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http://www.lowcarbon-societies.eu/
A scenario of realistic and sustainable energy transition

1. Hierarchy of options
   - First, action on energy demand through conservation and efficiency
   - Priority to the use of energies based on flows rather than stocks
   - Thus: no replacement of nuclear by nuclear, and no CCS

2. Technological realism
   - “Mature” solutions (i.e. at least industrially emerging)
   - Although knowing that ruptures will happen
   - A more robust trajectory still open to good surprises

3. Sustainable development
   - Multicriteria analysis instead of “carbocentrism”
   - Aim for reducing the whole of risks and impacts arising from energy
   - “Transfering revenues rather than debts to future generations”
The need of a consistent trajectory

- A prospective analysis to bring long term concerns in short term decisions
- A combination of a long term vision and a trajectory to reach it starting with our current situation
- A tool to project and quantify action: priorities, level of ambition, rhythm of policies
- An analysis consistent with physical constraints and realities: an energy model to question the economy and absolutely not the opposite!
Bottom-up energy and power model

**Ressources primaires**

- Charbon
- Pétrole
- Gaz naturel
- Uranium
- Elec. renouv.\(^1\)
- Biomasse\(^2\)
- Autres ENR\(^3\)

**Equilibre en énergie**

+ **en puissance** pour l’électricité

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**Notes**

1. Electricité primaire d’origine renouvelable : hydraulique, éolien, photovoltaïque, énergies marines...
2. Biomasse solide, biomasse liquide et biogaz.
3. Autres énergies renouvelables : solaire thermique, géothermie, déchets ménagers...
Framework hypothesis

- Base year (stats): 2010
- Horizon of the scenario: 2050
- No economic input (priority to analysing physical constraints and possibilities)
- Demography:

  - 5 years less to act while urgency grows

Geographic basis:
- Metropolitan France (Corse included, DOM-COM excluded)
- Search for self-sufficiency / balance or excess of exchanges
A basis for comparison of the négaWatt 2011 scenario with the alternative

Revised “trend” or “business-as-usual” scenario:
- demand: quasi-stabilisation post economic crisis and post “Grenelle”
- production: stability of nuclear capacity, slow development of renewables
négawatt 2011
Energy consumption

Buildings / heat
Buildings / specific electricity
Transports / people
Transports / goods
Industry
Agriculture
Heat in buildings

- Reduced increase of surface per person in housing (less de-cohabitation and priority to small collective housing) and tertiary sector
- For new buildings, application of best available technologies to reduce grey energy and reach less than 15 kWh/m$^2$ per year of primary energy for heat uses
- Progressive but massive programme of thermal retrofitting of existing buildings to reach the equivalent of 1 million operations per year by 2025 with a performance of:
  - 50 kWh/m$^2$ (PE) per year for heating
  - 25 kWh/m$^2$ (PE) for hot water
- Changes of heat and hot water systems, substitution by renewables when possible, reaching coverage of 94% of the needs by 2050, including solid biomass, biogas, renewable based heat pumps and thermal solar
Energy substitutions in heat for buildings

Consommation finale dans bâtiment/tertiaire pour usages chaleur

(TWh)

- Solaire thermique
- Réseaux de chaleur
- Electricité
- Combustible gazeux (réseau)
- Butane/propane
- Combustibles liquides (fuel, biomasse)
- Biomasse solide (bois,...)
- Combustibles solides (charbon, déchets)

Consommation finale
- 2010
- 2050

Consommation finale dont part énergies renouvelables
Specific electricity uses

- Total electric consumption for specific uses can be divided by 2 by 2050 in residential and tertiary sectors:
  - based on generalisation of best observed current practices
  - including > 15% margin for unknown new uses

### Résidentiel

- Gestion & hygiène
- Electronique de loisir
- Eclairage
- Froid
- Lavage

### Tertiaire

- Autres dont process
- Informatique
- Autres usages
- Eclairage public
- Eclairage commun d'immeuble

(TWh)
Sustainable evolution of transports

- Analysis of needs for mobility and solutions depending on the use, the distance, and the availability of transportation options (from most urban to most rural)
- Integration of factors for *sobriety*, including urban planning (reducing distances needed for the same service), reorganisation of services and production and distribution networks
- Modal transfer (individual car from 63% to 42% of km.cap, reduction of 38% of the share of road transport for goods)
- Evolution of cars towards electric cars for urban use and gas vehicle (fueled with biogas) for other needs
- Increased efficiency of engines and generalization of hybrid vehicles
Evolution of people’s mobility

Millions de km.voyageurs

- Total mobilité 2010
- Total mobilité 2050
- Mobilité régulière et locale 2010
- Mobilité régulière et locale 2050
- Mobilité > 80 km 2010
- Mobilité > 80 km 2050
- Autre mobilité 2010
- Autre mobilité 2050

- Autres
- Avion
- Voiture
- Transport en commun
- Individuel
Energy for mobility of persons

Évolution des consommations d'énergie

(TWh)

- Total
- Gaz carburant
- Essence/diesel
- Electricité
Energy for the transport of goods

Évolution des consommations d'énergie

(TWh)

- Total
- Gaz carburant
- Essence/diesel
- Electricité
Sustainable reorganisation of the industry

- Combining *sobriety* (level of consumption, use of goods, recycling...) and efficiency (processes, engines, CHP, recycling...) plus substituting renewables where it is possible
- Starting from needs of goods, then the needs of crude materials (connected to the evolution of other sectors)
- Relocate productions when possible, and adapt production to the needs
- Focus on recycling

<table>
<thead>
<tr>
<th></th>
<th>Taux de collecte 2010</th>
<th>Taux de recyclage 2010</th>
<th>Taux de recyclage prévu en 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acier</td>
<td>74%</td>
<td>52%</td>
<td>90%</td>
</tr>
<tr>
<td>Aluminium</td>
<td>44%</td>
<td>37%</td>
<td>86%</td>
</tr>
<tr>
<td>Verre</td>
<td>35%</td>
<td>35%</td>
<td>90%</td>
</tr>
<tr>
<td>Plastiques</td>
<td>15%</td>
<td>4,5%</td>
<td>30%</td>
</tr>
<tr>
<td>Papier carton</td>
<td>70%</td>
<td>60%</td>
<td>80%</td>
</tr>
</tbody>
</table>
Energy consumption of the industry

![Graph showing energy consumption over time with different scenarios labeled: Tendanciel, Reloc+sobriété, Recyclage, Efficacité.](image)

- TWh
Energy substitution in the industry

TWh

- Electricité
- Comb substituable
- DIB
- Biomasse
- GPL
- Fioul
- Gaz
- Charbon
- Vapeur
Sustainable agriculture scenario

- Combined approach with **Afterres 2050**, agriculture scenario by Solagro
- Sustainable approach to the uses of biomass (food, soil, energy, materials) starting with a change towards a better balanced everyday diet
- Development of integrated and biological agriculture (50/50% by 2050)
- Reduction of overconsumption, optimisation of uses, reuse of waste
Global approach of land use
négawatt 2011
Energy production

Biomass
Electric renewables
Nuclear
Fossil fuels
Balance of power
Energy from biomass

Total in 2050: 519 TWh
Includes:
- 296 TWh solid biomass
- 153 TWh biogas
- 44 TWh liquid biomass
Electric renewables

Total in 2050: 347 TWh
Includes:
- 194 TWh wind (½ land, ½ offshore)
- 90 TWh photovoltaics
Role of nuclear power in the French energy balance
- < 16% of final energy consumption
- > 75% of electricity generation
- + risk of substitution by carbon electricity

An energy with specific risks
- major accident
- accumulation of long-lived waste
- proliferation and security
- a growing problem with ageing of reactors

58 reactors and an industrial complex
- fuel “cycle” plants
- public R&D support
- assessment and control system
- Priority to energy shift then > 2025 safety “bottleneck”
- Moderate and regular use of gas for transition
- Phase-out of last reactors under industrial constraints
Nuclear phase-out in 22 years

- 3 500 MW / year
- 2 500 MW / year
- 4 500 MW / year

Diagram showing the phase-out with different MW/year levels.
Reduction of fossil fuel

- Reducing the use of fossil fuel mostly to the hardliest replacable uses (e.g. chemistry, iron industry, planes...)
- Division by 14 of the total use of fossil energy
Keeping the electricity balance

- The model checks hour per hour, year by year, balance between electric production and consumption by combining various options, by order of merit:

  - Flexibility of renewable production: hydroelectricity...
  - Flexibility of demand: displacement, smart grids...

  0%
  - Interconnexion of networks: mutualisation of offer and demand

  10%
  - Storage in Stations de Transfert d’Energie par Pompage (STEP)

  20%
  - Storage through production of hydrogen and then synthetic methane

  30%
  - Use of non-renewable flexible production in case of deficit
  - Disconnexion of renewable production in case of excess

  100%
- Flexibility of sources and uses of electricity
- Flexibility of sources and uses of (bio)gas
- Combination of gas and electricity networks
négaWatt 2011
Global balance and conclusion

Balance per use
Primary energy balance
CO₂ balance
Conclusion
Heat services balance

Graph showing the trend of TWh (final) from 2000 to 2050 for different energy sources:
- Fossiles/Fissiles
- Renouvelables
- Efficacité (consommation)
- Sobriété
- nW
- Tendanciel
Mobility services balance
Specific electricity balance
Primary energy balance
• Compared to 2010, CO$_2$ emissions from energy are divided by 2 by 2030 and **divided by 16 by 2050** (and consistent with a division by 2 of agricultural GHG by 2050)

**Millions de tonnes de CO2**

- Red line: tendanciel
- Light blue line: nW
Cumulated CO$_2$ emissions 2011-2050 are in line with France’s equitable share in a global mitigation scenario (keeping global warming below 2°C by 2100, Postdam Institute)
Conclusion

- A positive change of society: consume less for better (less wasting, better quality), produce more local, reorganise urban and rural space, etc.
- High climate change performance
- Riddance of nuclear risks
- Strong reduction of fossil fuel use
- High level (>90% domestic production) of energy security
- An economic opportunity rather than an economic burden
  - Employment (> 600,000 net local jobs by 2020)
  - Energy bill (currently > 50 G€ per year)
  - Investment better paid-off than reinvesting in the same system
Thank you!

Scénario négaWatt 2011-2050

Rendre possible ce qui est souhaitable ...