



WASTE GASIFICATION IN FLUIDIZED BED FOR COGENERATION APPLICATION – TERRACOTTA COLLABORATIVE PROJECT

M. INSA – EDF

2018



EDF GROUP AT A GLANCE

WORLD'S NO. 1 ELECTRICITY COMPANY

- EDF Group is particularly well established in Europe, especially France, the United Kingdom, Italy and Belgium.
- A marked increase in the use of renewables is bringing change to its power generation operations, which are underpinned by a diversified low-carbon energy mix founded on nuclear power capacity.

LEADER IN LOW-CARBON POWER GENERATION

- No. 1 in the world for nuclear power generation.
- No. 1 in Europe for renewable energy generation.
- No. 3 in Europe for energy services.

EDF COVERS ALL ELECTRICITY- RELATED ACTIVITIES

- Generation
- Transmission, distribution
- Trading, supply
- Energy services



EDF GROUP IN 2015

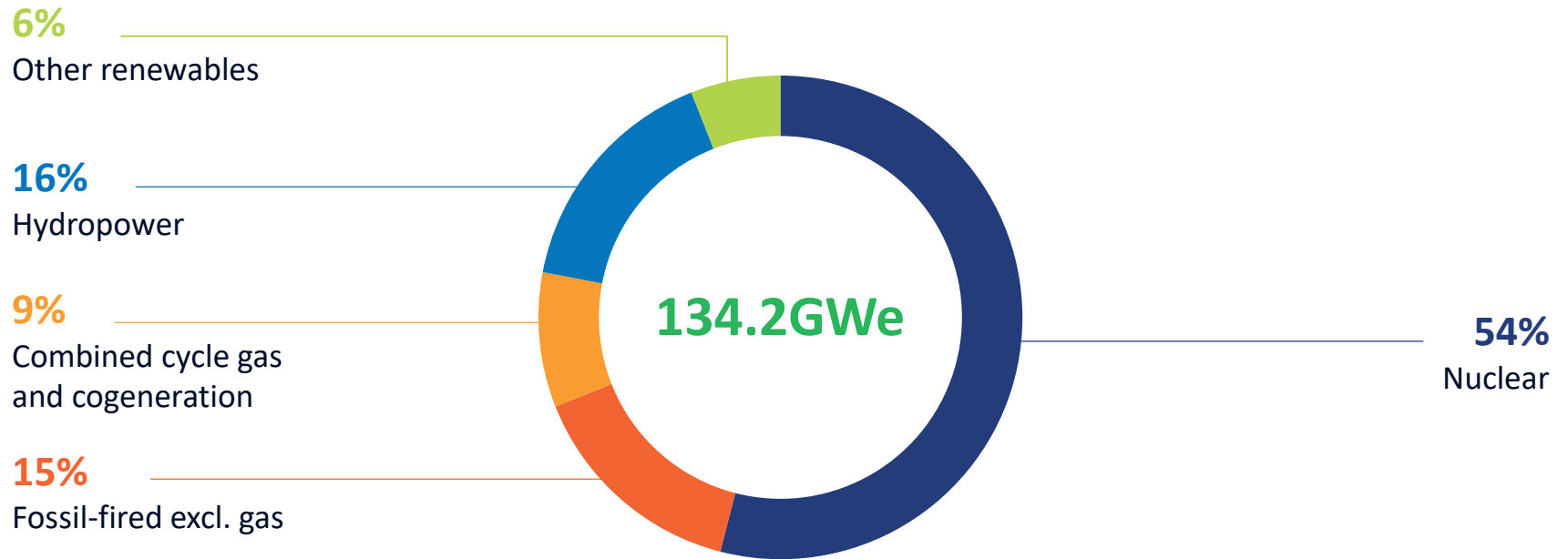
37.6 million
customers worldwide

159,112
employees

€75 billion
sales

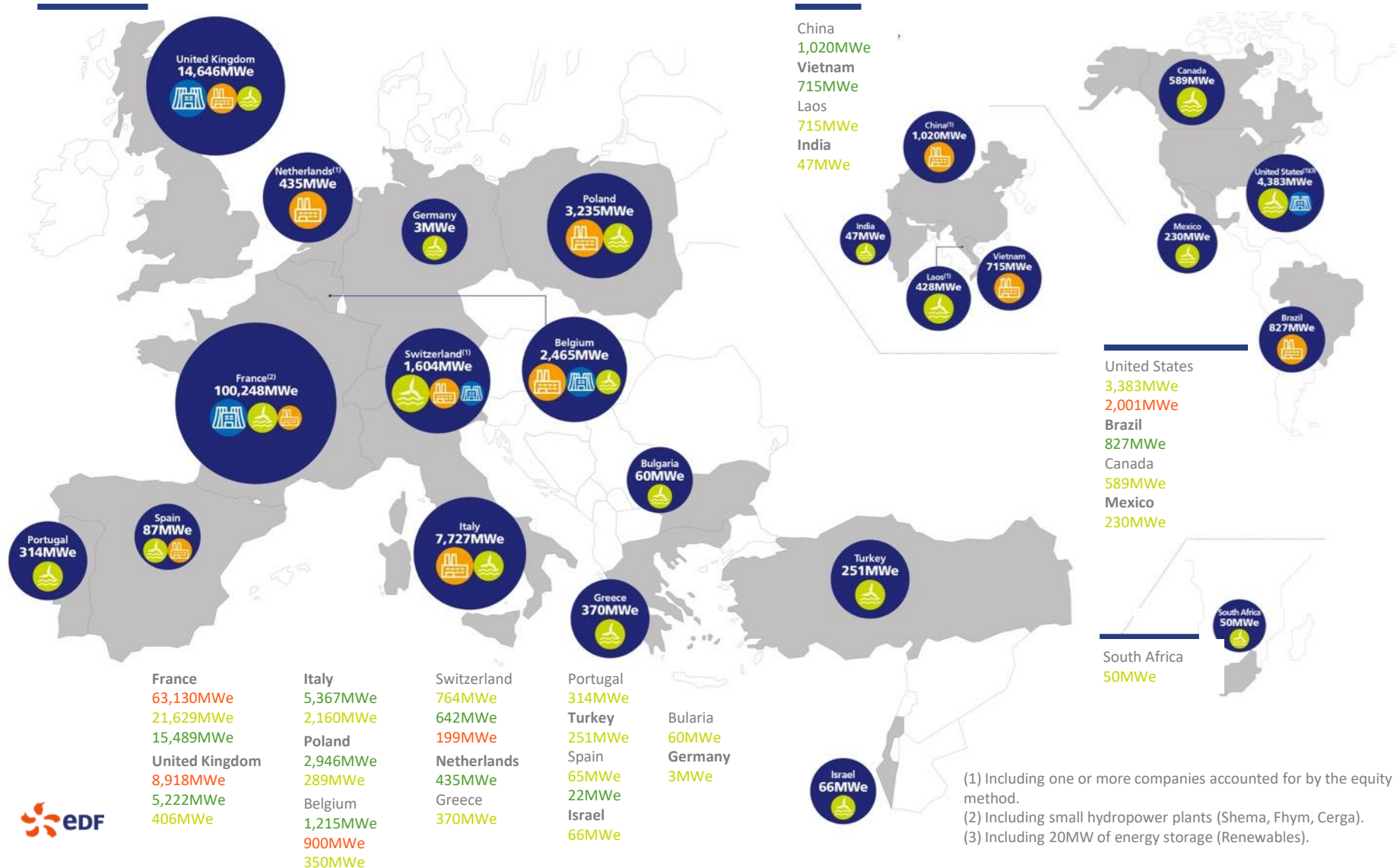
619.3TWh
electricity generation

EDF GROUP'S INSTALLED CAPACITY IN 2015

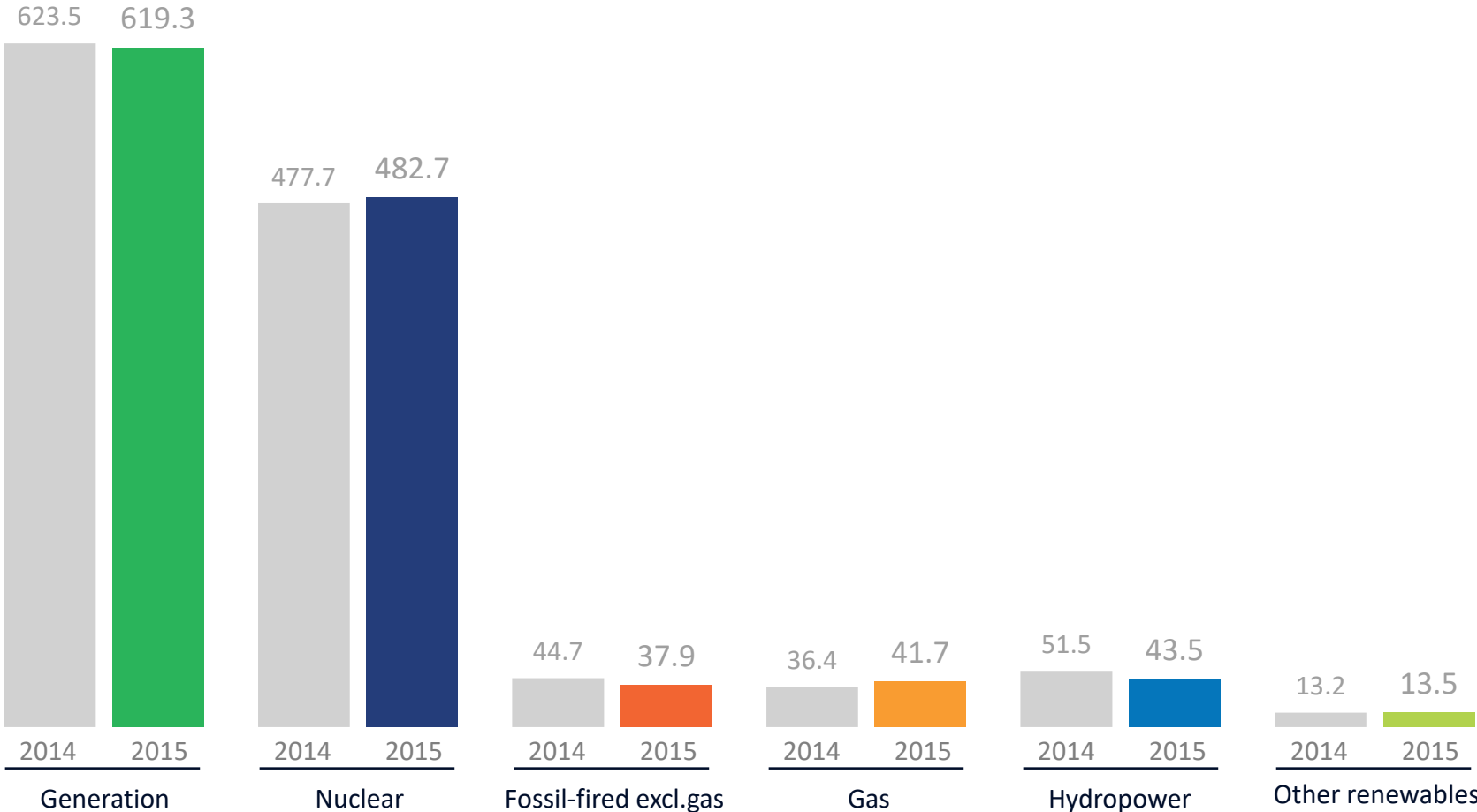


EDF GROUP'S INSTALLED CAPACITY IN 2015

Fully consolidated companies except for companies accounted for by the equity method (SZPC, SanMenXIA, Sloe, Alpiq, NTPC, CNEG), based on the percentage stake.



EDF GROUP'S ELECTRICITY GENERATION IN TWH IN 2015



FRANCE'S BIGGEST BIOMASS CHP PLANT AT BIGANOS

- High experience on biomass energy
- A unique expertise in developing, constructing, operating and managing high energy performance facilities
- Creating energy savings



BIGANOS BIOMASS CHP KEY FIGURES (SMURFIT COMPANY)

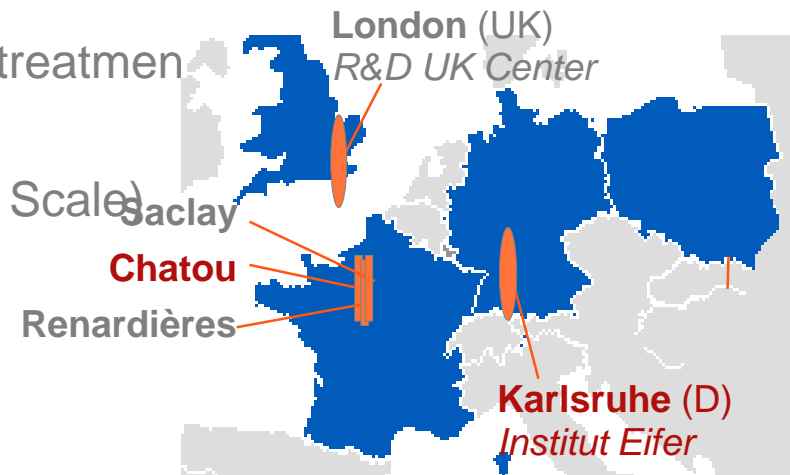
- BFB biomass boiler: **140 MW (LHV)**
- Gas back up boilers : **3x25 MW**
- Steam characteristics : **120 bars @ 520°C**
- 2 GE steam turbines : **69 MWe**
- Steam production for paper process : **260 tons/h**
- Dalkia investment cost : **135M€**
- Biomass fuel : **503,000 tons/y**
 - 219 000 t of barks
 - 200 000 t of forest residues & stumps
 - 84 000 t of pruning residues
- Project : **20 months**
- Commissioning : **Sept 2010**



Biomass & Waste activities

Teams located in 2 EDF R&D centers:

- Chatou, close to Paris, France
 - Biomass & waste combustion for CHP and power-only applications
 - Co-firing at large scale (CHP, Power-only)
 - Gasification : CHP, BioSNG and 2G biofuels
 - Biomass and waste prospective and technology survey activity (maturity)
- Karlsruhe, Germany
 - Biomass and waste feedstock and pretreatment
 - Biogas
 - Biomass and wastecombustion (Small Scale)



BACKGROUND

■ Biomass and waste conversion technologies and their development status

	Basic and applied R&D	Demonstration	Early commercial	Commercial
Biomass pretreatment	Hydrothermal treatment	Torrefaction	Pyrolysis	Pelletisation/ briquetting
Anaerobic digestion	Microbial fuel cells		2-stage digestion Biogas upgrading	1-stage digestion Landfill gas Sewage gas
Biomass for heating			Small scale gasification	Combustion in boilers and stoves
Biomass for power generation				
Combustion		Stirling engine	Combustion with ORC	Combustion and steam cycle
Co-firing		Indirect co-firing	Parallel co-firing	Direct co-firing
Gasification	Gasification with FC	BICGT BIGCC	Gasification with engine	Gasification with steam cycle

BIOMASS AND WASTE GASIFICATION IN BFB

■ R&D projects: Improved gasification for cogeneration applications (2011-2015)

- Fluidized bed technologies offer high efficiency, low emissions and high fuel flexibility. The commercial implementation of biomass gasification is still challenging because few processes have been proven to be economically viable

Electrical efficiency ~ 25%_{LHV} / Thermal efficiency ~ 40%_{LHV} / Overall efficiency ~ 65%_{LHV}

- The industrial research project is coordinated by EDF and aims at building up knowledge on air-blown bubbling fluidized bed (BFB) gasification to improve an existing competitive technology to open new small-to-medium cogeneration markets

■ 1. Control bed agglomeration risks

- Understanding of bed material and ash interactions
- Lab-scale experiments in static and fluidized bed conditions

■ 2. Control tar content in the syngas

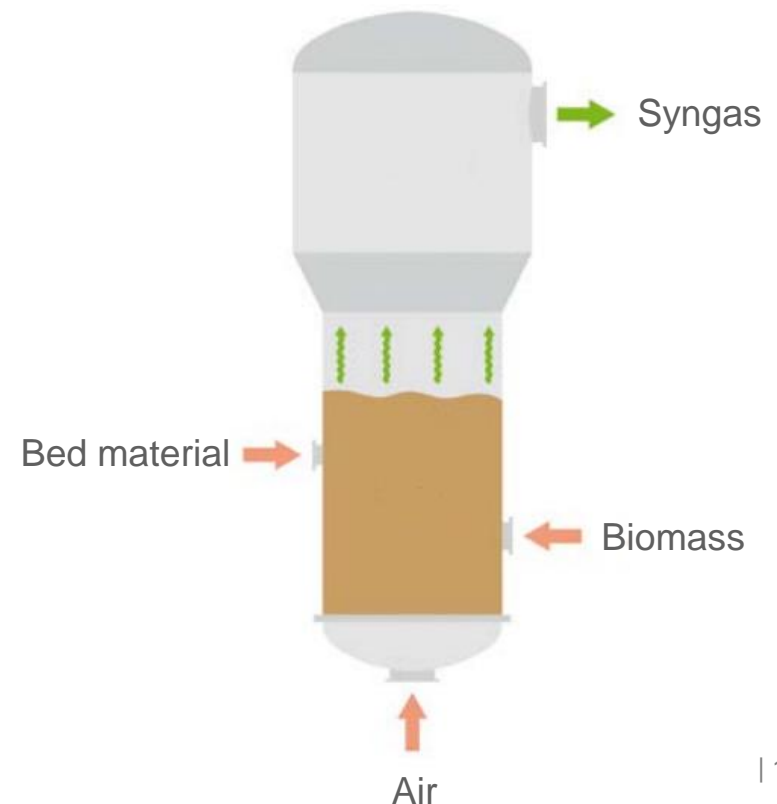
- Understanding of tar gas-phase and catalytic conversion
- Lab-scale experiments on tar model compounds

■ 3. Improve biomass size flexibility

- Understanding of bed material – biomass mixing and segregation
- Lab-scale experiments in a fluidized bed at ambient temperature

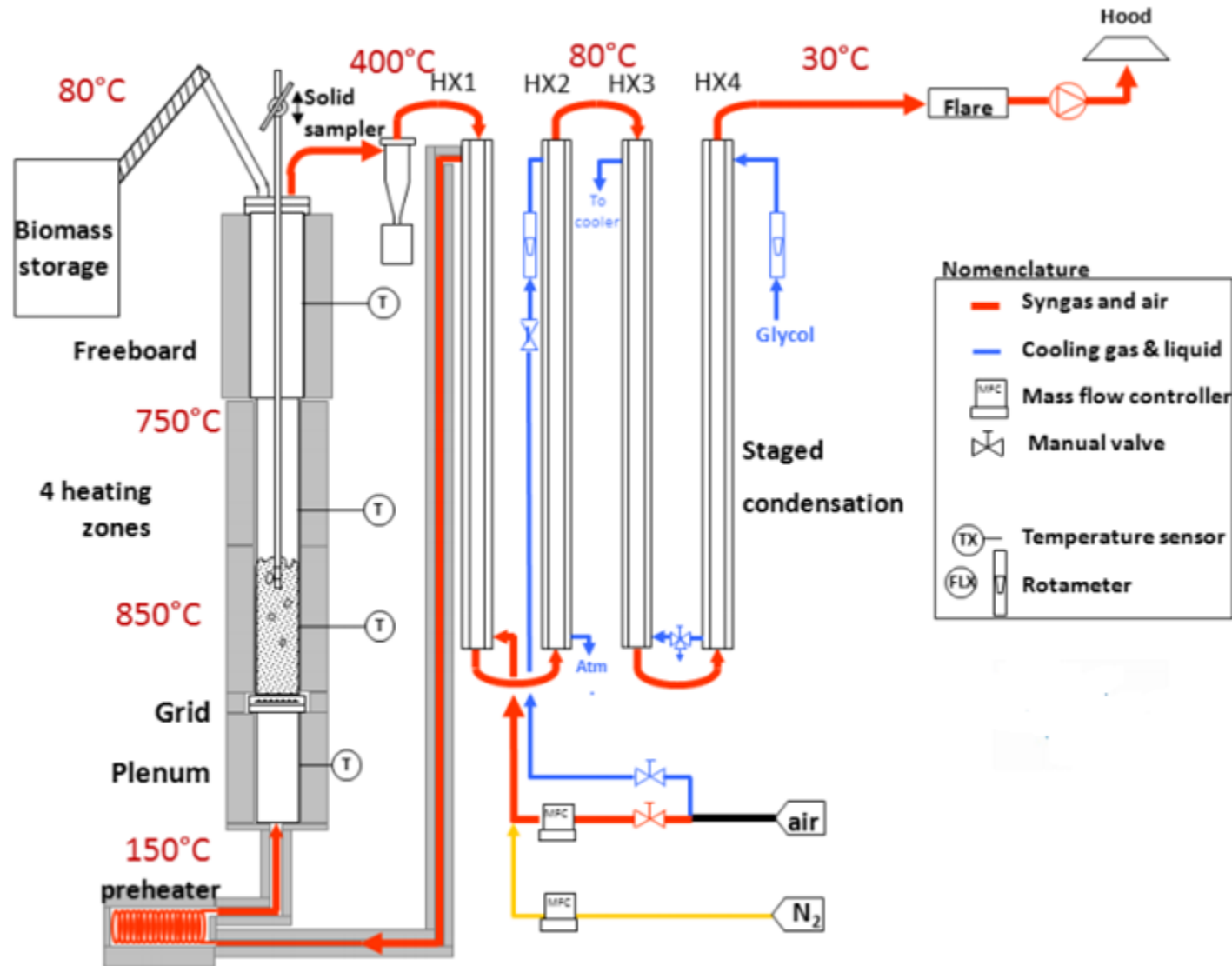
■ 4. Select suitable biomass resource

- Technical and economic analysis and environmental assessment

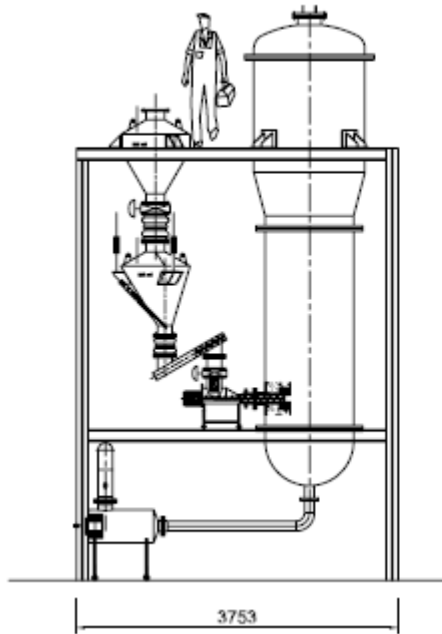


LAB SCALE EXP / PARTNERSHIP WITH UNIVERSITY

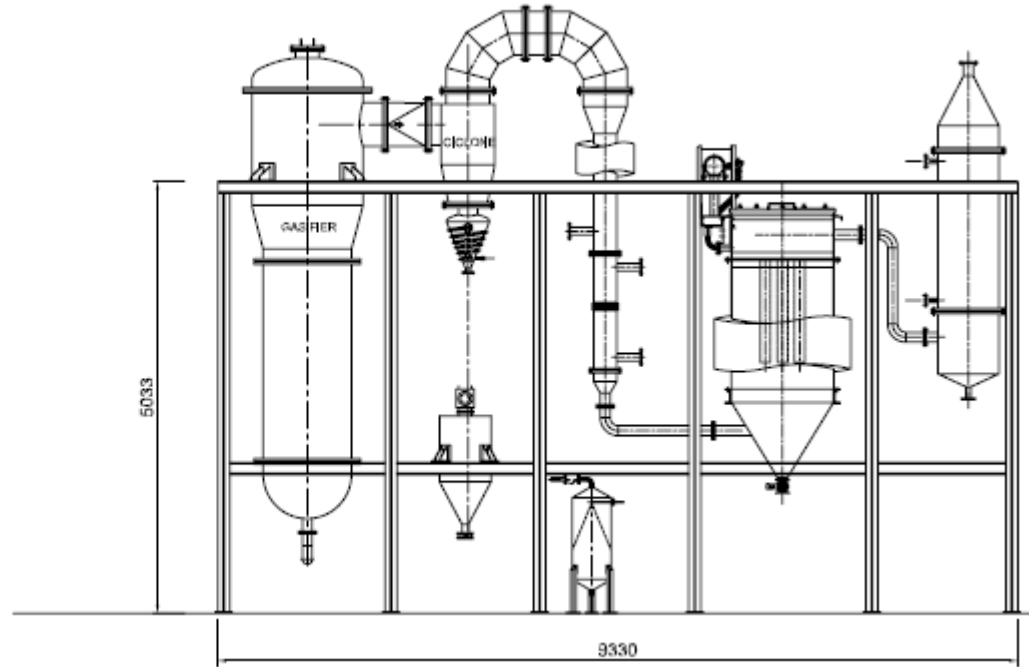
Bed internal diameter:
10 cm
Bed temperature:
700-1000°C
Equivalence ratio in gasification:
0.15-0.4



GASIFICATION PILOT PLANT IN EPINAL



Vue de côté / gauche



Vue de face

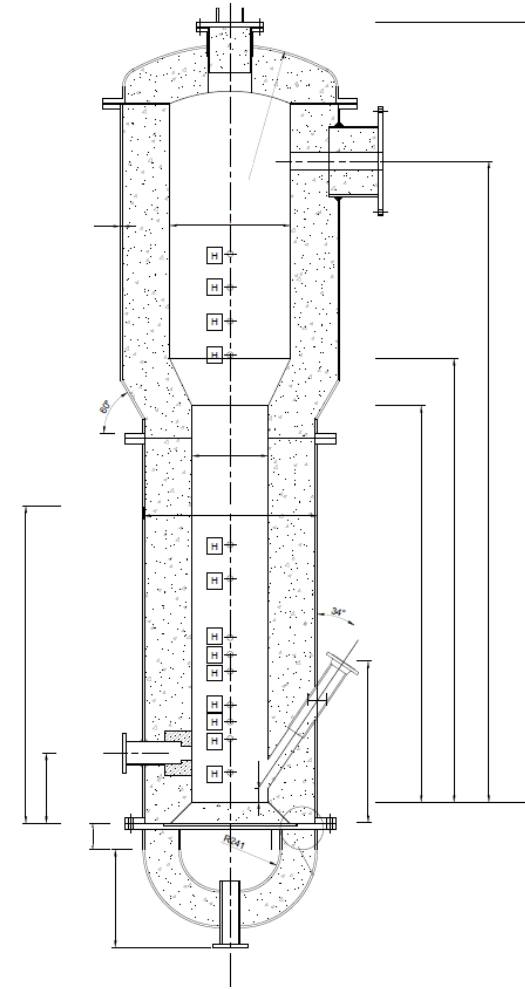


Vue d'architecte / insertion
sur le site du LERMAB à
Epinal

PILOTE DE GAZÉIFICATION

■ Gazogène LFB

- Diamètre interne / hors réfractaires : 0,45 m
- Hauteur utile totale : 3,8 m
- Débit de biomasse : 50 kg/h / 200 – 250 kW_{th}
- 1 vis d'injection refroidie au pied du gazogène
- Débit d'air / pré-chauffé ou non : 60 Nm³/h
- 9 injecteurs d'air primaire au pied du gazogène
- 3 injecteurs d'air secondaire au bas du freeboard
- Matériau de lit injecté au bas du freeboard : 0,5 kg/h
- Masse de matériau de lit : 120 – 180 kg
- Démarrage par combustion de gaz naturel / 30 kW_{th} puis combustion de biomasse
- Temps de démarrage : 2 – 3 heures
- Pertes thermiques théoriques < 2% de la puissance entrante



LFB

Vue de face

TERRACOTTA project

■ SRF gasification for cogeneration at territorial level

- Demonstrate the energetic and environmental performances of SRF gasification in bubbling fluidized bed coupled to a treatment unit of product gas
- Optimize the process and make more reliable the industrial development

■ Key data

- APR Energie Durable 2016 – ADEME

32 months

- 6 partners

Academic laboratories : LRGP, LERMAB

Process developer : EQTEC

End-user : EDF R&D (coordinator), DPIT, TIRU

- 4 technical work packages

Preparation and characterization of SRF

Tests in lab plant

Tests in pilot plant in representative environment

Preliminary study of process industrialisation

- Budget / ADEME financial contributions : 651 k€ / 299 k€






EQTEC



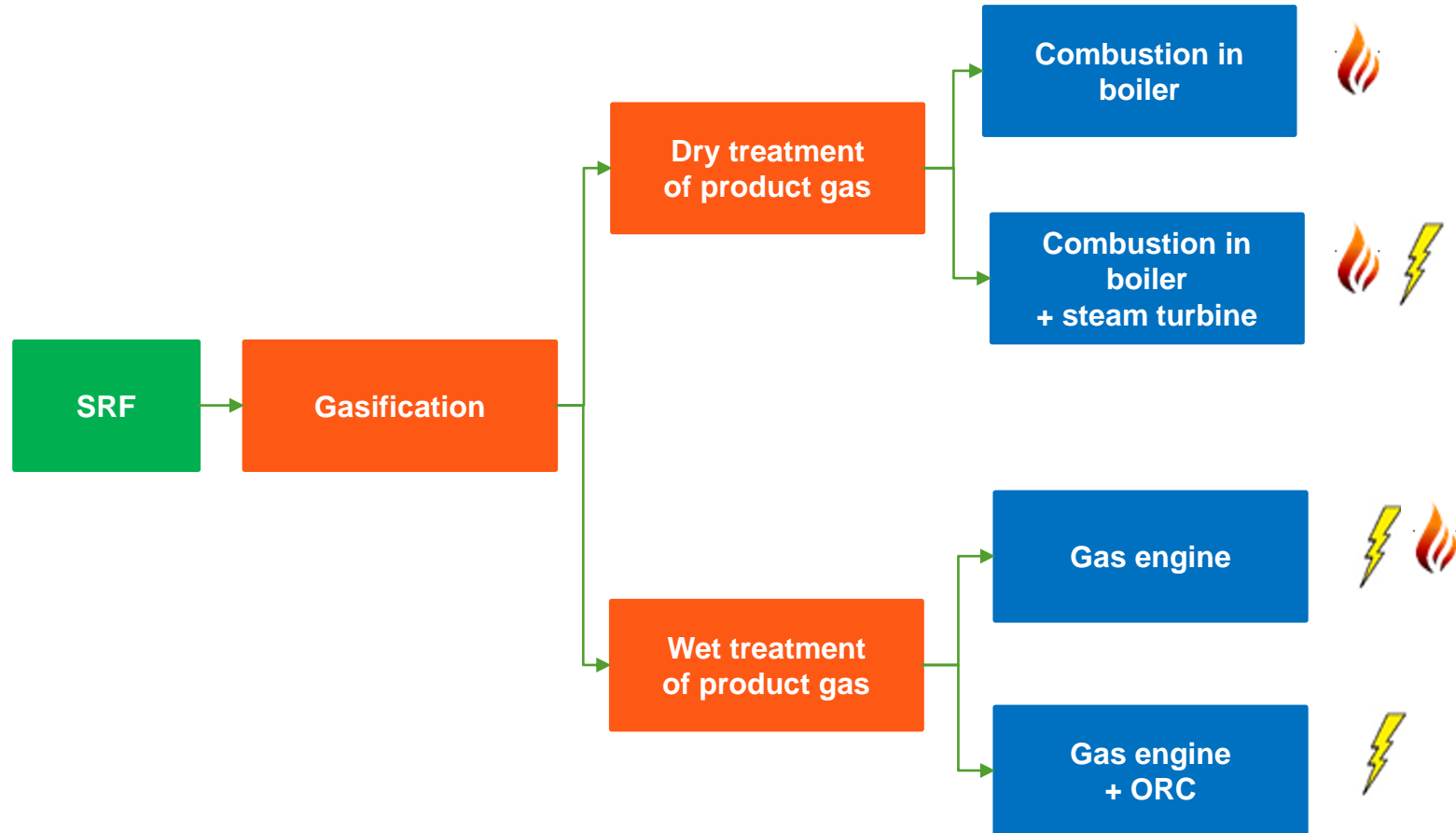
Background

■ Regulatory environment

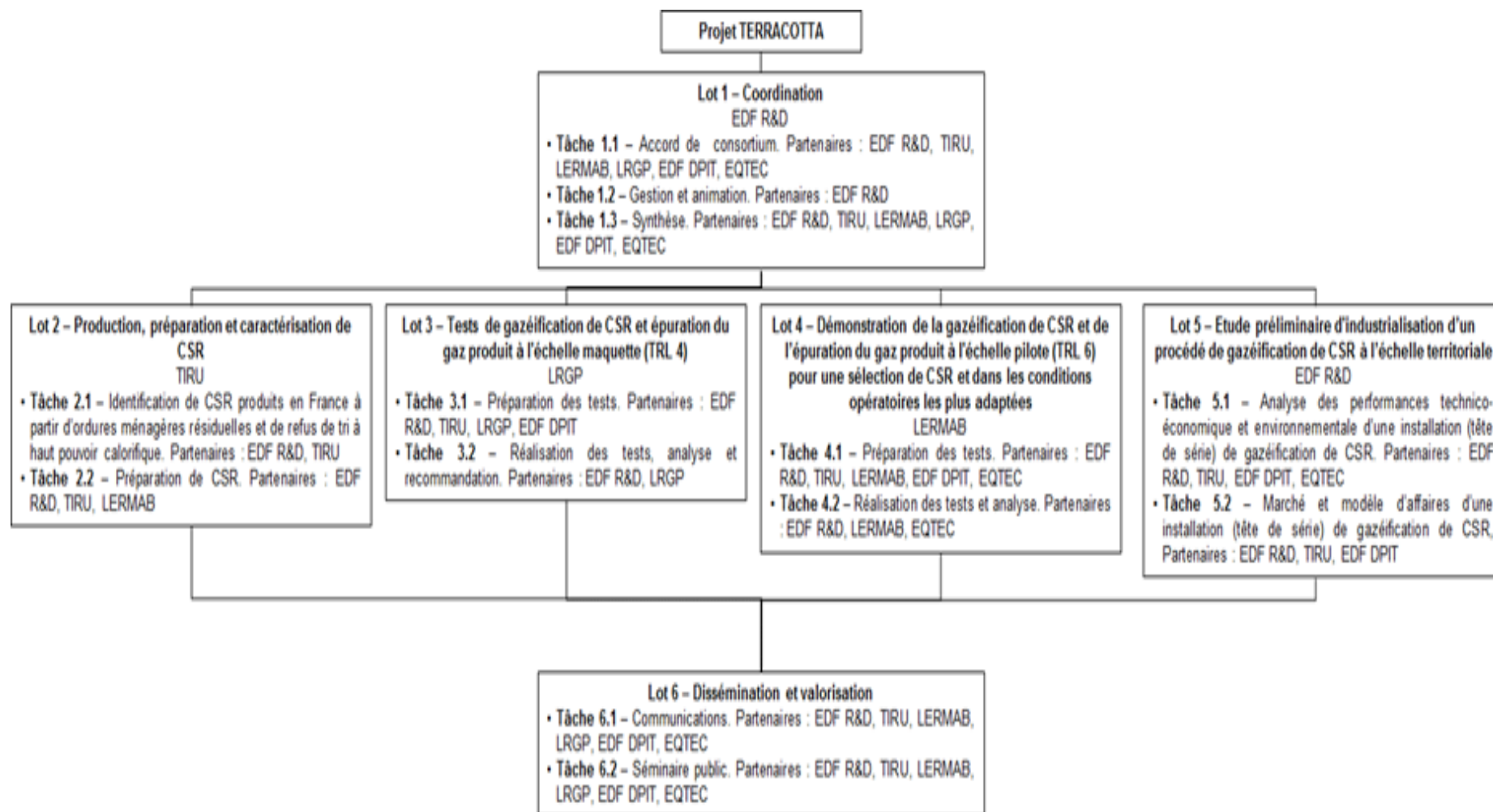
- « Loi relative à la **transition énergétique** pour la croissance verte » (17 August 2015)
- « Arrêté relatif à la **préparation des combustibles solides de récupération** en vue de leur utilisation dans des installations relevant de la rubrique 2971 de la nomenclature des installations classées pour la protection de l'environnement » (23 May 2016)
- « Arrêté relatif aux **installations de production de chaleur et/ou d'électricité** à partir de déchets non dangereux préparés sous forme de **combustibles solides de récupération** dans des installations prévues à cet effet associés ou non à un autre combustible et relevant de la **rubrique 2971** de la nomenclature des installations classées pour la création de l'environnement » (23 May 2016)

Heat		Efficiency > 70%	
Cogeneration		Efficiency > 70%	from November to March
Electricity		Efficiency > 30%	< 20 MW _{LHV} or overseas departments

Applications



Work packages



Work packages

- **Control of SRF preparation** for gasification in bubbling fluidized bed (**WP2**)



- **Make more reliable** the process and **control** the quality of product gas (**WP3** and **WP4**)



*LRGP Nancy – 3 kg/h
Lab-plant (WP3)
15 tests*



*LERMAB Epinal – 50 kg/h
Pilot plant (WP4)
3 campaigns*



- **Study of industrialisation** for SRF gasification at territorial level (**WP5**)



SRF PROCUREMENT

SRF Ludres



SRF NPC



Planning

Lot Tâches	2016						2017												2018												2019	
	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1 Coordonation																																
1.1 Accord de consortium							J0.1																									
1.2 Gestion et animation							J0.2																									
1.3 Synthèse																																
2 Production, préparation et caractérisation de CSR																																
2.1 Identification et caractérisation de CSR produits en France à partir d'ordures ménagères résiduelles et de refus de tri à haut pouvoir calorifique							J1.1																									
2.2 Préparation de CSR							J1.2												J1.3												J1.4	
3 Tests de gazéification de CSR et épuration du gaz produit à l'échelle maquette (TRL 4)																																
3.1 Préparation des tests																			J2.1													
3.2 Réalisation des tests, analyse et recommandations																			J2.2													
4 Démonstration de la gazéification de CSR et de l'épuration du gaz produit à l'échelle pilote (TRL 6)																																
4.1 Préparation des tests							J3.1																									
4.2 Réalisation des tests et analyse																			J3.2													
5 Etude préliminaire d'industrialisation d'un procédé de gazéification de CSR à l'échelle territoriale																																
5.1 Analyse des performances technico-économique et environnementale d'une installation (tête de série) de gazéification de CSR																			J4.1													
5.2 Marché et modèle d'affaires d'une installation (tête de série) de gazéification de CSR																			J4.1													
6 Dissémination et valorisation																																
6.1 Communications																																
6.2 Séminaire																																

THANK YOU FOR YOUR ATTENTION

