Biomass to Liquid a second generation technology for biofuels production

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Biofuels production impact on the environnement

	ADEME/DIREM study 2004		JRC/EUCAR/CONCAWE study 2005	
	Gain Energy consumption (%)	Gain GES Emission (%)	Gain énergie consumption (%)	Gain GES Emission (%)
Ethanol ex wheat	57	60	**22**	**30**
Ethanol ex beet	58	61	**24**	**32**
Ethanol ex ligno cellulosique *	-	-	76	78
EMHV ex rape	69	70	**64**	**70**
EMHV ex sun flower	71	75	**74**	**78**
BTL *	-	-	94	94

The 2nd generation technologies expectations

- Valorisation of the « entire » plant (1st G = starch, sugar, lipids)
- Higher yields expected (tep/ha)
- Broader source of raw materials
- Less competition with food related raw materials
- Larger flexibility for biofuels raw materials sourcing

Ressources

Ethanol de cellulose

BTL

- agro-industry byproducts (straw, drèches, beet pulp, ..)
- Dedicated annual plants (as biomass)
  - Compatibility with annual economic cycles
  - Backward return possible
- Perennial cultures (miscanthus, switchgrass)
  - Best compromise between productivity and local environnement (nitrogen, pesticide)
  - C4 Plants : best efficiency in water and nitrogen
  - N2 Transfert / remobilisation in rhizomes
  - Use of fields and non-fields soil
  - Forestry and forestry by-products

Raw materials

Europe (biocarburants) **(Mtep)**	4% 15	5.75% 22	8% 31	10% 40
France (biocarburants) **(Mtep)**	5.75 % 3.3	7% 4	10% 6	10% 6
Europe (Mha)[1]	10	15	20	27
France (Mha)	3.3	4.0	6	6

[1] On passe des productions aux hectares en utilisant un ratio Tep éthanol/ha. On a utilisé dans ce chapitre le ratio 1ha= 1.5 Tonne de biocarburant

Ref: « How much bioenergy can Europe produce without harming the environment » (2006)

Bioenergy

	2010	2020	2030
Agriculture	**46 MTep**	**95 MTep**	**142 MTep**
Forestry	42	39	39
By-products	100	100	102
Total	188	234	280

MTep	2010	2020	2030
biofuels	**20**	**27**	**21**
biogaz	**13**	**33**	**53**
Heat/ electricity	13	35	68
Total	46	95	142

Potential for 2nd generation biofuels

Coproduits (estimations actuelles)

- Pailles récoltables (20%) 5.2 MT ms
- Sons 1.2 MT ms
- Pulpes betteraves 1.4 MT ms

Concurrence alimentation animale et chaleur/électricité !

Cultures énergétiques

- Sorgho biomasse, triticale 10 à 15 Tms/ha.an
- Miscanthus, switchgrass 15 à 25 Tms/ha.an
- Taillis à très courte rotation 10 à 12 Tms/ha.an

Concurrence surfaces alimentaires et autres filières énergétiques !

Surfaces CE ???

Production forestières

- Bois : accroissement biologique actuel : 103 Mm^3/an

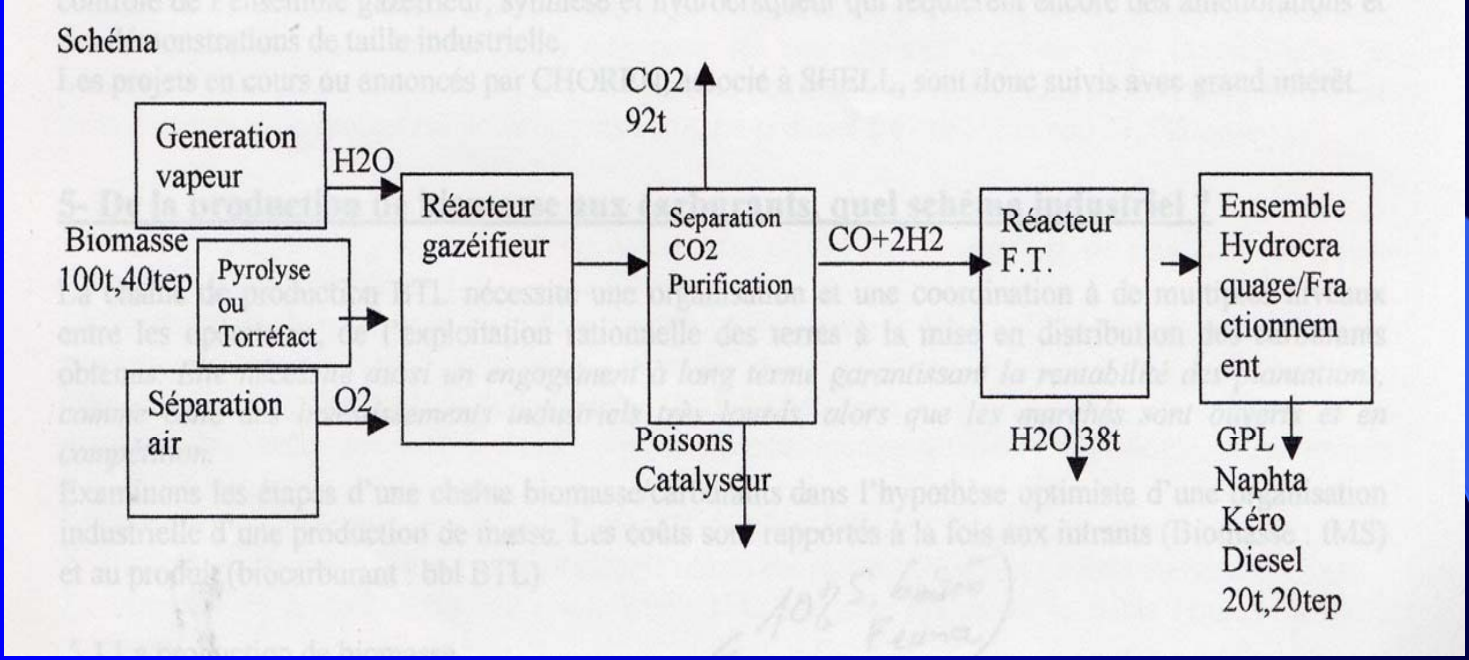
  récolte annuelle 59 Mm^3/an dont 21 Mm^3/an bois d'œuvre.

enjeu : mobiliser plus de bois sans déstabiliser usages existants

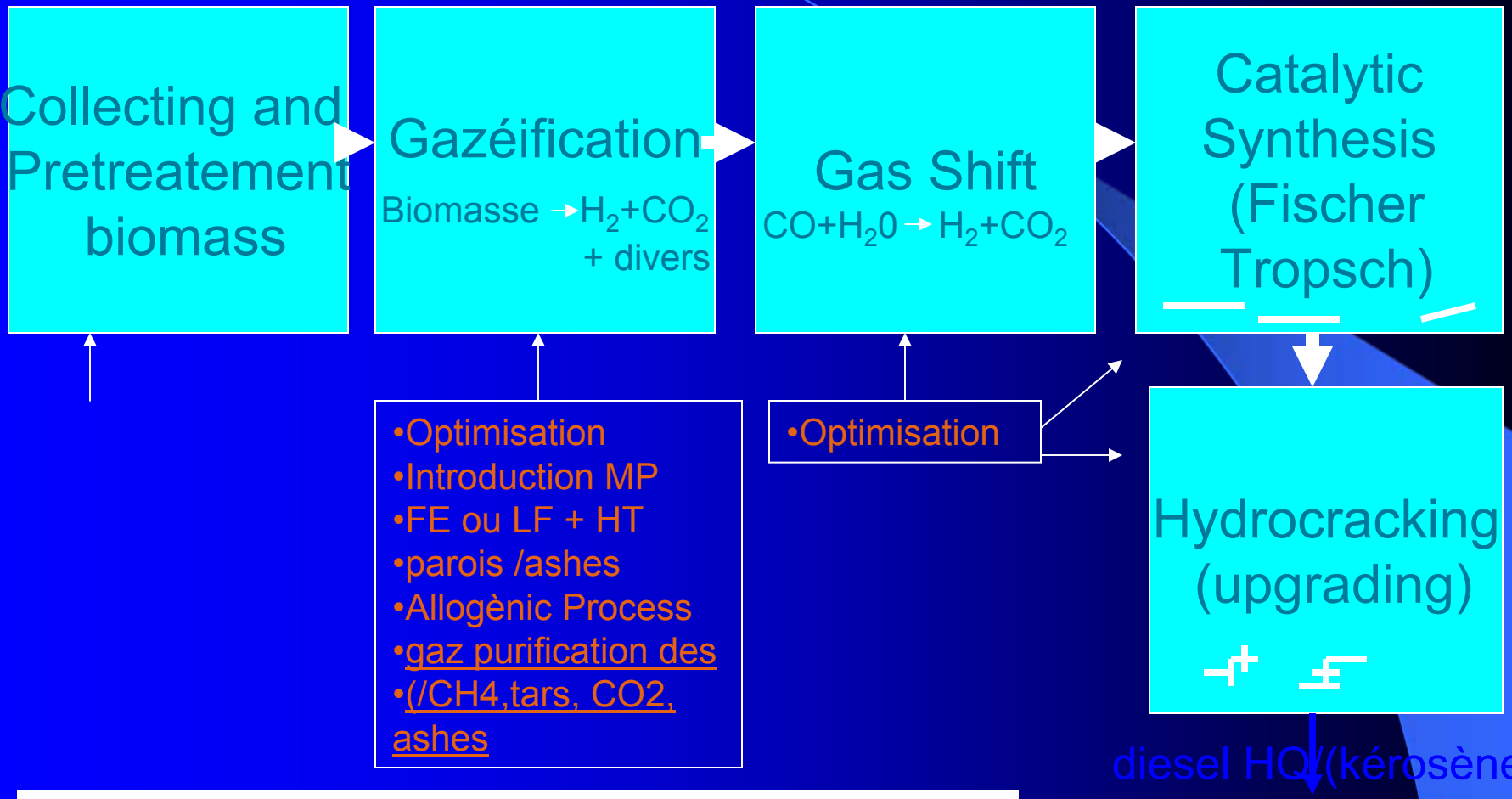
maximum absolu théorique : 8 Mt/an de bois industriel supplémentaire

Potentiel max théorique avec coproduits + 1 Mha CE dédiées + forêt : 28 MTms/an = 4.2 Mtep/an ~10 % consommation nationale actuelle ???

The thermochemical route

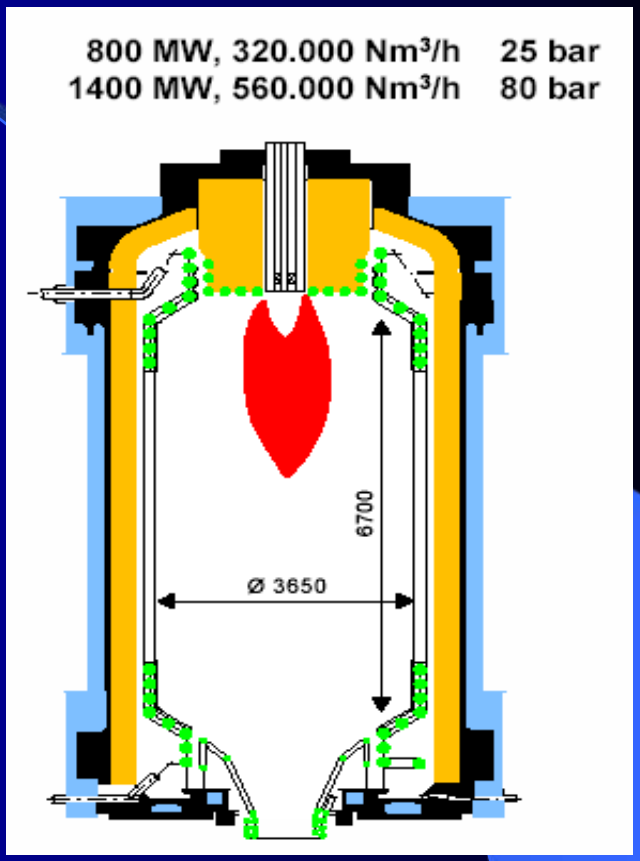


BTL process



+ global process optimisation +
technico-économical validation

Gazeification



Gazéificateur à flux entrainé (pilote FZK) industrial size

Mass yield of gazéification process

$C_6H_9O_4 + 2\ H_2O \longrightarrow 6\ CO + 6{,}5\ H_2$

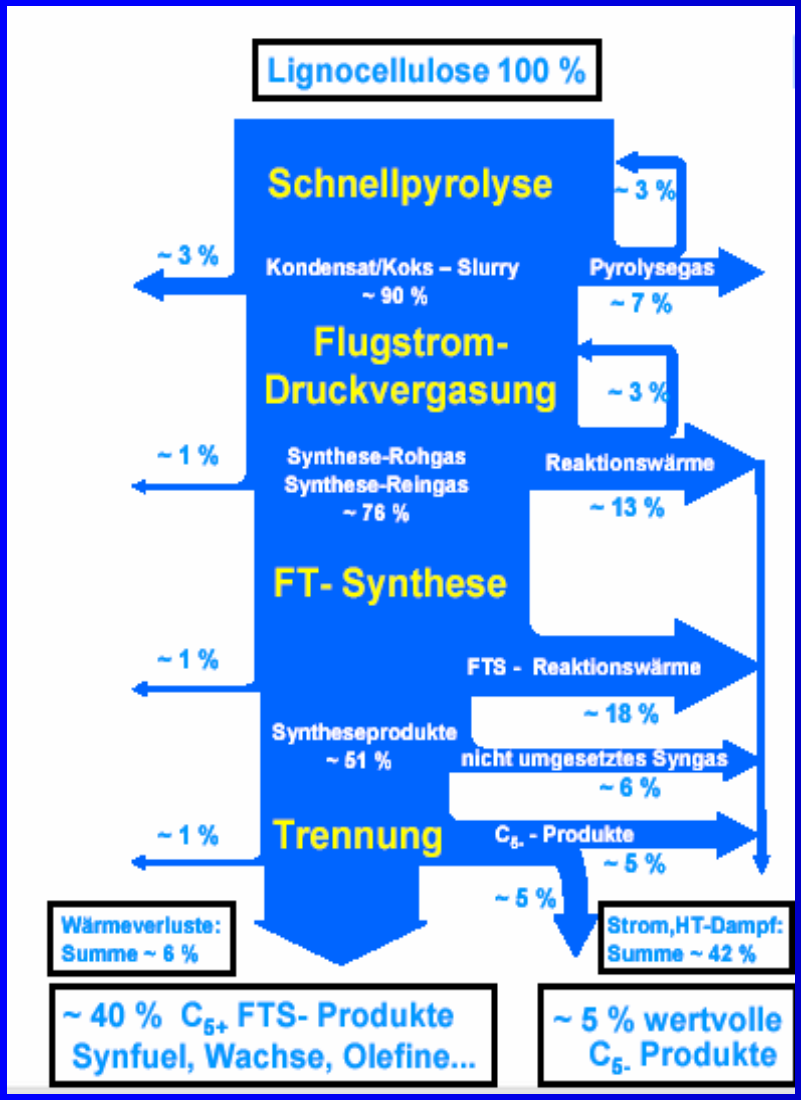
Endothermal Réaction

autothermal route:	Allothermal route : external energy added (no combustion)
combustion ~ $2C + 2H_2$	
Remain 4 CO + 4,5 H_2	Remain 6 CO + 6,5 H_2

Synthèse FT nécessite $H_2/CO \sim 2$

Gaz Shift Réaction	Gaz Shift Réaction	No Gaz Shift
1,5 $CO \longrightarrow 1{,}5\ H_2$	2 $CO \longrightarrow 2\ H_2$	But H_2
Remain 2,5 CO + 6 H_2	Remain 4 CO + 8,5 H_2	Remain 6 CO + 12 H_2
Max yield : 2,5 CH_2	4 CH_2	6 CH_2
réal yield: ~ 1,5 CH_2	~ 3 CH_2	~ 5 CH_2
η real mass : ~ 16 %	~ 30 %	~ 48 %

Energy/Mass yields



7 t wood or straw

collecting stocking drying

6 t dry wood / straw

pyrolysis

4,7 t slurry (coal + oil)

gazéification + FT

1,25 t FT products

upgrading

1 t biofuel

Yield BTL brut

= 1,7 tep/ha/year for 12 tDM/ha/year

Énergy

40 % biofuel and synthesis products

54 % primary énergy heat / élec

6 % minimal losses

Allothermal processes

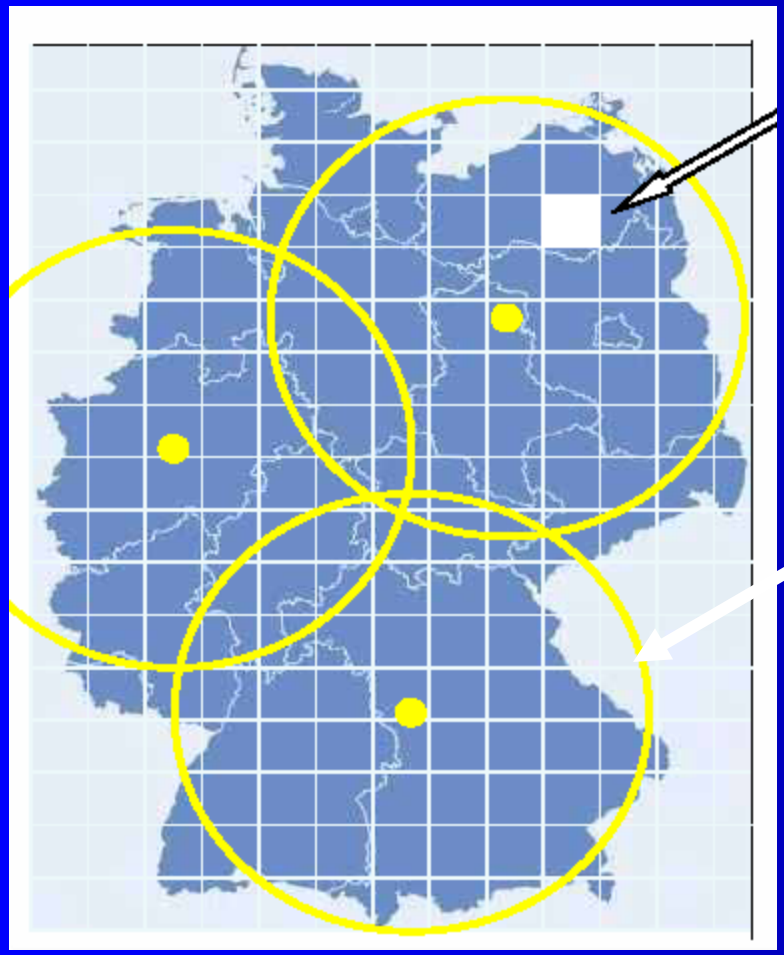
- Basis Concept :
  - Fuel prices(mobile)increasing
  - Energy prices for non mobile use moderate

Basis case	6,7 Mt /year biomass		1,94Mt biofuels
+heat		9,3 Twh/year (1 NE plant)	2,61
+ heat+ H2		32,6 Twh/year (3 NE plants)	3,9

BTL process :logistics

- Scale effect implies very large plants with continuous process : over one million tons biomass /year !!!
- Transport cost: new logistics required
- - biomass densification for transport + easier introduction in gazéificator. Fast pyrolysis (L + S = slurry)

BTL plants : concept in Germany



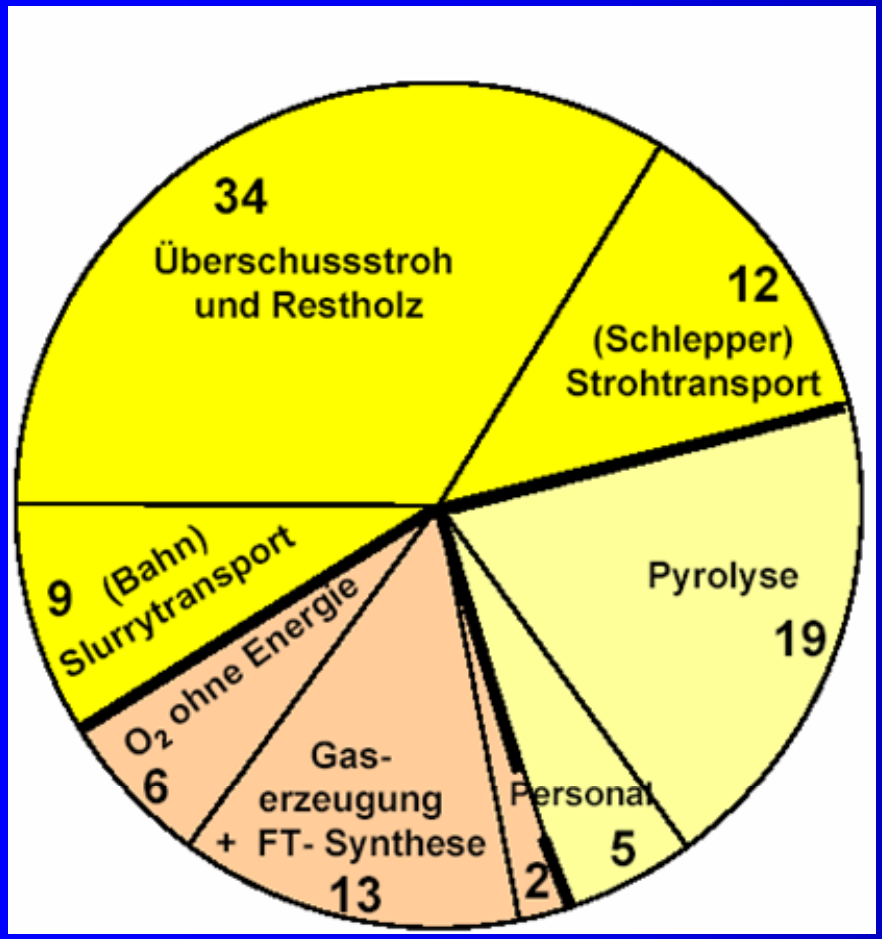
White squares:

100 MW pyrolysis installations

Yellow circles : feeding basins for BTL units

1 Mt/an biofuel

BTL: structure of production costs(%)



Source : FZK

HYPOTHESIS :

- 38pyrolysis plants

(20-25 M€ / units)

Unit load : 0,2 Mt/year biomass (straw and forestry by-products) output 134 000 t/year

- Product shipped to a central production unit

(500 à 625 M€)

Capacity central unit :

1 Mt/year BTL

Research

•Germany world leader : demonstration plant CHOREN(β-plant = 15000 t /an), FZK/Lurgi, Gussing, TU Freiberg (Future Energy).

• (Finlande, USA)

• SASOL (Afrique du sud) gazeification know how and world leader FT. biomass incorporation trials.

• France: - PNRB : 3 projects in 2005 + 5 in 2006 + 3 in 2007

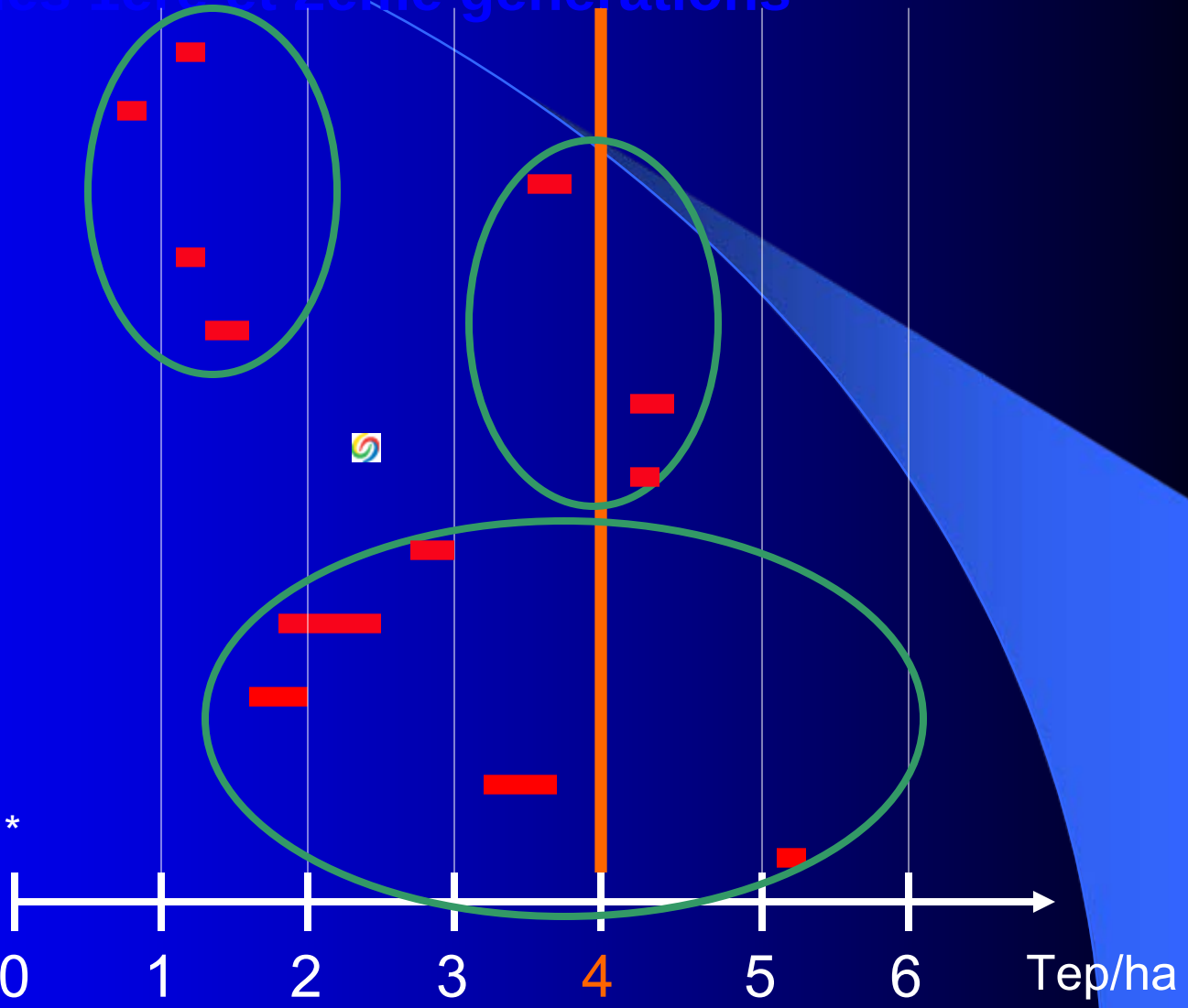
Partenaires : CEA, DCPR, ARMINES, CIRAD, EdF, IFP, GdF,…

- LURGI (german firm with CTL + GTL technologies bought by Air Liquide)

- Pilot (s) CEA and Sofiprotéol + prétreatment biomass

Comparison rYields cYomparisonsendements bruyts des 1ère et 2ème générations

EMHV rape
EMHV sunflower
Ethanol beet
Ethanol wheat
Ethanol corn
Ethanol sugar cane
Biogaz corn base
Biogaz corn base *
Ethanol ex cellulose *
BTL authothermal *
BTL allothermal *
BTL allothermal + H2 *



* with 12 tdm/ha

Sources : Comité 2B, FZK, CEA, DOE, DTU, ICÔNE, MAP, Claude Roy