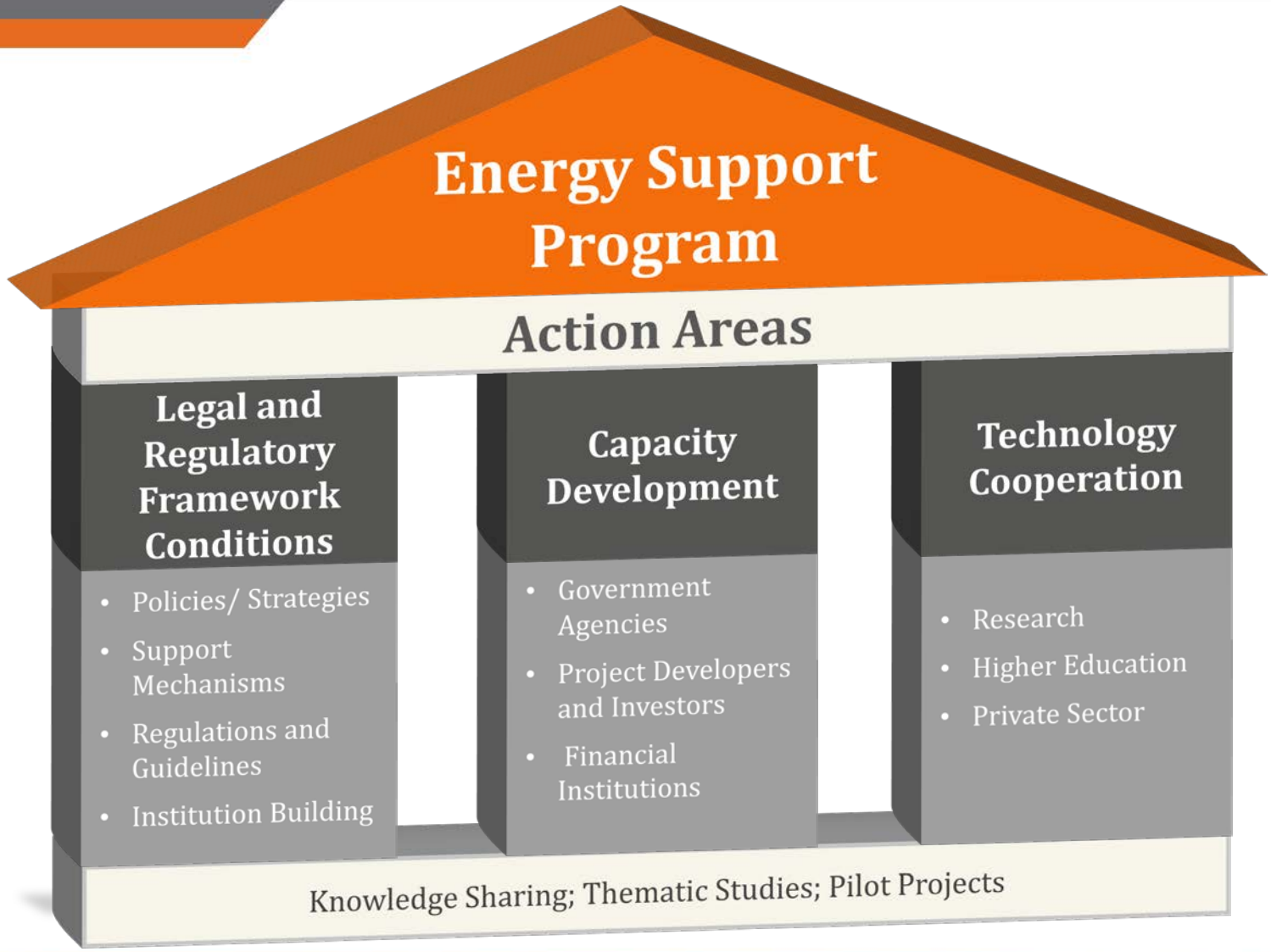
Context

2009
Start of the German development cooperation with a focus on wind energy

July 2013
(G2G consultations)
Energy becomes one of three priority areas of Vietnamese-German cooperation

Now
Mutually agreed strategic areas of cooperation: Renewable Energy and Energy Efficiency

Approach of the Energy Support Programme (ESP)



ESP Cooperation Partners

Co- and parallel financing

Hợp tác Đức
DEUTSCHE ZUSAMMENARBEIT

Key *national* partners

- **Ministry of Industry and Trade**
  - Electricity & Renewable Energy Authority (EREA)
  - Department of Energy Efficiency and Sustainable Development (DEESD)
  - Electricity Regulatory Authority of Viet Nam (ERAV)
  - Viet Nam Electricity (EVN)
- **Vietnam Wind Power & Sugar Associations**
- **Research & Academic Institutions**
- **VIET, GreenID, etc.**

Key *international* partners

Viet Nam Energy Partnership Group

KFW

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

Ministry of Foreign Affairs of Denmark
DANIDA | INTERNATIONAL DEVELOPMENT COOPERATION

Energy Situation in Viet Nam

From 1990 to 2015

From 2015 onwards

Viet Nam's energy success story

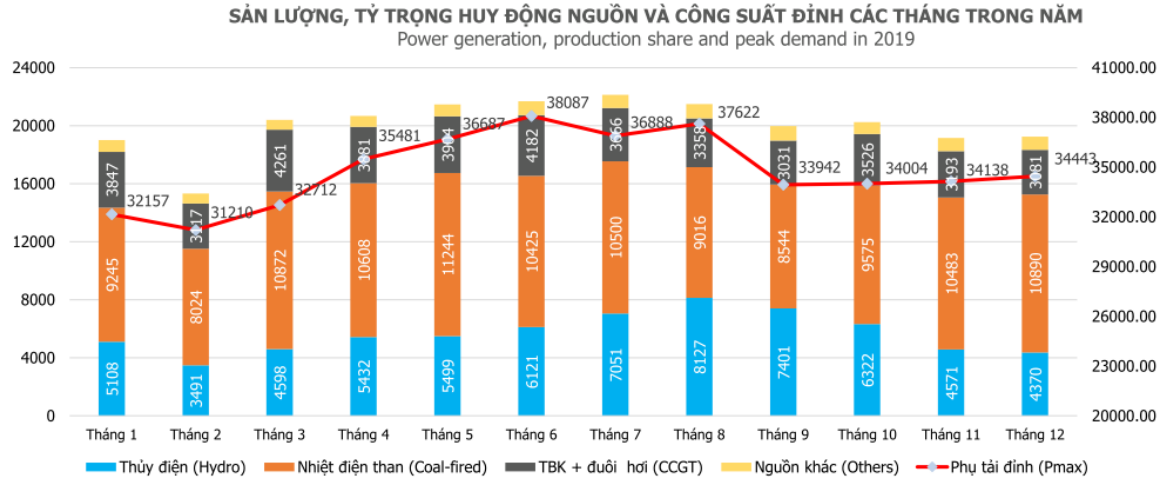
- High electrification rate (98%)
- Installation of ca. 39 GW of power generation (40% hydro)
- All investments publically funded

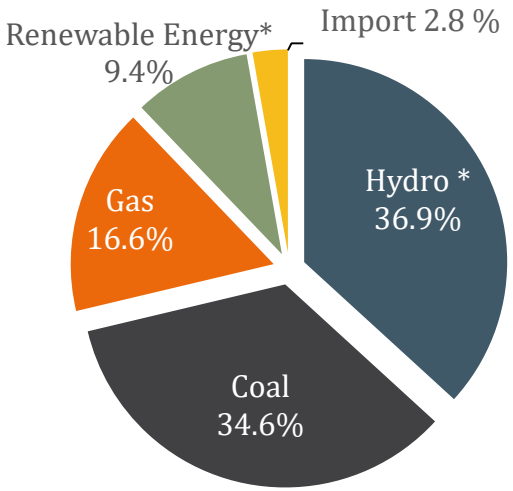
Viet Nam is still facing many challenges

- Persistent gap between economic and electricity growth rate
- Energy security and environmental/health concerns
- Public investments will not suffice to address future energy infrastructure requirements

Energy Situation in Viet Nam

Installed Generation Capacity (Mid 2019)





240.81 TWh

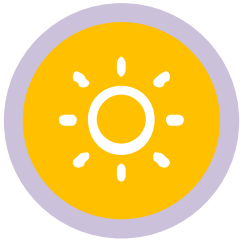
55 GW

Electricity Production (2019)

* Including small hydro power

Data Source: EVN NLDC (2019)

Renewable energy – incentive support mechanism

Solar	Wind	Biomass	Small Hydropower	MSW
				
US¢ 7.09/kWh FiT for ground-mounted	US¢ 8.5/kWh FiT for onshore	US¢ 7.03/kWh FiT for combined heat and power projects	AVCT	US¢ 7.28/kWh FiT for Landfill
US¢ 7.69/kWh FiT for floating solar	US¢ 9.8/kWh FiT for offshore	US¢ 8.47/kWh FiT for non-combined heat and power projects		US¢ 10.05/kWh FiT for Incineration
US¢ 8.38/kWh FiT for solar rooftops system			By year, by season, by region	
20 years	20 years	20 years	20 years	20 years
PPA	PPA	PPA	PPA	PPA

Note: **FIT** stands for **Feed-in tariff, AVCT** stands for **Avoided cost tariff.** The AVCT is calculated annually based on the production cost of the most expensive power plant in the power system.

Key policies and support mechanisms of biomass energy

Revised **National Power Development Plan VII (Revised PDP VII)**
for the 2011-2020 period with a vision to 2030

- Next to capacity targets specified for wind and solar, the share of electricity **produced from biomass sources** is expected to reach approx. 1% in 2020, **1.2% in 2025 and 2.1% in 2030.**

- Further development of biomass power sources through applying **cogeneration** method in sugar mills and food processing plants as well as co-combustion of biomass and coal in coal-fired power plants, etc.

- *The next PDP, PDP 8, is currently being developed for the period of 2021-2030 with the vision to 2045.*

The **Viet Nam Renewable Energy Development Strategy (VREDS)**
up to 2030 with a vision to 2050

- **Gradually increase the rate of access to clean energy and electricity sources** by local people in rural, mountainous, remote and border areas as well as islands.

- **RE production targets** including big hydro power will contribute 38% of total electricity production in 2020 and 43% in 2050. Solar power will play a major role in the RE share (20% in 2050) as well as **bioenergy (8.1% in 2050)** and wind (5% in 2050).

Decision number 24/2014/QD-TTg
by the Prime Minister

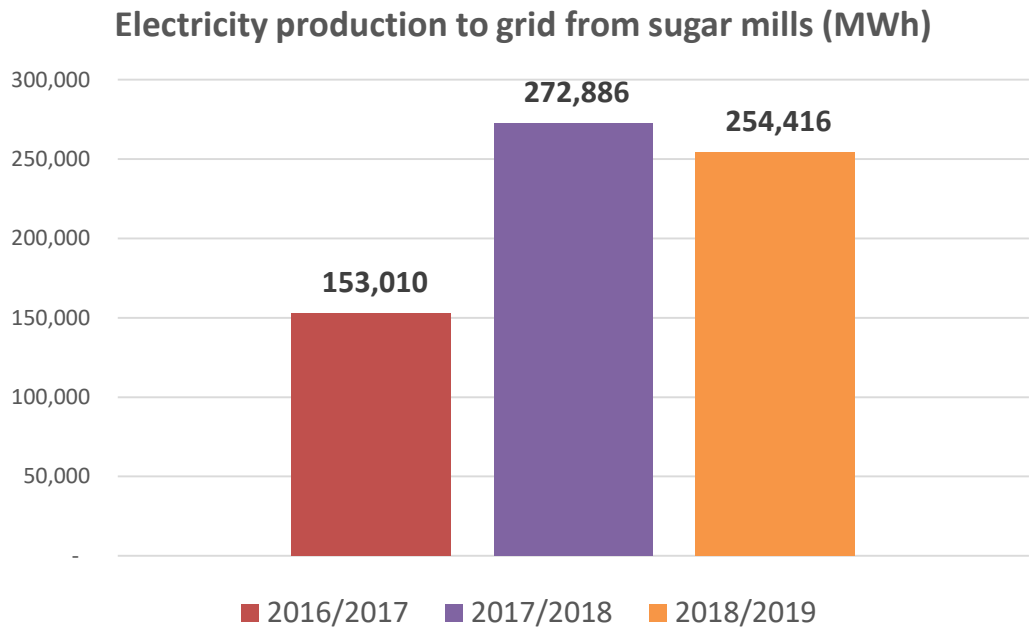
- Feed-in tariff (FIT) of 5.8 UScents/kWh applicable to **grid-connected biomass combined heat and power (CHP)** projects and an avoided cost tariff (AVCT) applicable to grid-connected biomass power projects.

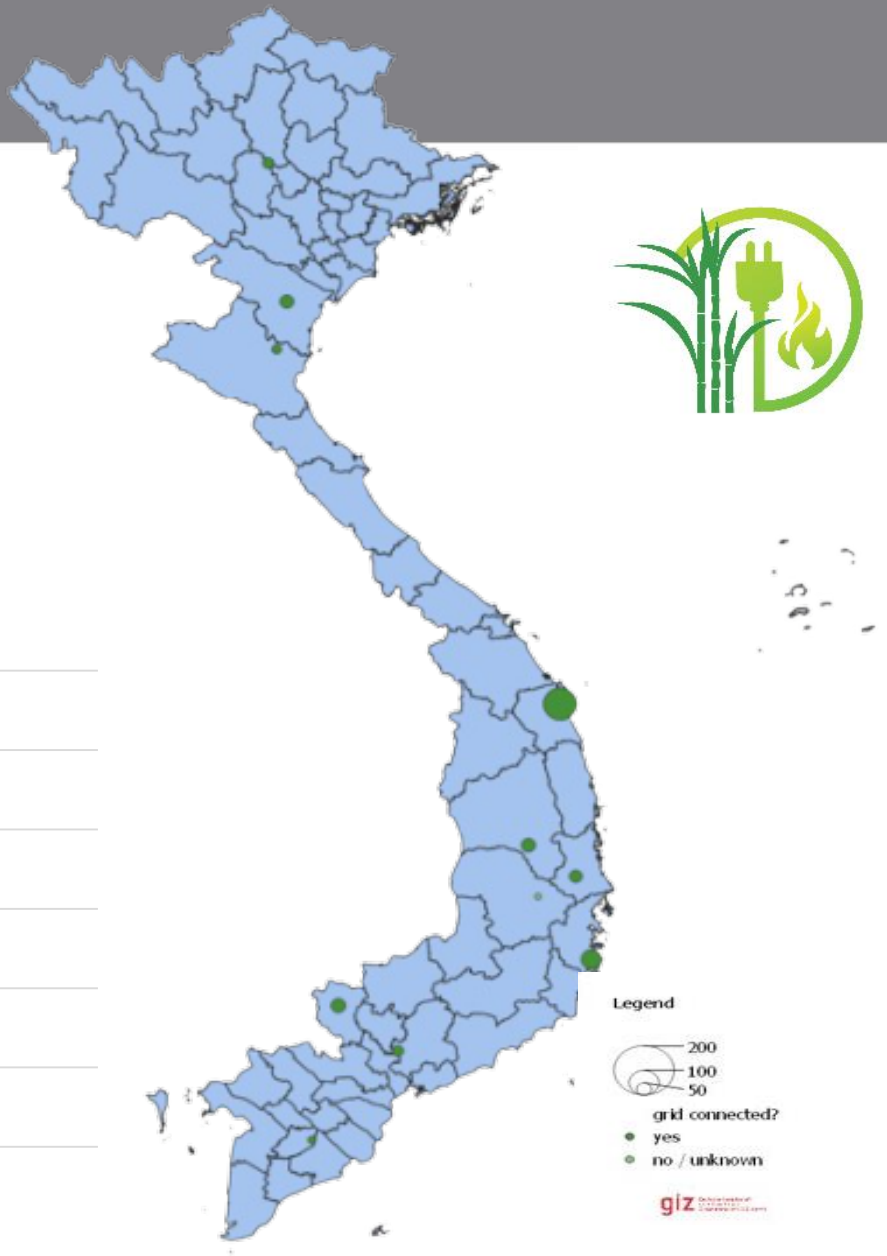
Decision No. 08/2020/QD-TTg
by the Prime Minister

- FiT of 7.03 US cents/kWh applied for **co-generation heat power** project; while the FiT of 8.47 US cents/kWh applied for **other types of biomass** projects.

Bioenergy in Vietnam

- There are **11** bioenergy plants in operation with **a total installed capacity** of **391.1 MW.** Thereof, only **197 MW** is generation capacity (**grid connected**).





Barriers to biomass energy development in Viet Nam

- Insufficient knowledge on state-of-the-art technologies and respective technology transfer partnerships to catalyze market development.

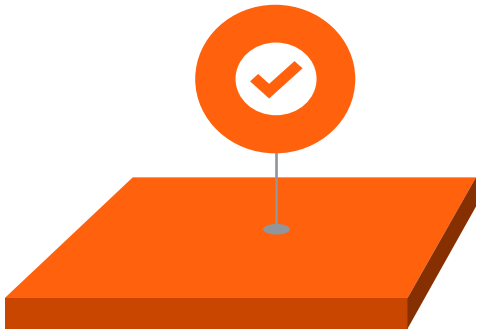
- Capacity shortage of provincial governments for timely planning and licensing procedures.

- Investors‘ lack of access to information and qualified experts to evaluate bioenergy projects‘ full potential and feasibility.

- Inadequate capacity of financial institutions in evaluating biomass energy projects; lack of access to financing mechanisms.

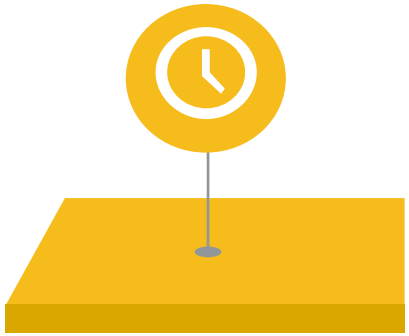
BEM project structure and objectives

About BEM project



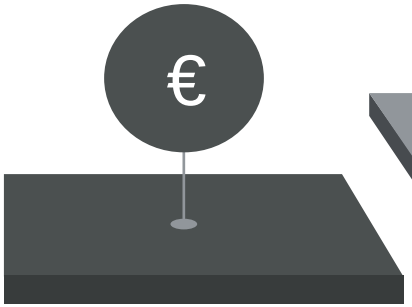
Objectives

The aim of BEM is to improve the preconditions for a **sustainable use of biomass for electricity and heat generation** in the country.



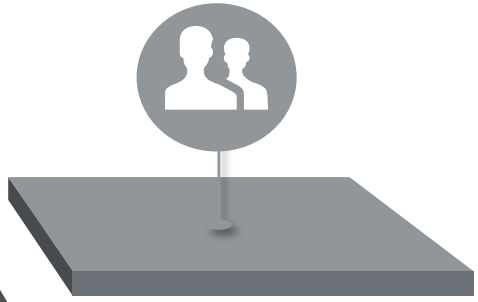
Time Frame

April 2019 – March 2023



Funding Agency

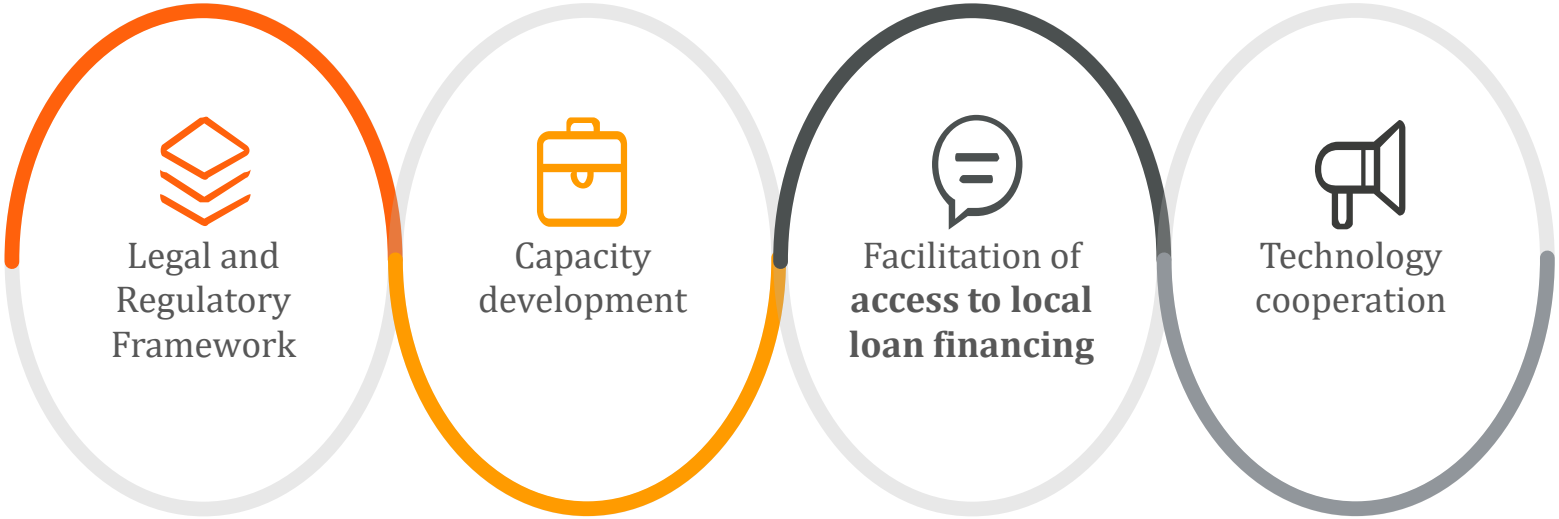
- German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) through its International Climate Initiative (IKI)



Partners

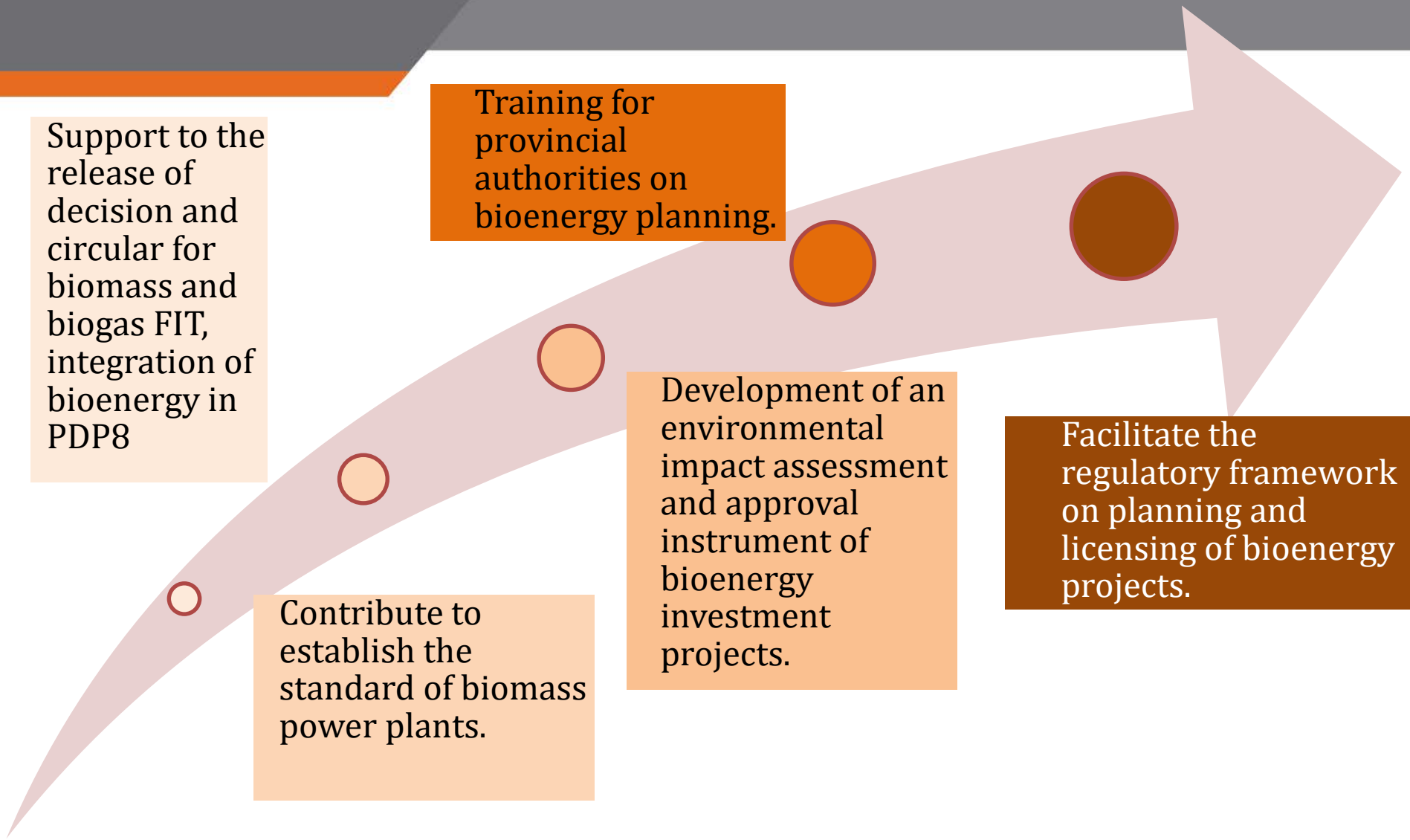
- Line Agency: MOIT
- Responsible Department: EREA

Expected results of BEM

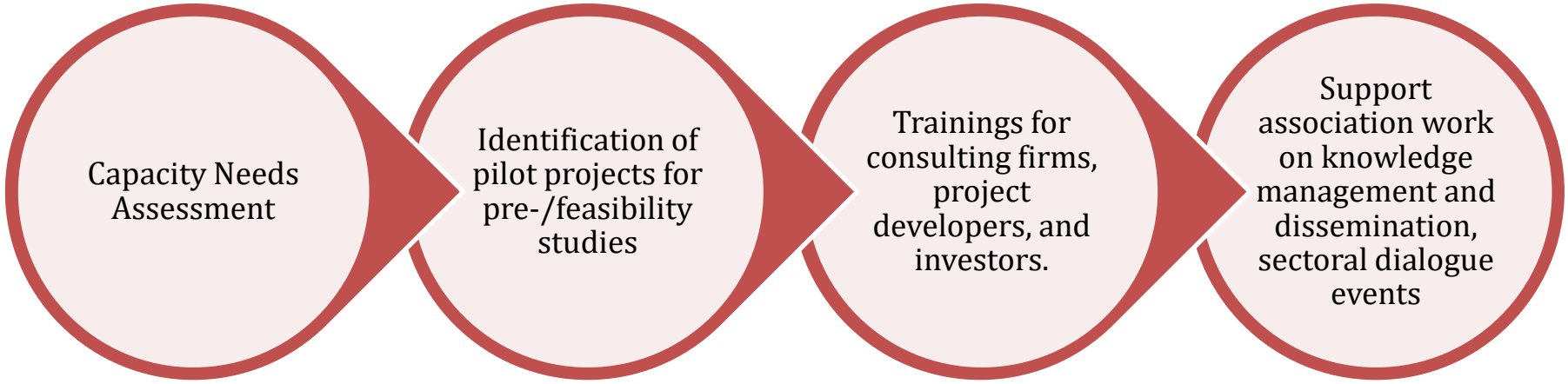


1. Facilitate and support adjustment to the **regulatory framework on planning and licensing** of biomass energy projects, in particular on provincial level.
2. Provision of **capacity building to private sector companies** on the design and development of modern biomass energy investment projects.
3. Provision of technical support and instruments for the **appraisal and financing** of biomass energy investment project by local financing institutions, in particular local commercial banks.
4. Support and enhance **technology cooperation and networks** between Vietnamese and international enterprises, research and development institutions and universities on the use of biomass resources for electricity and heat generation.

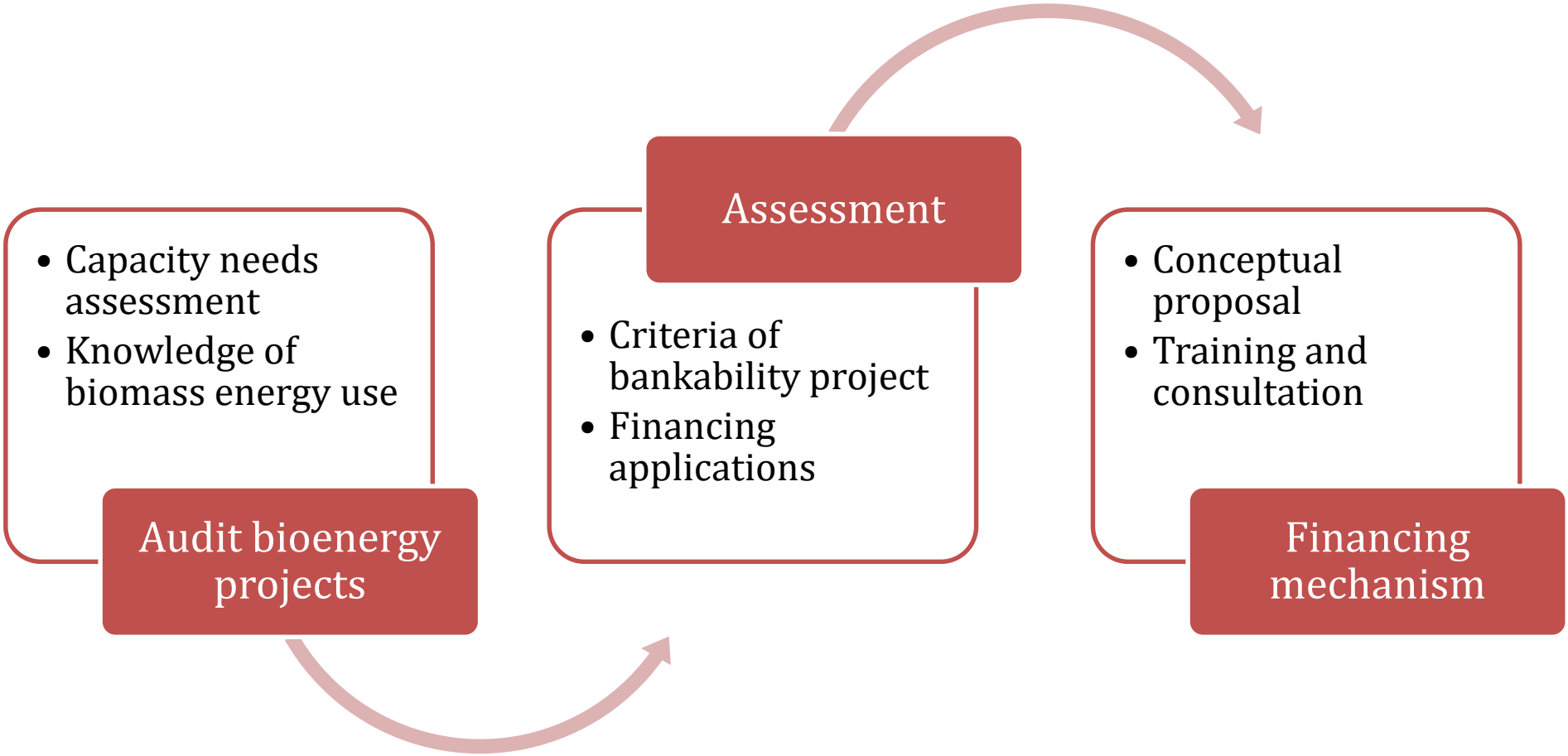
Action area 1: Legal and regulatory framework



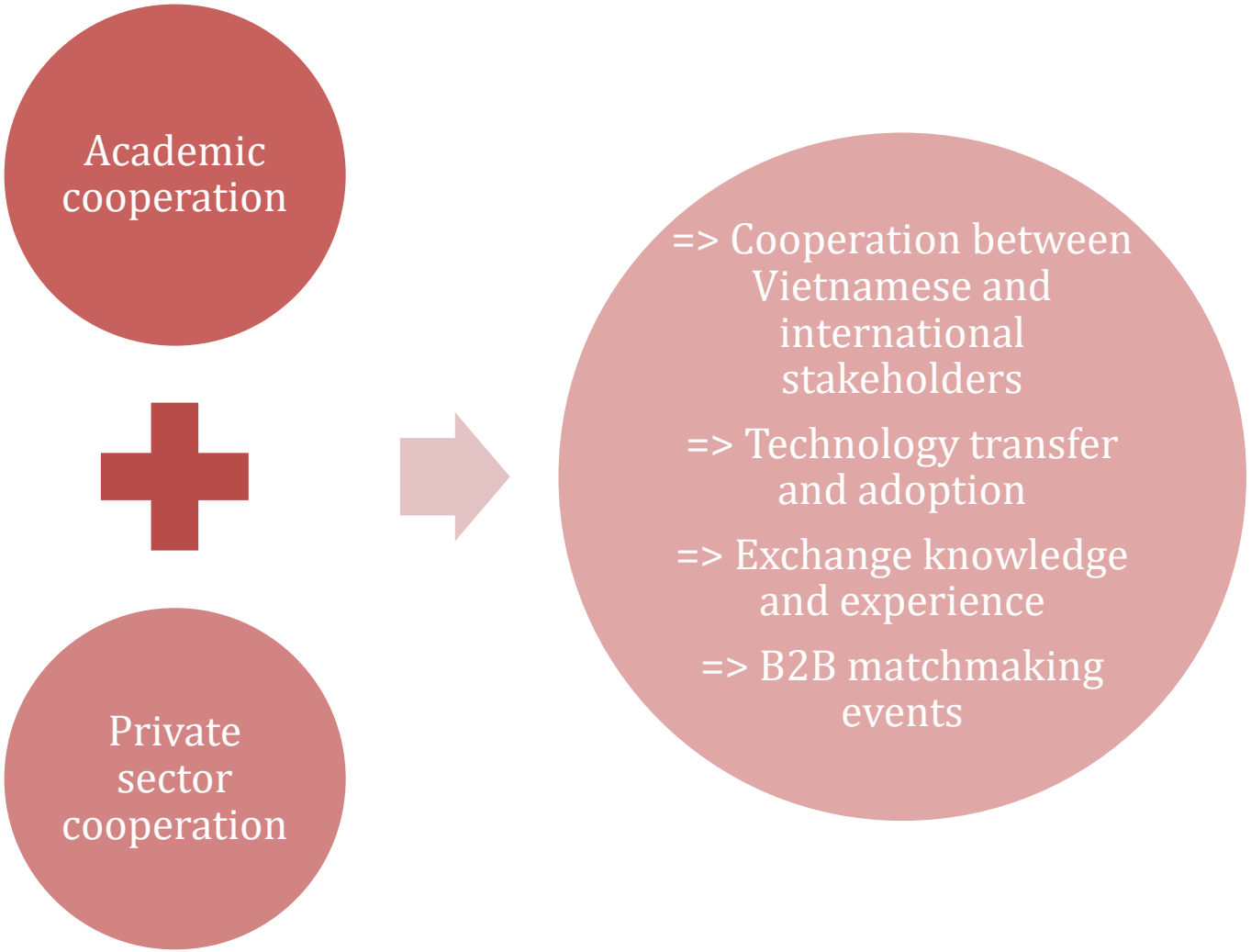
Action area 2: Capacity development



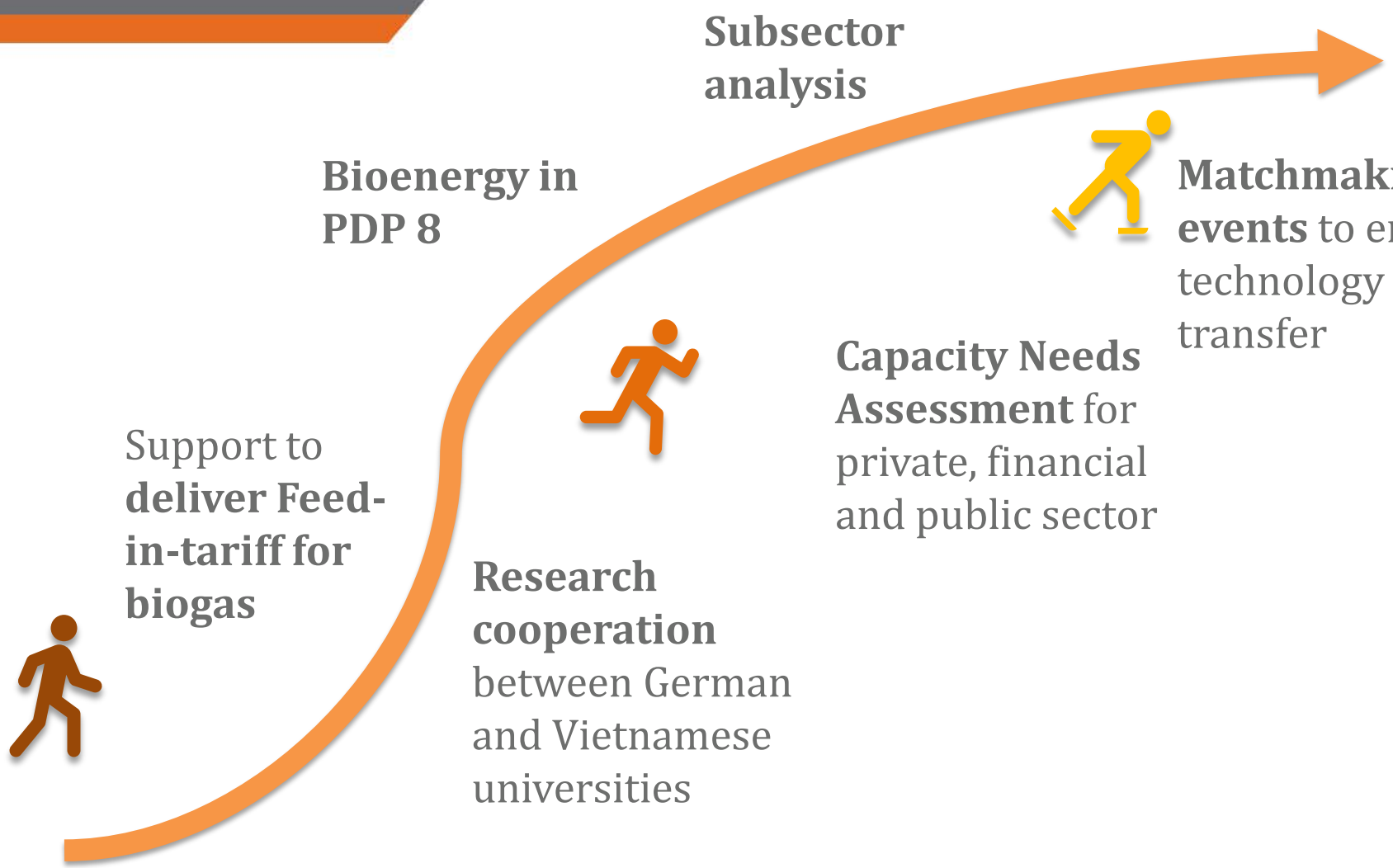
Action area 2: Financing of bioenergy project



Action area 3: Technology cooperation



Selected activities in 2020



An overview about the structural approach

1 Market status and legal framework conditions

2 Business delegations & networking events

1 Technical assistance: technology consultancy and pre-/feasibility study for investors

2 Facilitating partnership between international and Vietnam stakeholders

1 Project financing

2 Capacity building

Perspectives for stakeholders

We offer support to plan and implement bioenergy investment projects through:

- …facilitating technology cooperation
- …financing pre-/feasibility studies
- …provide training and study tours to obtain knowledge and state-of-the-art technology
- …working with business associations
- …advising commercial banks on the development of criteria for assessing the bankability of these projects
- …facilitating sector dialogues, matchmaking events
- …organizing trainings and study trips for consulting firms, project developers, investors and financial institutions
- …*and possibly more*!

Thank you!

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Further information:
http://gizenergy.org.vn/en/

Vietnam Energy Partnership Group
http://vepg.vn/

Selected literatures on Bioenergy in Vietnam

Up-scaling result for bioenergy development under MOIT/GIZ Energy Support Programme

Legal and regulatory framework

- **Feed-in-Tariff** for Biomass power project
- National and Provincial Biomass **Energy Planning**
- Biomass Energy Project **Development Guidelines**

Capacity development

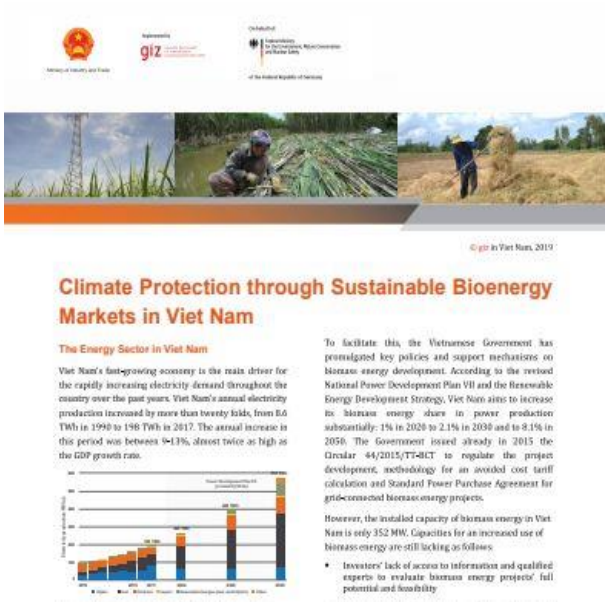
- **Theoretical and on-the-job trainings** for local firms on bioenergy **project development**
- **Training** on bioenergy for **project investors & banks**

Technology cooperation

- **Sub sector analysis** of the **sugar and timber** industries
- **Project pipeline development** via pre-feasibility studies

Reports and information

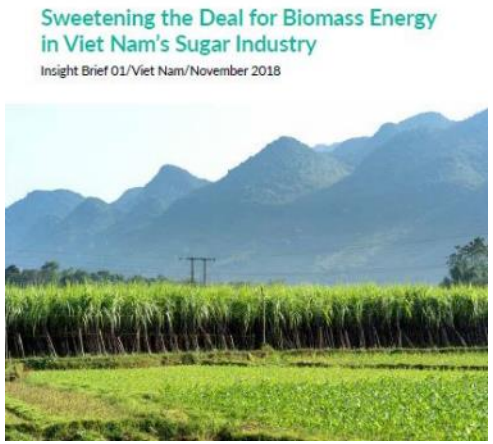
Biomass Energy Project Development Guidelines is a reference for project development in Vietnam which was introduced by the General Directorate of Energy – Ministry of Industry and with support from Renewable Energy and Energy Efficiency Project under the GIZ Energy Support Programme in Vietnam.

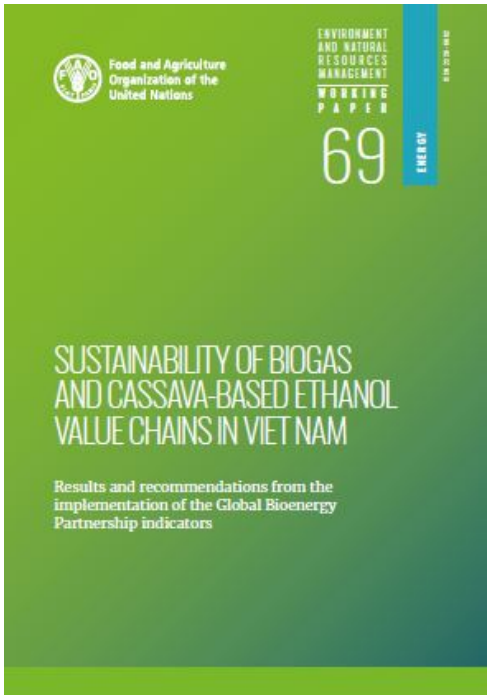


Climate Protection through Sustainable Bioenergy Markets in Viet Nam (BEM) Fact files is the product of the Climate Protection through Sustainable Bioenergy Markets in Viet Nam project (BEM).

Reports and information

Sweetening the Deal for Biomass Energy in Viet Nam's Sugar Industry is an insight brief builds on the results of the pre-feasibility studies conducted in 2017 by the Global Green Growth Institute and GIZ for five sugar mills.





The Food and Agriculture Organization of the United Nations and Viet Nam Academy of Agricultural Sciences, on behalf of the Ministry of Agriculture and Rural Development, launched the report on Sustainability of Biogas and Cassava-based Ethanol Value Chains in Viet Nam

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BIOENERGY IN VIETNAM

PAST - PRESENT - FUTURE

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Email: bbt@ievn.com.vn

Hanoi, ..., 2020

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CONTENT

1: Exploitation status

2: Development potential

3: Opportunities and challenges

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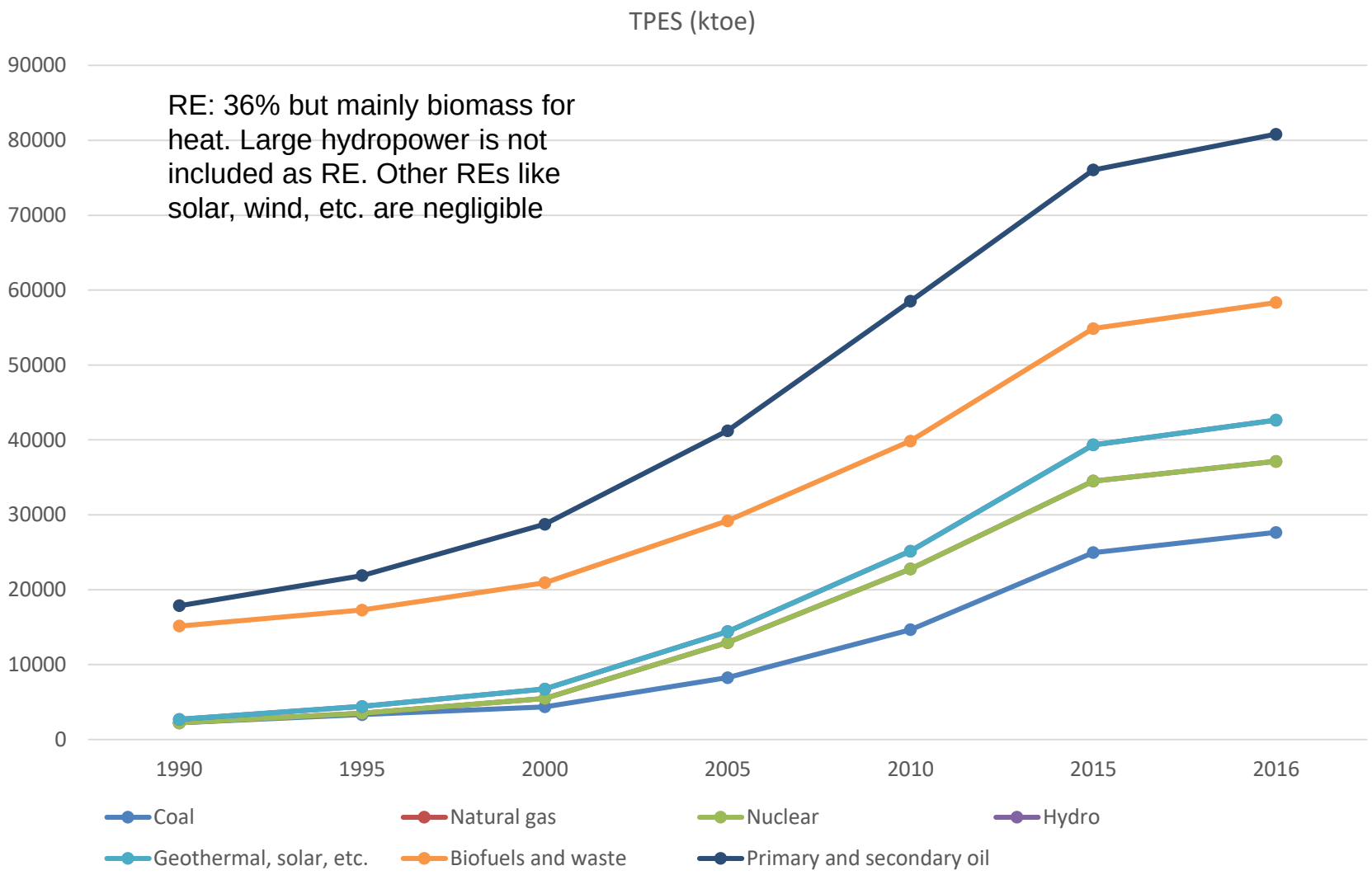
Primary Energy Supply in Vietnam



Source: www.iea.org

EXPLOITATION STATUS

BIOMASS

Main types of biomass

Agricultural waste
- Rice husk and straw
- Corn waste
- Coffee waste
- Coconut shell
- Sugarcane waste (bagasse, tree-tops, leaves)
- Peanut waste
- Cashew skin
- Cassava root
- Others

Energy crops
- Energy crops (fast growth and high heating value)
- Fountain grass
- Others

Forest waste
- Fuelwood and wood fuel
- Bamboo
- Others (activated charcoal)

Others
- Garden plants and indoor plants
- Timber
- Wood processing residues (shavings, sawdust)
- Scattered trees, etc.

EXPLOITATION STATUS

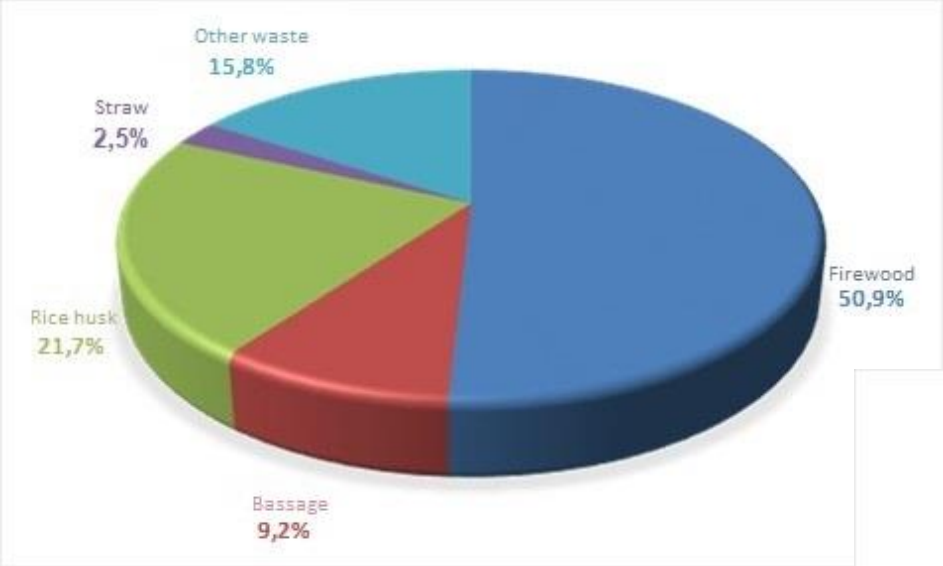
Biomass energy consumption by type and use, 2016

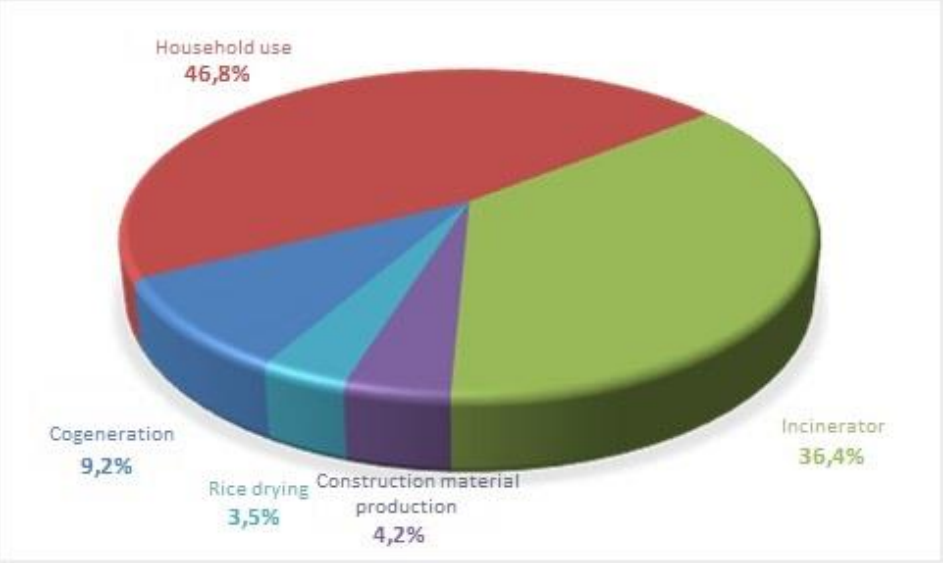
Unit: MWh

Use	Type of Biomass					Total
	Firewood	Bagasse	Rice husk	Straw	Other waste	
Power generation						
Cogeneration	184,228	9,081,352	-	-	-	9,265,580
Heat generation						
Household use	30,663,746	232,759	2,706,914	2,490,908	11,170,863	47,265,190
Incinerator	18,722,031	-	13,264,416	-	4,773,180	36,759,627
Construction material production	1,790,213	-	2,419,040	-	-	4,209,253
Rice drying	-	-	3,487,005	-	-	3,487,005
Total	**51,360,218**	**9,314,111**	**21,877,375**	**2,490,908**	**15,944,043**	**100,986,655**

EXPLOITATION STATUS

Biomass energy consumption type, 2016





Biomass energy consumption by use, 2016

EXPLOITATION STATUS

The share of biomass power in the national grid, 2019

	Installed capacity (MW)	Commercial power (MWh)
Nationwide (*)	**55,367**	**240,101,000**
Biomass power (**)	522.27	346,999
Sugar refinery	499.77	346,999
Paper & pulp mill	22.5	0
The share of biomass power	**0.94%**	**0.14%**

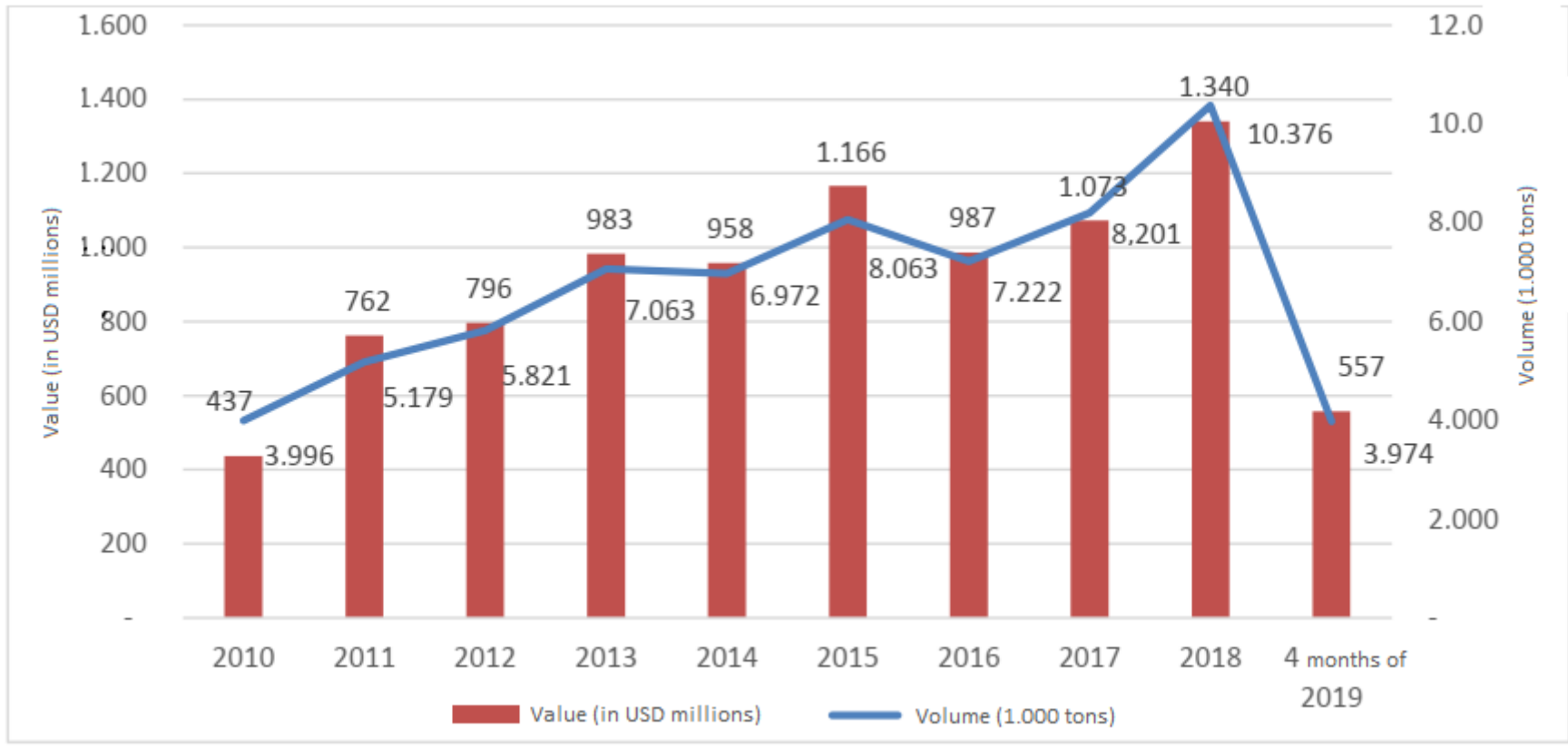
Source:

(*): (EVNNLDC, 2020)

(**): Results of surveys and estimates, Institute of Energy research team, 2020

EXPLOITATION STATUS

Woodchip Export



Vietnam's woodchip export volume

Source: General Department of Vietnam Customs, 2013 - 2019

EXPLOITATION STATUS

BIOGAS

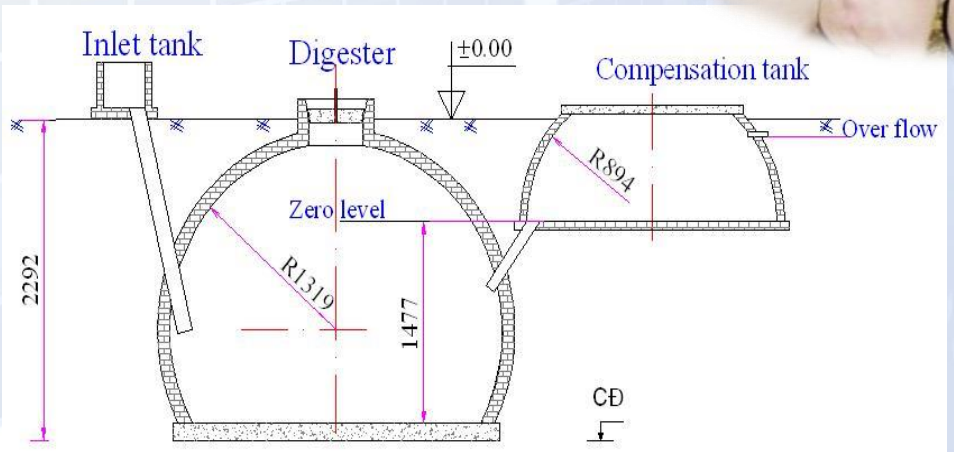
Biogas

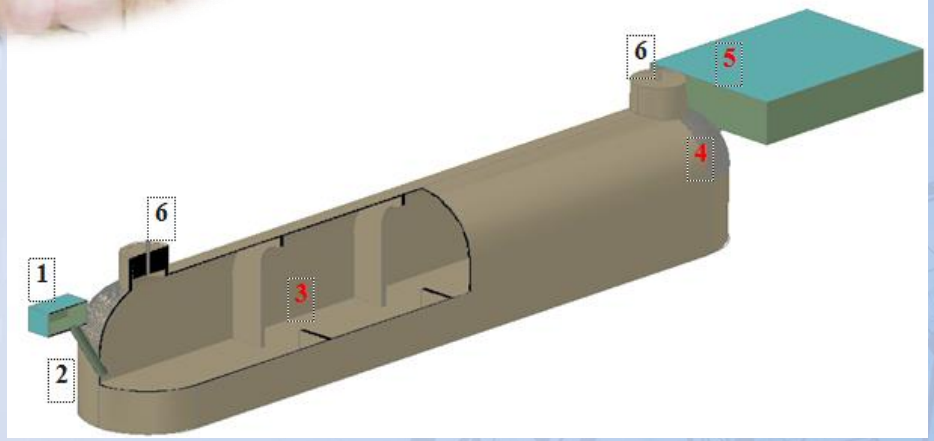
Animal husbandry:

- Household level
- Farm level

Technology:

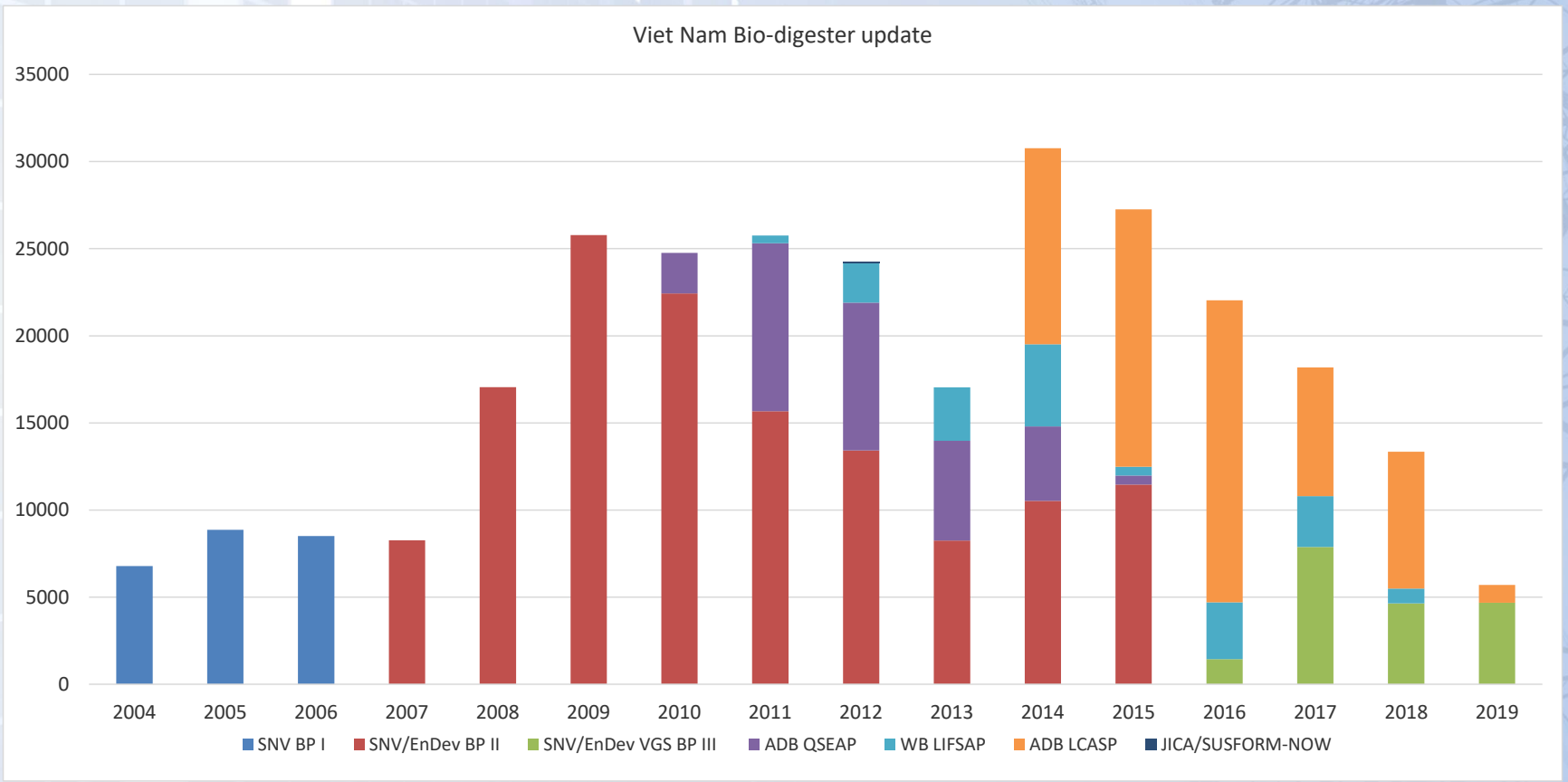
- Brick tank
- HDPE tarpaulin
- Composite, etc.





EXPLOITATION STATUS

The number of bio-digesters at the household level



Source: SNV, 2020

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EXPLOITATION STATUS


100kVA, Phu Tho


60kVA, Hanoi

Source: SNV, 2020

50kVA, Nam Dinh

100kVA, Bac Giang

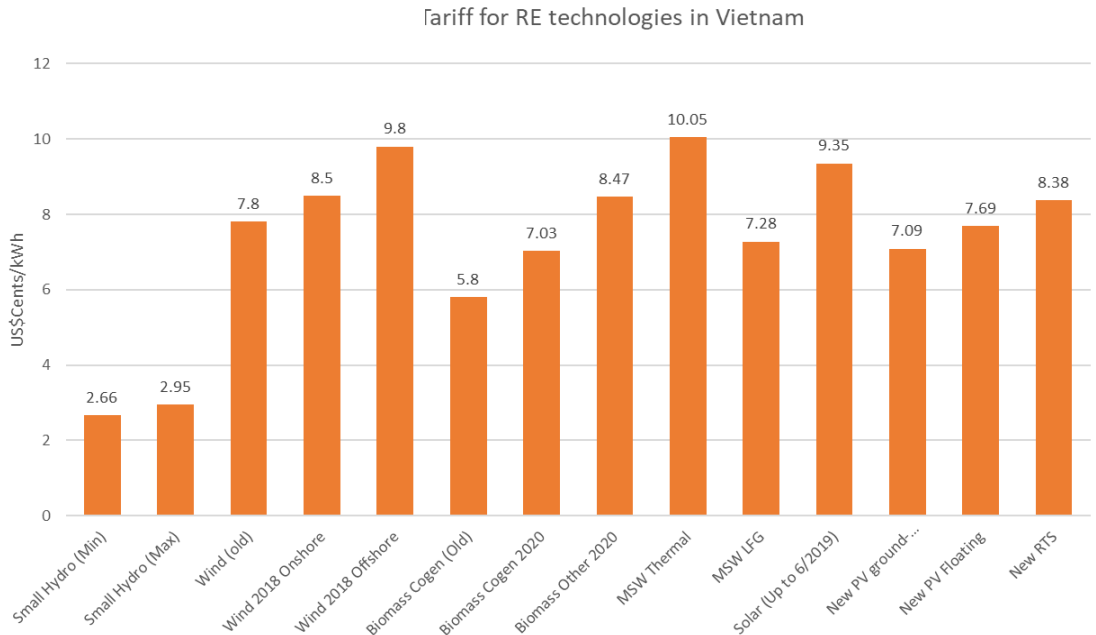
45kVA, Nam Dinh

Power generation from biogas at household level

EXPLOITATION STATUS

Incentives for bioenergy projects

Type of RE	Technology	Capacity limit	Tariff (VAT excluded) per Decision 08/QD-TTg
Biomass	Cogeneration	None	• 7,03 USc/kWh
	Other biomass	None	• 8,47 USc/kWh
Biogas	Decision unavailable		



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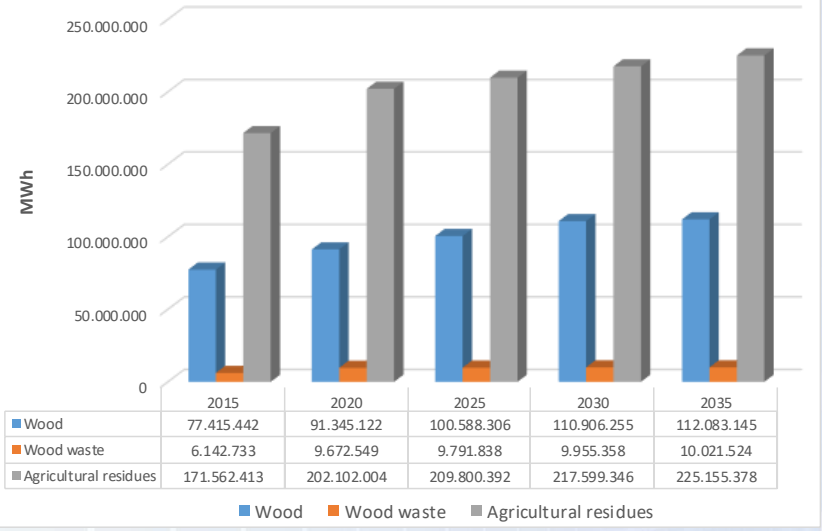
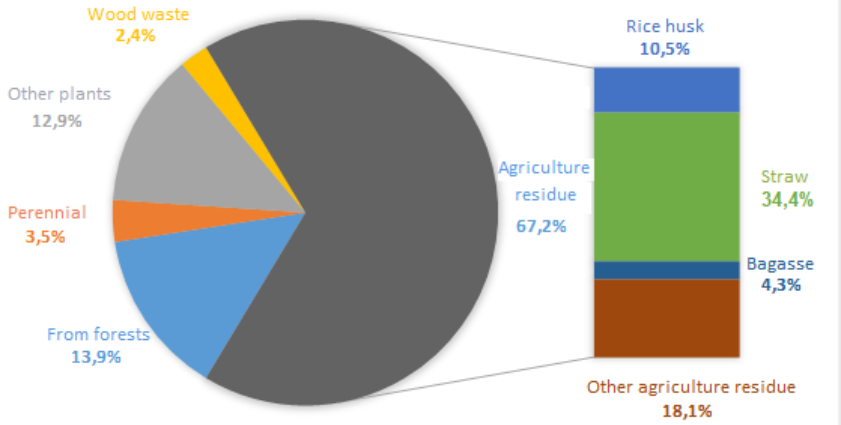
BIOMASS



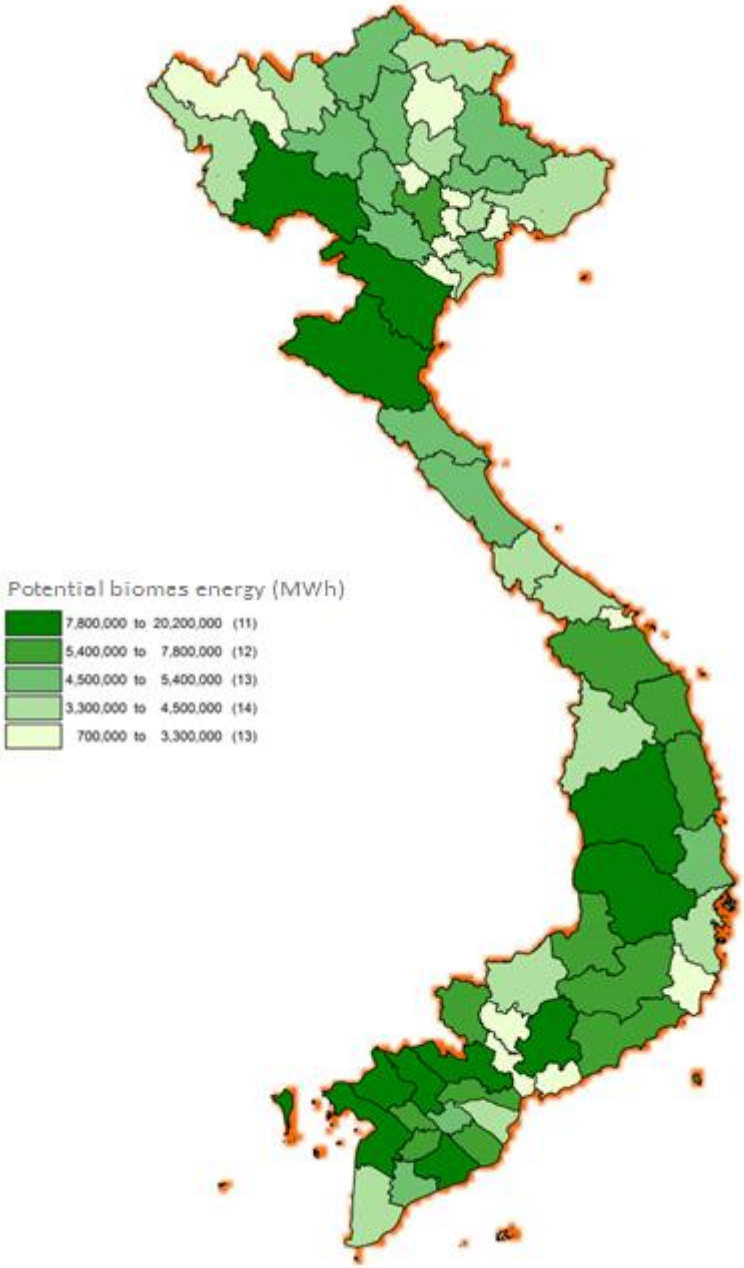
	2015	2020	2025	2030	2035
Wood	77.415.442	91.345.122	100.588.306	110.906.255	112.083.145
Wood waste	6.142.733	9.672.549	9.791.838	9.955.358	10.021.524
Agricultural residues	171.562.413	202.102.004	209.800.392	217.599.346	225.155.378



Technical potential of biomass energy

Monday, June 8, 2020

DEVELOPMENT POTENTIAL



Potential for power generation from biomass

Biomass power plant	2020	2025	2030	2035
Rice husk	360	365	367	370
Wood-Firewood (*)	2,563	2,900	3,286	3,360
Bassage	470	470	470	470
Straw	1,295	1,305	1,314	1,324
Woodfuel (**)	1,300	1,300	1,300	1,300
Others (***)	360	360	360	360
Total	**6,348**	**6,700**	**7,097**	**7,184**

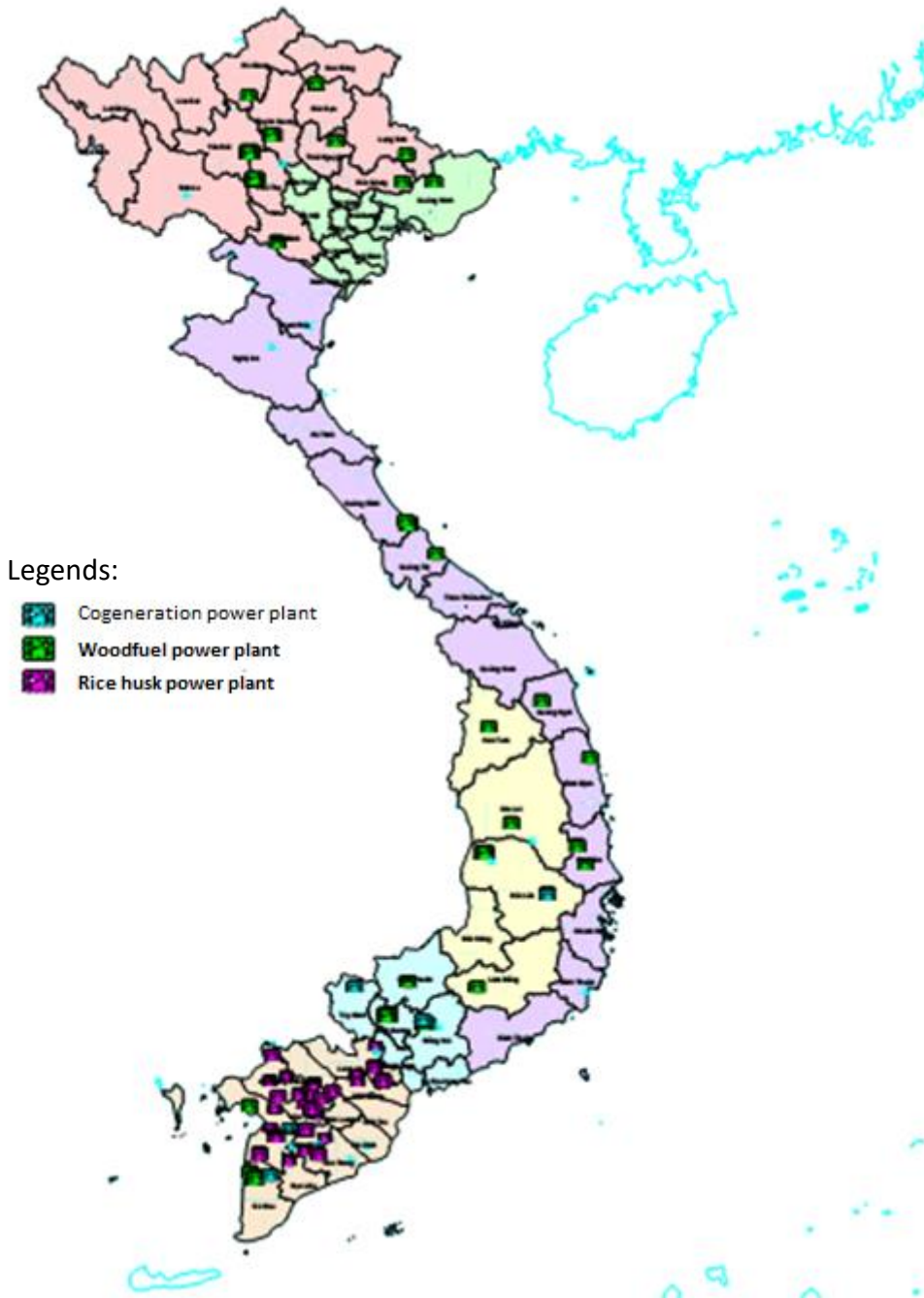
Notes:

(*) Wood/firewood-fired power plants run on sustainable sources of wood from trimming forest trees, industrial perennials, fruit trees, and their waste (from processing (sawdust, woodchips, etc.) and exploitation (branches, tree tops, stumps, etc.)).

(**) Woodfuel-fired power plants run on wood from planted forests - a supply of raw material for exported woodchip production.

(***) Others include those running on agricultural residues such as corncob and cashew skin, or a combination of multiple types of biomass

PIPELINED BIOMASS POWER PLANTS BY 2030



DEVELOPMENT POTENTIAL

BIOGAS

Consider the possibility of power generation from biogas from:

- Animal husbandry and aquaculture: waste, etc.
- Agricultural product processing factories: waste from cassava processing factories, dairy processing plants, etc.
- Treatment of domestic solid waste using the anaerobic degradation technology, biogas production for power generation

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CONTENT

1: Exploitation status

2: Development potential

3: Opportunities and challenges

OPPORTUNITIES AND CHALLENGES

Opportunities

- Bioenergy has a huge potential for power generation
- Vietnam's energy and power demand is huge
- The significance of RE in general and bioenergy in particular has been recognized by the Government:
  - Strategy for RE development in Vietnam by 2030 with a vision to 2050 approved by the Government (Decision 2068/QD-TTg dated November 25th, 2015)
  - Climate change adaptation strategy: biomass and biogas considered one of many solutions to reduce greenhouse gas emission.
  - Green growth strategy: promoting green energy/industry and low-carbon technologies (from waste to energy)
  - Incentives issued for biomass power generation projects; incentives proposed for biogas power generation projects.

OPPORTUNITIES AND CHALLENGES

Challenges

- Difficulty in controlling the fuel supply into power plants:
  - Unstable and unsustainable fuel supply
  - Seasonal changes in fuel pricing
- High CAPEX - one of the biggest obstacles
- Small-scale and distributed projects (except sugar refineries)
- Unattractive power purchase incentives
- Lack of development experience, and skilled engineers and workers for bioenergy projects
- Lack of information and unreliable databases
- Land fund for the development of bioenergy projects (land for fuel supply, etc.)

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THANK YOU!

Renewable Energy Center,

Institute of Energy, Ministry of Industry and Trade

Email: RE_center@ievn.com.vn

DEVELOPMENT OF BIOMASS THERMAL POWER PLANT PROJECTS IN VIETNAM

M. Sc. Mai Thanh Ha Hue

Hanoi, June 2020

CONTENTS

Development potential;
Opportunities;
Challenges;
Development orientations;
Conclusion.

DEVELOPMENT POTENTIAL

- Favorable natural conditions:
  - Agriculture-based country with potential expansion of farming land;
  - Abundant water source.
- Diverse sources of fuel;
  - Agricultural co-products;
  - Planted forest products;
  - Wood processing waste;
  - Scientific advances in plants and varieties.
- Infrastructures: transportation, logistics, power grid.

DEVELOPMENT POTENTIAL

- Technologies:
  - Traditional technology: steam-condensed thermal power;
  - Scientific and technical advances: approaching global standards;
- Human resources:
  - Skilled and knowledgeable;
  - Experienced;
  - Abundant.

DEVELOPMENT POTENTIAL

❖ Policies and mechanisms:

- Incentive for Feed-in-tariff;
- Simple and quick negotiation of Power Purchase Agreement (PPA) with no limitations on output;
- Having incentive mechanism.

❖ Evaluation of policies and mechanisms:

- Enable investors to access diverse sources of credit;
- Able to attract **capable investors in the country**;

OPPORTUNITIES

- Policies and mechanisms;
- Opportunities to access to advanced technology;
- Natural conditions of the country;
- Human resources;
- Capital sources for development;

Favorable conditions to develop in this field

CHALLENGES

- Fuel sources:
  - Normally available at a small scale;
  - Lack of large and sustainable fuel areas;
  - Unstable output, reserves, and quality of the supply;
  - Unreliable and inconsistent data on fuel sources;
  - Improper investment in the fuel areas.

CHALLENGES

- Limited access to advanced technology due to:
  - Moderate tariff;
  - High-priced advanced technology;
  - Limited applicability.
  - Required partial localization

CHALLENGES

- Mechanisms:
  - Planning issue;
  - Issue in additional planning process;
  - Incentives to develop the fuel sources.

CHALLENGES

- Investment and tariff:
  - Favorable but remains at a moderate level of tariff (currently US$8.37);
  - Delayed investment due to large procedures for project approval;
  - To mobilize the capital source;
  - To find the best way to appeal to foreign investor;
  - To approach cutting-edged technology.

CONSIDERATIONS

- Power supply:
  - Under the management of MOIT.
- Fuel sources:
  - Under the management of MARD.

CONSIDERATIONS

- Land:
  - Under the management of MARD.
- Water resources:
  - Under the management of MARD.

CONSIDERATIONS

- Mechanism for investment in fuel areas:
  - At present, only agricultural extension mechanisms are available;
  - The mechanism for promoting the development of fuel areas has not been expanded;
- The supply chain and reinvestment mechanism for fuel areas have not been established;
- Large fuel areas have not been established;
- The integration of scientific and technical advances into the development of fuel areas still faces various difficulties.

CONSIDERATIONS

- Mechanism for power development:
  - Result from the ambiguity of power development planning;
  - Development of power grid is not matching with the power supply;
  - To be consistent compliance with the proposed planning and investment needs.
- Mechanism for foreign investors:
  - To be more attractive;
  - To leveraged credit sources;
  - Must approach to leading technologies.

SUMMARY OF IDEAS

- Establishment of mechanism for sustainable development of fuel sources:
  - Expanding large-scale fuel areas;
  - Applying scientific & technical advances in development and exploitation;
- Development of sustainable supply chain;
  - Stabilized fuel quality;
  - Stabilized fuel prices.

SUMMARY OF IDEAS

- Establishment of sustainable mechanism for power development:
  - Establishing a reasonable structure of power price to attract investors;
  - Conducting a balanced and appropriate power development planning;
  - Considering to develop an incentive mechanisms for small projects, projects in disadvantaged areas or areas with limited access to electricity grid.

SUMMARY OF IDEAS

- Investment and development of biomass power plants:
  - Advantages: Favorable state mechanisms and policies for power development;
  - Difficulties in evaluating and collecting the data on fuel sources;
  - Difficulties in stabilizing the fuel quality;
  - Difficulties in stabilizing the fuel prices, which makes it impossible to negotiate long-term fuel supply contracts for coal, oil, or gas.

RECOMMENDATIONS

- Implement an evaluation program in fuel areas to obtain more accurate data.
- Establish a development mechanism for fuel areas.
- Further promote coordination between ministries, sectors, and agencies in the development program.

THANK YOU!

Study on Biomass Energy Conversions

TS LÊ ĐỨC DŨNG

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❑Outline

1. Biomass introduction
2. Biomass conversion
3. Laboratory for Biomass Conversion

1. Biomass introduction

Dry biomass (<50-60 $\%_{water}$)

Wet biomass (>60 $\%_{water}$)

2. Biomass conversion-

Which routes for Ligno cellulosic biomass ?

Biochemical process (wet)

Hydrolysis / Fermentation

Thermochemical process (dry)

Pyroysis Torrefaction

Gasification

Combustion

Cellulosic ethanol

Biofuels "2nd génération"

Diesel SNG

Gas

Electricity

Biomass composition : Proximate analysis

Moisture *measured after drying*

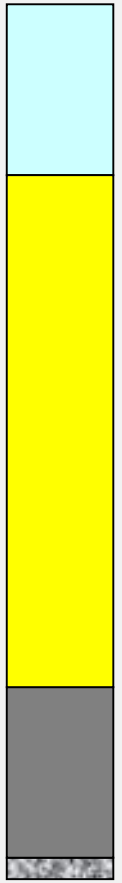
19% to 52% at tree cutting
10 % to 20% for a « dry wood »
Strongly affects the LCV

Volatile matter *measured after pyrolysis* **50 to 85 %**

Fixed carbon *By difference (100-Moist-VM-Ash)*
5 to 35 %

Ash *Measured after oxidation*

1% typically for wood: **very low**



Pyrolysis

Thermal transformation without Oxygen

Energy

Carbon residue
(Charcoal or char)

Volatiles Matters
50 - 70 % of the total mass

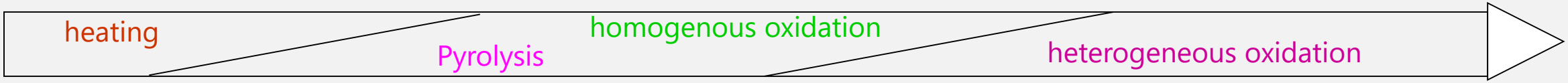
non condensables
(CO, H_2, CO_2,CH_4, ...)

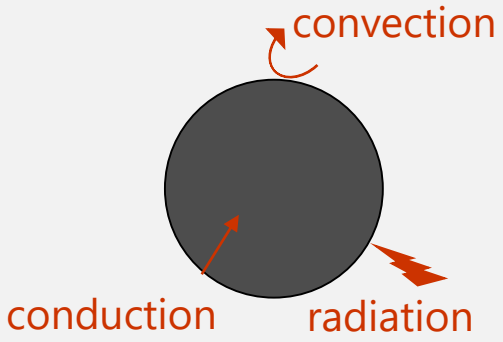
condensables
(water, **tars**)

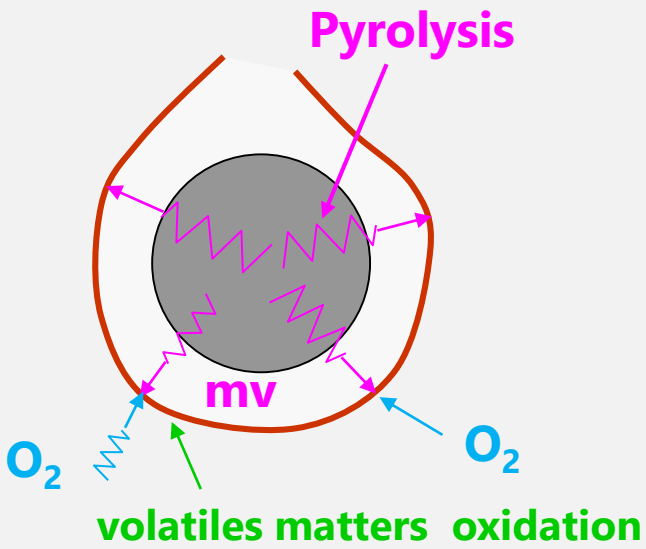
Heating rate
Final temperature
Pressure

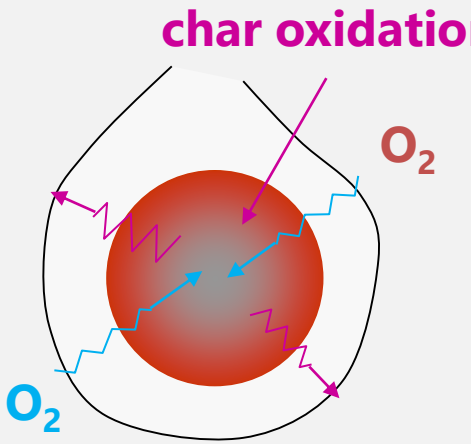
Charcoal → Volatiles Matters

Combustion



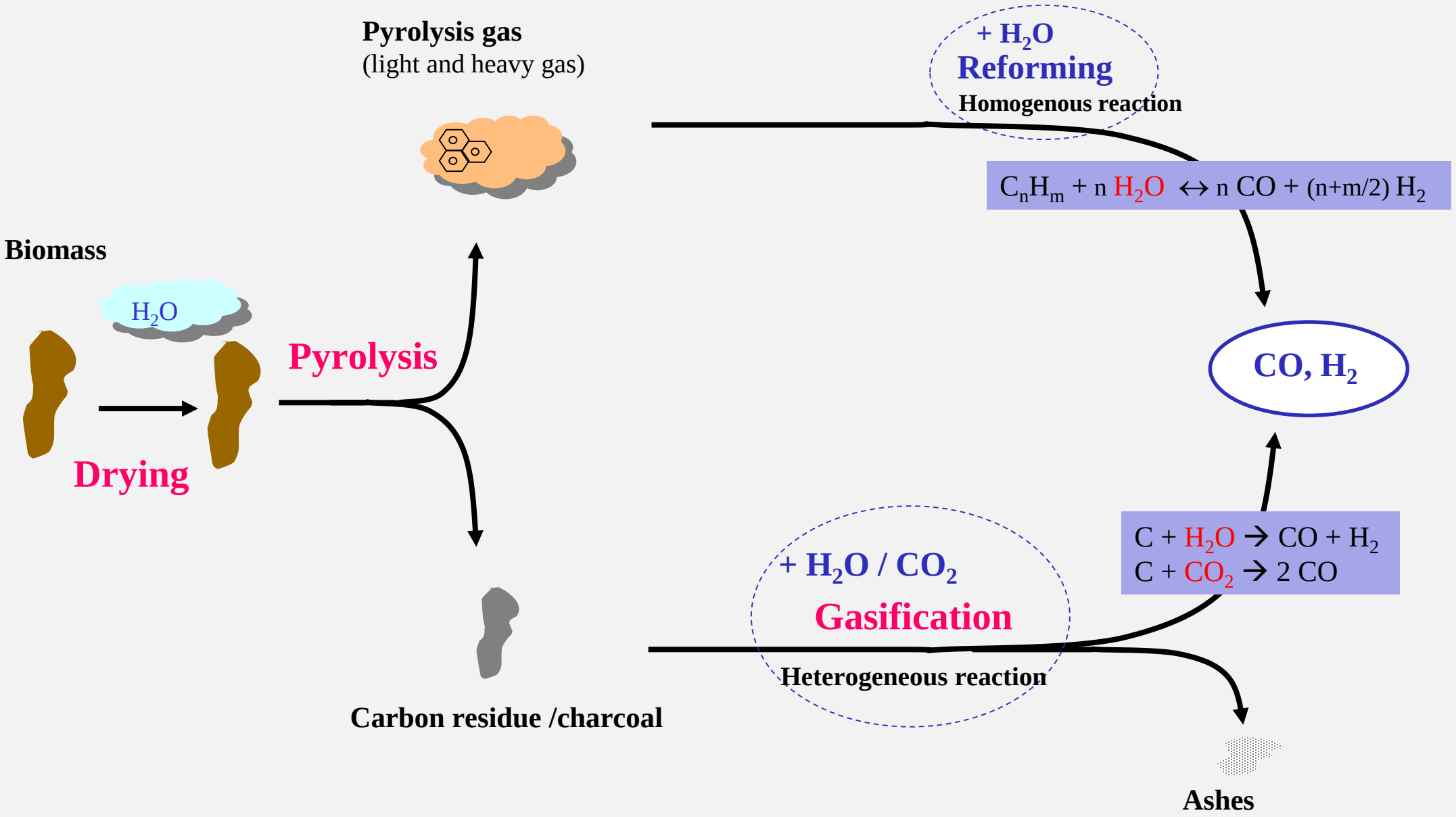




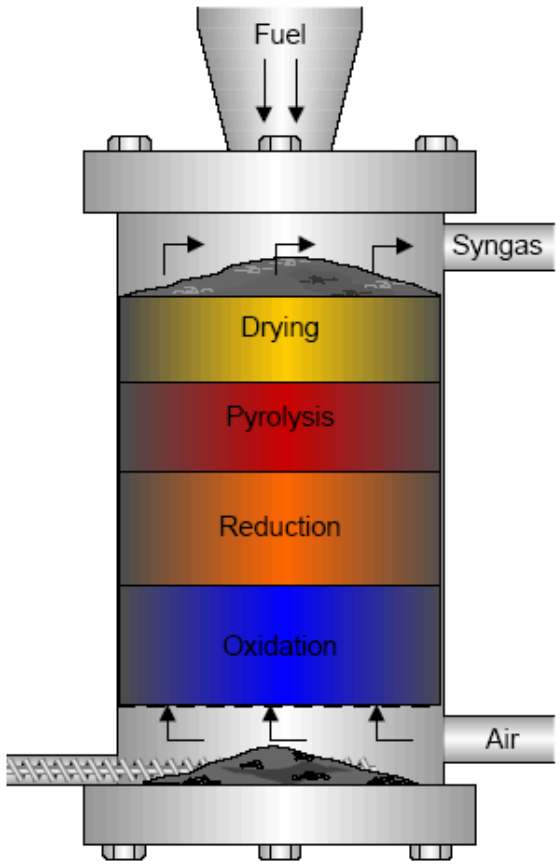


What is happening here?

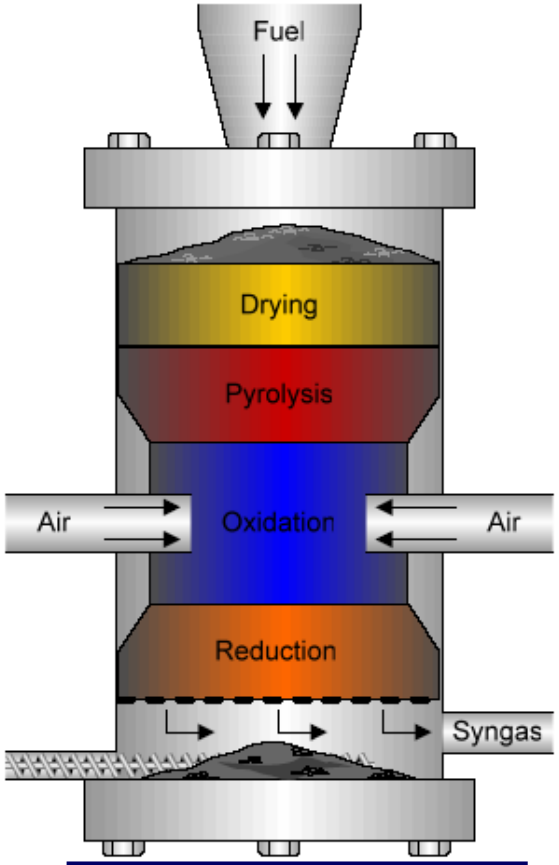
Gasification



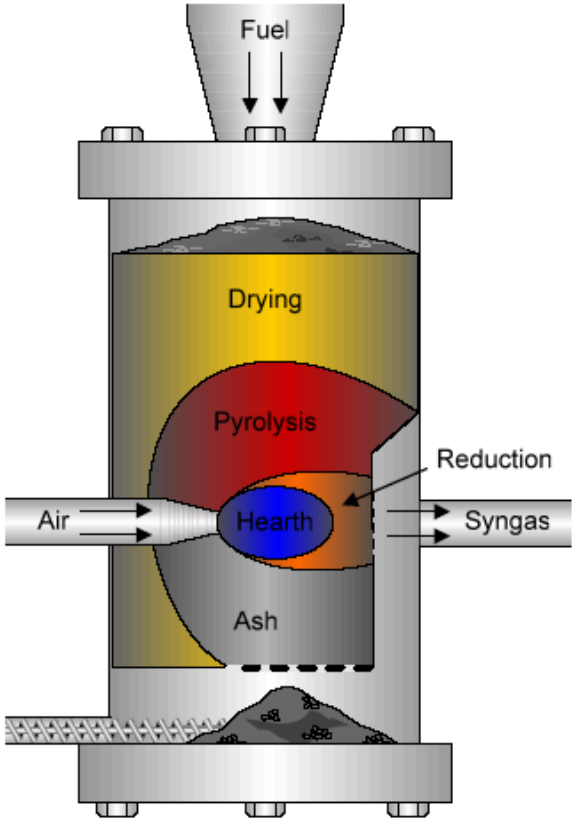
Types of Gasifiers



Up draft



Down draft



Cross draft

Laboratory for Biomass energy –
School of Heat Engineering and Refrigeration
Human/technical means and Methodology

- **Permanent staff active in Biomass technologies:**
  - **6 Researchers , 3 Technicians (mechanical and thermal engineering)**
- **Technical means :**
  - **Analytical laboratory**
  - **Lab experimental tools**
- **Methodology**
  - **Multi-scale: particle, CFB bed reactor, Industrial reactor**
  - **Experimental**
  - Modelling (with academic partners)

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INSTITUE OF SCIENCE AND REFRIGERATION TECHNOLOGY

Analytical laboratory

Downdraft Gasifier – Gensets System (200kWth/50kWe)

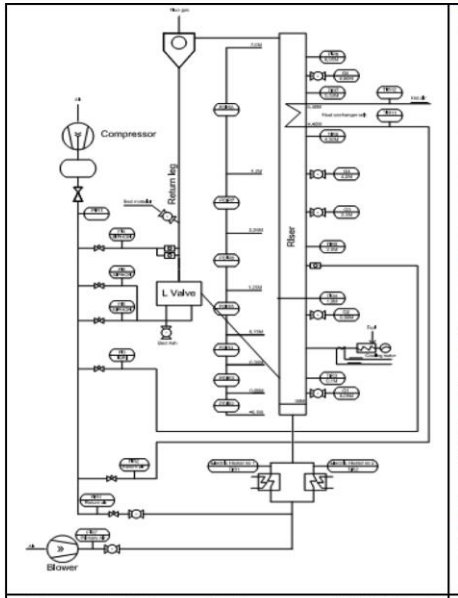


Figure 1: Schematic diagram of CFBC at IHERE

Figure 2:A Viewing CFBC installatic IHERE

Figure 3: A Viewing CFBC installation at IHERE

Figure 4: Primary air flow meter (F1

Circulating Fluidized Bed -Test Reactor 100kWth

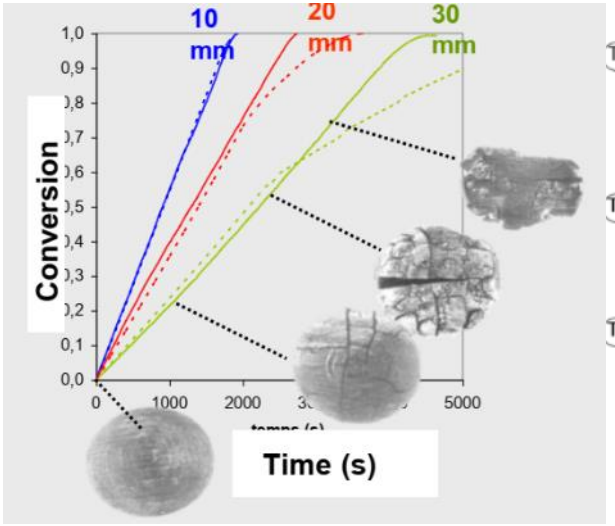
Cook stove testing Laboratory

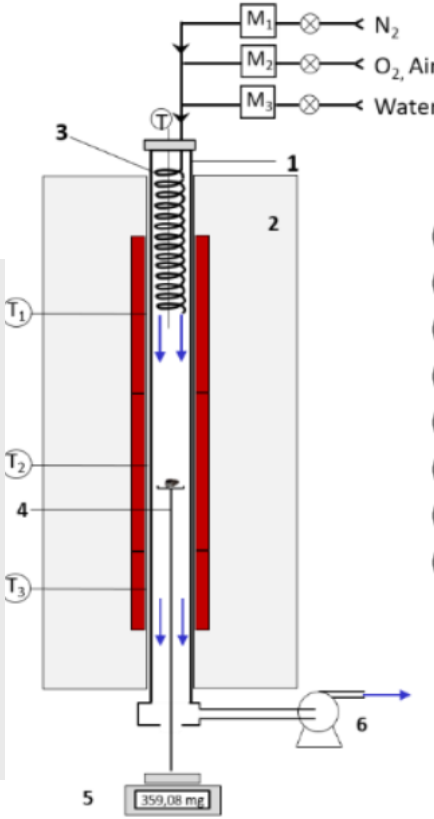
Scientific

- Fundamentals of pyrolysis, oxidation, gasification
- Thermochemical and mechanical behaviors of fixed beds during conversion
- Impact of type of biomass on gasification
- Biomass co-firing with coal

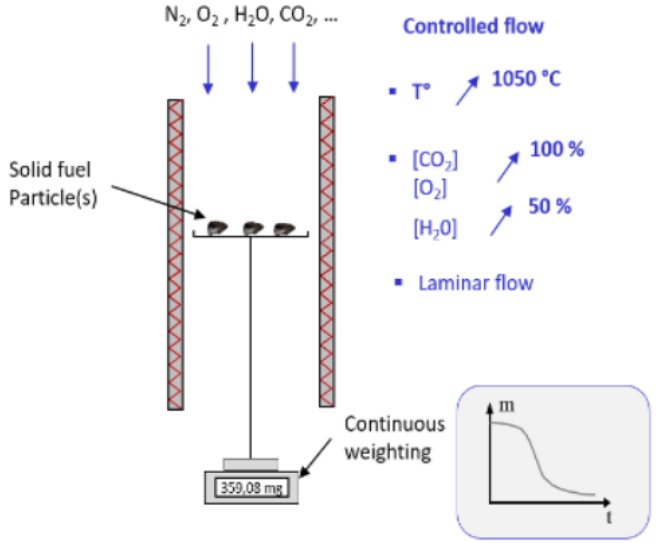
THERMOGRAVIMETRIC ANALYSIS: Biomass and subbituminous oxidization

- An useful tool to perform reactivity measurements
- Measurement of mass loss/gain of a substance under controlled conditions
- Isothermal

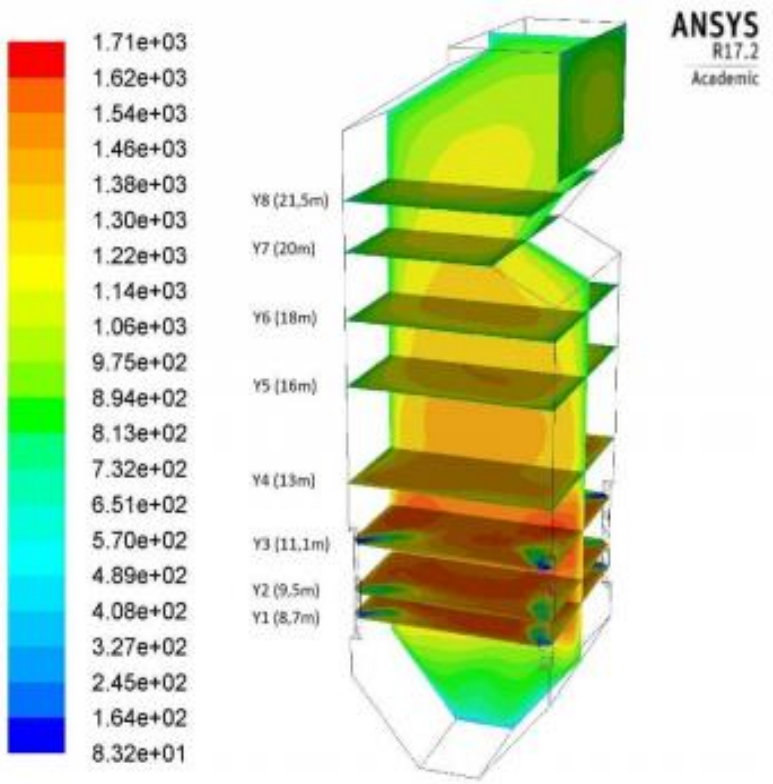




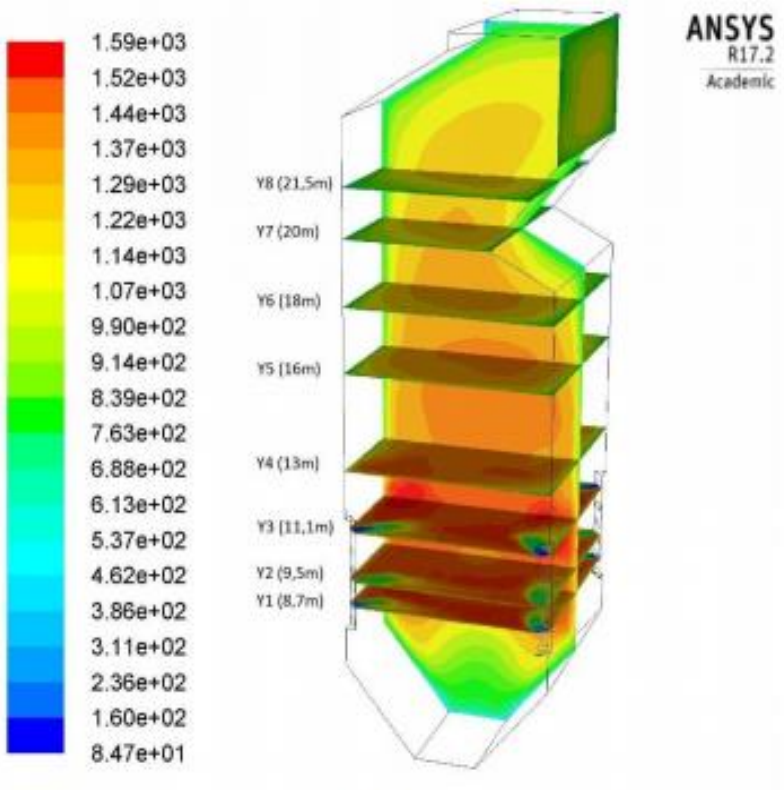
(1) Ceramic tube
(2) Electrical furnace
(3) Preheater
(4) Sample holding
(5) Weighting scale
(6) Extractor
(T_i) Regulation thermocouples
(M_i) Mass flow meter



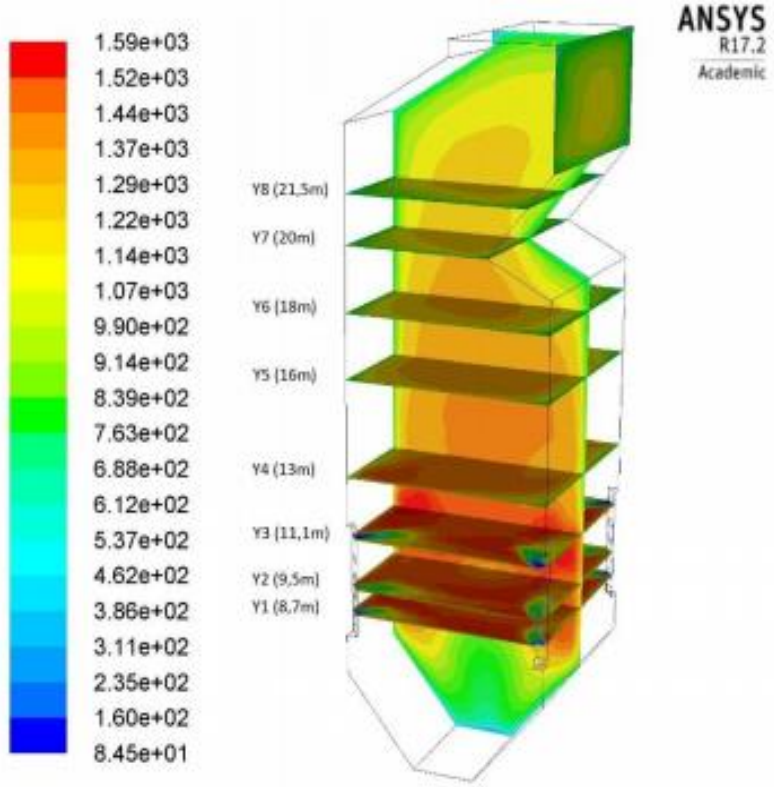
Biomass co-firing simulation in a coal-fired boiler



a - Trường hợp đốt 100% than Hòn Gai



b - Trường hợp đốt kèm 5% sinh khối



c - Trường hợp đốt kèm 10% sinh khối

❑ Biomass energy applications

Biomass is used as fuel for industrial steam boiler

Biomass fuel: Wood chip, wood pellet, saw dust, solid waste

It is still remained many questions

- High CO emission

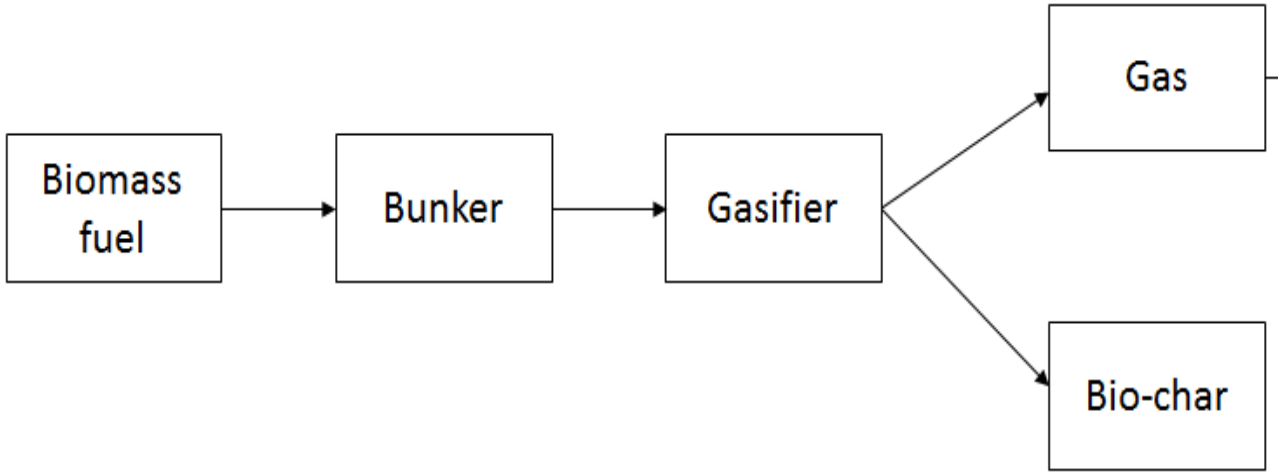
- Reduce capacity of boiler

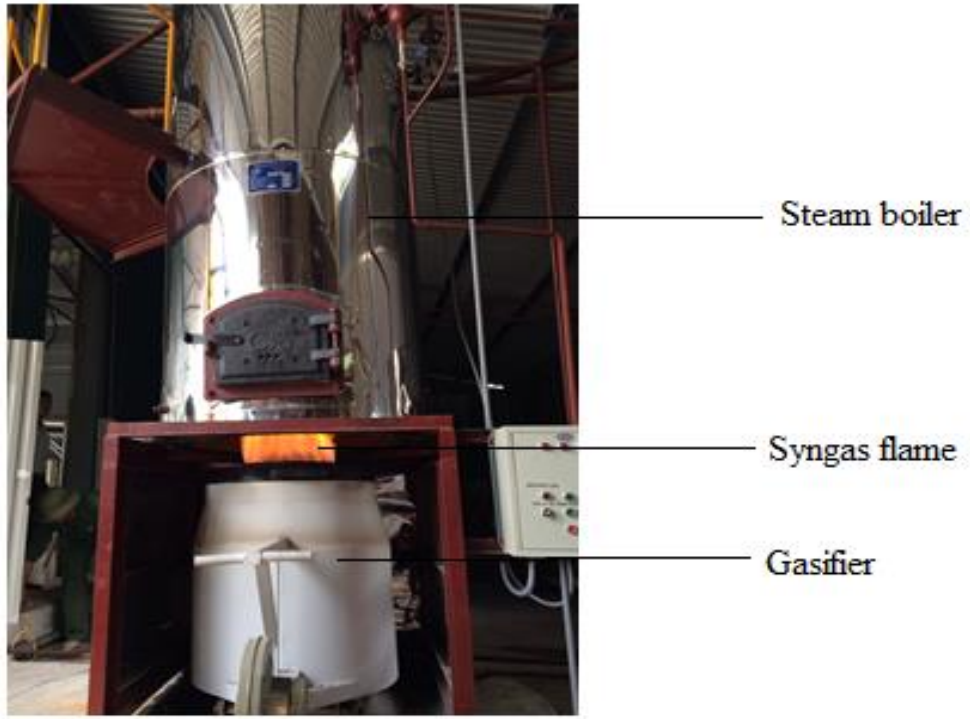
- Reduce boiler efficiency by dust accumulation on heat exchanger surface.

- Tube fauling

❑ Biomass energy applications

Biomass is used as fuel to replace coal in industrial steam boiler





- Gasification technologies for heat application are a very good option. It is good for environment impact.

It is still remained many questions to improve them.

Cook stove testing and development

Cook stoves are needed to improve such as: Batch operation; high CO emisssion, PM 2.5 emission - low efficiency

Thank you for your attention!

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