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Biomass as a helpful support to sun and wind for insulated small electrical networks

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CIEM 2019 – Energy for a green digital world
Timisoara, october 17 – 18, 2019

- Context
- Renewable energies - overview
- Intermittent energies
- Ensuring continuous power delivery
- Conclusions



❖ The aim is to generate electricity ...

- ... with minimal consumption of fossil fuels
- and maximal use of local resources

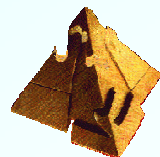
❖ We focus on little islands:

- Little : Small population
- Islands : no connection to any other electrical network
- Small population : production units will be modest
- Small territory : no smoothing effect related to geographic extent
- Isolated : no smoothing opportunity from neighboring networks

Maximal use of local resources

- ❖ Assumption: if no oil or gas resources
 - Energy drawn from water, sun, wind or biomass

- ❖ Concurring with a minimal use of fossil fuel
 - Hence a « greener » energy mix
 - ... and incidentally lower imports and energy dependence ...



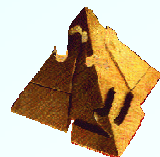
Most popular ones : wind energy

❖ Assets:

- Very trendy
- Reasonable investment (≈ 1.5 M€/MW in Europe)
- Appropriate power range
- Well-mastered technology and engineering
- « Free » energy

❖ Drawbacks

- Erratic behaviour
- Unpredictable behaviour
- Quick variations (wind gusts)
- Poor load factor ($\approx 22\%$ in France)
- « Not that green » ...



Most popular ones : Photovoltaic sun energy

❖ Assets:

- Very trendy
- Reasonable investment ($\approx [0.8 - 2]$ M€/MW in Europe)
- Appropriate power range
- Well-mastered technology and engineering
- « Free » energy

❖ Drawbacks

- Erratic behaviour
- Unpredictable behaviour
- Quick variations
- Poor conversion rates ($\approx 15-20\%$ of the incident solar radiation)
- Poor capacity factor ($\approx 15\%$ in France)
- « Not that green » ...



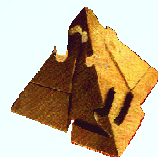


❖ Assets:

- Better conversion rates and capacity factors
- More stable behaviour than PV
- High temperatures → thermal inertia
- Allows a form of storage → continuous operation

❖ Drawbacks :

- Performance heavily dependent on sunshine
- Significantly more expensive than PV





❖ Hydroelectric dams

- Require important water flowrates

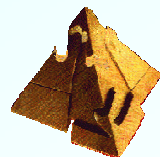
❖ PHES – Pumped Hydroelectric Energy Storage

- Requires significant level differences



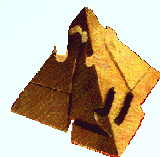
In both cases : great dependance on geography

You don't do what you want where you want
 Much less fashionable



- ❖ Tidal power
- ❖ Mechanical energy of waves
- ❖ Ocean thermal energy conversion

- ❖ In all cases :
 - Strong dependance on geography
 - Significant investments
 - Development still at an experimental stage

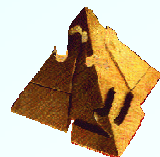


❖ Assets:

- Well-mastered and proven technology
- Neutral carbon balance
- Offers valorization of agricultural by-products
- Easy storage of raw materials
- Can be coupled with fossil fuels
- Small engineering efforts

❖ Drawbacks :

- Furnace → boiler → steam → gas turbine : great inertia
- All that could be done has already been done ...

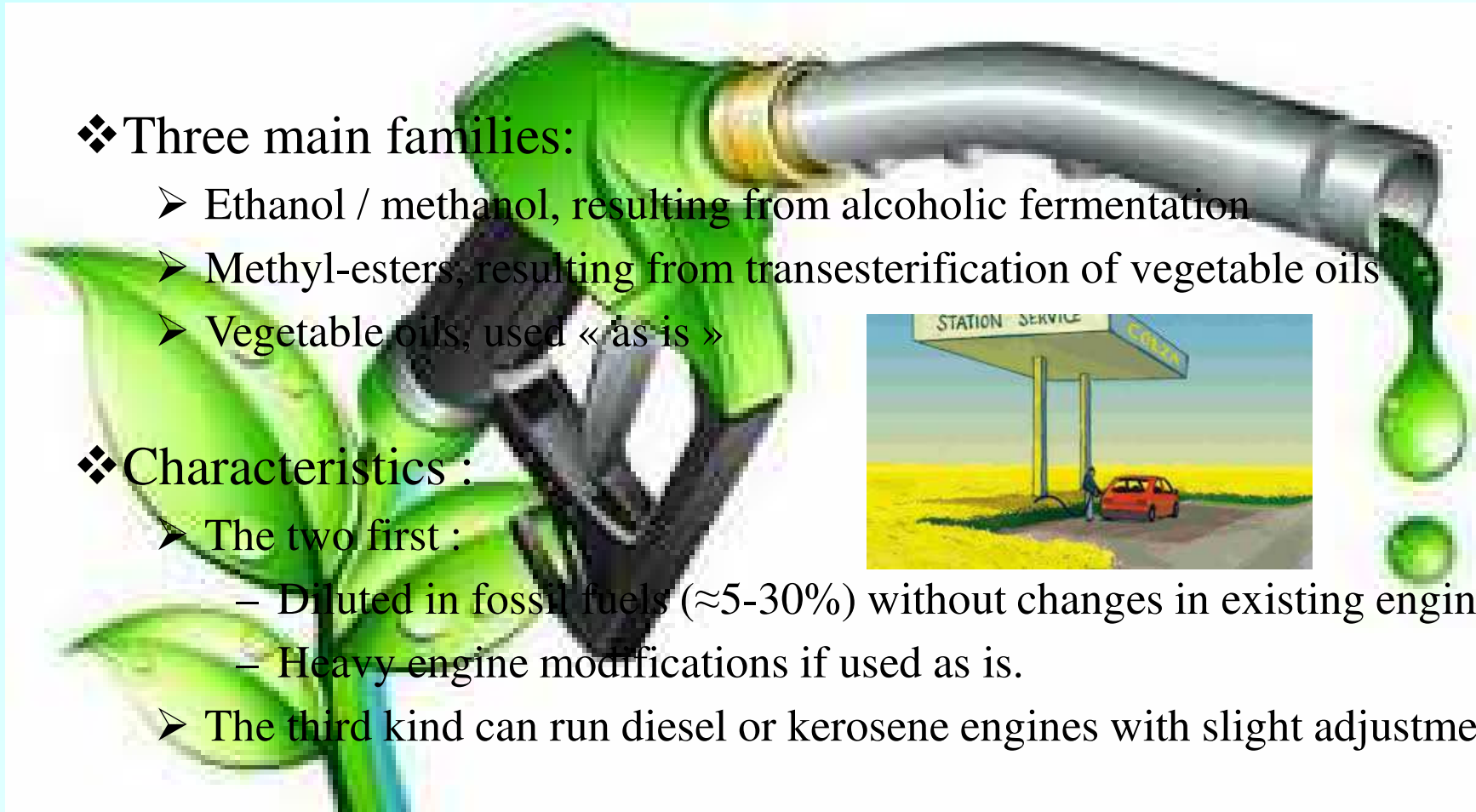


❖ Three main families:

- Ethanol / methanol, resulting from alcoholic fermentation
- Methyl-esters, resulting from transesterification of vegetable oils
- Vegetable oils, used « as is »

❖ Characteristics :

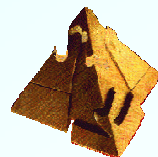
- The two first :
 - Diluted in fossil fuels ($\approx 5-30\%$) without changes in existing engines
 - Heavy engine modifications if used as is.
- The third kind can run diesel or kerosene engines with slight adjustments



Qualitative summary

- 1 – Easy
- 2 – Average
- 3 – Tough

Energy sources	Engineering effort	Installation Cost	Operating Cost	Steadiness	Predictability	Σ
WindMill Farms	1	1	1	3	3	9
Solar – PhotoVoltaic	1	1	1	3	3	9
Solar – Concentrated Power	1	2	1	2	2	8
Water – Hydroelec. Dams	2	3	2	2	1	10
Water – Pumped Storage	2	3	2	1	1	9
Water – Sea Energy	3	3	2	1	1	9
BioMass – as a Fuel	1	1	2	1	1	6
BioFuel – Alcohol	1	2	3	1	1	8
BioFuel – Diesel	1	2	3	1	1	8
BioFuel – Oil	1	1	2	1	1	6



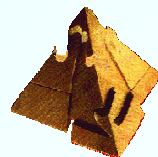
- ❖ According to the previous synthesis :
 - Windmill farms and photovoltaic solar energy are easy to implement and to operate
 - This mainly explains their popularity
 - But they both suffer from serious defects :
 - ✓ They can vary or simply vanish from times to times ...
 - ✓ Changes in their production can be brutal
 - ✓ Without long-term forecasts
 - If no compensation is available :
 - ✓ Need for an alternative means of electricity generation
 - ✓ Ideally, should require reasonable investments



Supplemental means of production

- ❖ Considered as an auxiliary electricity provider :
 - Must be economic (double investment, often at rest)
 - Must be adapted to various ranges of power delivered
 - Must be responsive
 - ... must be green ...

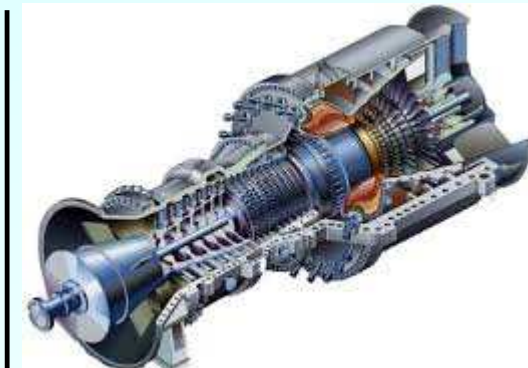
- ❖ The synthesis table indicates engines running with vegetable oils
 - Piston engines (diesel) or turbines according to the desired power



Engines powered by biofuels



Piston engines

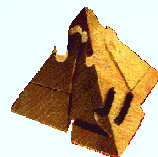


Turboshafts

Design effort
 Equipment cost
 Shipping & installation
 Operating cost – maintenance
 Power delivered
 Energy efficiency
 Response time

Weak
 Weak
 Easy
 Frequent and cheap
 A few 10s of MW
 35 – 40%
 A few 10s of mn

Weak to moderate
 Weak
 Easy
 Reliable, expensive
 A few 100s of MW
 30 – 35%
 A few mn



❖ Context :

- Low population → Minimize investments
- Ecology + importations + independence → green local resources
- Remoteness → full-time reliability

❖ Solar and wind :

- Winmills + PV collectors satisfy the first 2 constraints ...
- ... but require responsive auxilliary power generation

❖ Seen from another point of view :

- Vegetable oils as biofuels would match all the requirements
- ... but require huge cultivated area :
 - Limited to sparsely populated territories
 - Limited to poorly industrialized territories





Thank you for attention.

Any question?



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- Akhtar Saeed, « Prospects of Bagasse as a feasible bio-fuel for electricity generation in Pakistan — A realistic approach », conference on Power Generation System and Renewable Energy Technologies, 10-11 june 2015, Islamabad, Pakistan, IEEE, 2015.
- Antoine Arousseau, Valery Vuillerme, Jean-Jacques Beziau, « Control systems for direct steam generation in linear concentrating solar power plants: a review », Renewable and Sustainable Energy Reviews, Elsevier, 56, pp. 611-630, 2016.
- Fengzhen Chen, Neven Duic, Luis Manuel Alves, Maria da Graça Carvalho, « Renewislands—Renewable energy solutions for islands », Renewable and Sustainable Energy Reviews, 11, pp. 1888–1902, Elsevier, 2007
- Shafiqur Rehman, Luai M. Al-Hadhrami, Md. Mahbub Alam, « Pumped hydroenergy storage systems: A technological review », Renewable and Sustainable Energy Reviews, 44, pp. 586–598, Elsevier, 2015
- Abdelrahman Azzuni, Christian Breyer, « Energy security and energy storage technologies », 12th International Renewable Energy Storage Conference IRES, Energy Procedia, 155, pp. 237-258, Elsevier, 2018
- Jean-Pierre Favennec, Yves Mathieu, « Atlas Mondial des énergies – Ressources, consommation et scénarios d’avenir », Armand Colin, 2014
- Robert Scott, « Historical Trends in Turboshaft Engine Procurement Cost », Journal of the American Helicopter Society, Volume 62, Number 3, July 2017, pp. 1-9, Vertical Flight Society, 2017
- Alain Chauvel, Gilles Fournier, Claude Raimbaud, « Manuel d'évaluation économique des procédés », Technip, 2001
- Agneta Forslund, Fabrice Levert, Alexandre Gohin, Chantal Le Mouël, « La base de données du modèle MATSIMLUCA », ADEME, 2013

