Harnessing potential energy saving in the French industry

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Abstract

Industry in France can improve its energy efficiency by 30 % in 2020 compared with 2008, with potentially 42 % in the later decades. By 2020 20 % of heat use can be saved economically, and up to 46 % in the long term. As for electricity, economic potentials are 12 % with later savings of 49 %. As for CO_2 emissions, gains of 30 % in 2020 compared to 2008 (-40 % from 1990) are achievable, and longer term potential is over 76 % with the same industry structure.

The study, sponsored by WWF-France, shows a much higher potential than often suggested by industry groups. In France, about 700 units in heavy industries represent over 80% of energy consumption. They have important margins in their processes, either for incremental change in the short term, or radical innovation later. The rest of industry has many potential gains, mainly with regards to electricity use, in cross-sectoral uses such as motors, lighting, pumps, compressed air, ventilators, etc.

For large firms, the difficulties in realizing potential stem from the low cost of carbon quotas and electricity prices, and from focus on energy supply in French public policy. For small and medium firms, data is poor, as is the availability of equipment and engineering. There is also a lack of policy focus on the potentials for electricity efficiency in general industries. The calculation of projections for industry production could also be improved by widening access and participation so as to avoid overestimations.

Introduction

After the oil crisis of the seventies in France, important efforts were made to render industries less dependent on oil and to save energy. This period was followed by two decades of low oil prices , compounded in France by a significant overcapacity of electricity supply (Bonduelle 2006). Part of this surplus was linked to the economic slump and part came from efficiency gains in all sectors.

This situation led to twenty years of low electricity prices of and a low level of political attention to electricity efficiency that remains to this day. In the nineties, and early this century, energy efficiency in industry kept on declining, with fuel economies compensated by "dis-efficency" in electricity (MINEFI 2003–2006). More recently, French policy has been described as "lacking in ambition and efficiency", with most gains in efficiency coming not from public policy, but from innovation and economic competition (Dessus 2012).

Efficiency has only recently regained prominence with the adoption of climate policies:

- In 2005, a framework law included commitments to limit emissions, to develop renewable energy "with the same level" of importance as nuclear energy, and created a system of traded certificates for efficient equipment.
- In 2009, the Climate Package was adopted at EU level, combining commitments on climate emission levels, renewable energy development and a less stringent goal for energy efficiency.

Since then, climate policies and attention have focused mainly on buildings. A large consensus has developed among French stakeholders in favour of new standards for new housing and for large public and private investment in the renovation of ex-

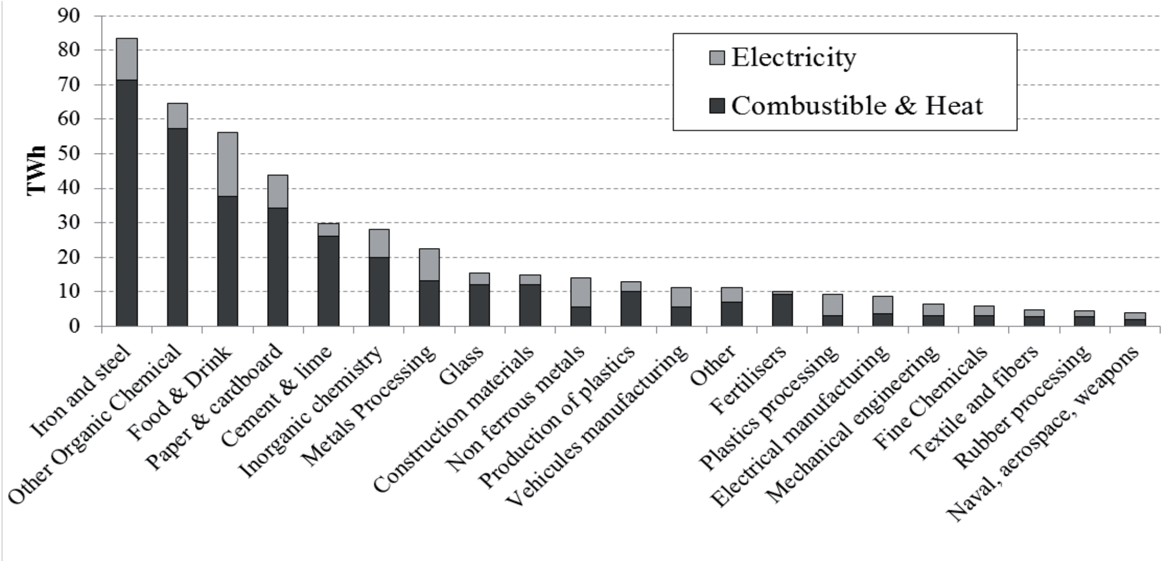

Figure 1. Energy consumption in French industry (2010).

isting stock. Focus on industry is limited, with for example only a small chapter on industries, with few concrete proposals, in the "efficiency plan" submitted by France to the EU in accordance to a 2006 directive (MEDDTL/MEFI 2011). During the recent discussions at EU level for a new efficiency directive, French civil servants were instrumental in convincing their colleagues on the EU Council to avoid binding commitments for Member States.

In this context of weak political support for two decades, it was interesting to focus on the situation of the French industry. In 35 years, the structure of industry has changed considerably. With the growth of the service sector, its share has shrunk to about 15 % of the GDP compared to 26 % in 1978. Notably, the early eighties witnessed the end of coal production, the concentration of steel industries, the decline of fertilisers and cement, changes in the fuel used in sugar mills or chemical plants.

This period of turmoil remains clearly in the memory of decision makers: industries had done much to move away from oil dependence, often at a very high social cost. Other sectors (housing, transport) increased their emissions in the same time, with few new standards to apply.

This idea that "industry has already done its part" remains well beyond industry representatives. Certainly, since the seventies, the French manufacturing sector has halved its consumption of coal, divided by three its oil consumption, and nearly doubled its consumption of natural gas and electricity. Its emissions were slashed due to this fuel change and the decline of heavy industry. But efficiency in industry has indeed decreased in the nineties and over the last decade. This paper, based on a study commissioned by WWF-France, shows that French industry still has important efficiency potential, and that these savings offer clear economic gain.

Present state of consumption

The present state of energy consumption is presented in Figure 1.

In France, the bulk of coal consumption is used by the primary steel production and to a lesser extent in cement and construction materials. Gas and grid electricity dominate most other branches, often in similar proportions. The detail of energy usage is given in the following graphs, first for heat and then for electricity.

Evaluation of potential savings

METHODOLOGY AND HYPOTHESIS

The work is based primarily on official data and resources, such as the EACEI[1] questionnaire sent yearly to French industry units with over 20 staff. They were completed with statistics published by sectors and branches such as the Paper and Cardboard or the Cement industry. Beyond the statistics, reports in the literature were used, in particular from CEREN[2] (Worrel 2007, CE Delft 2010).

Two horizons are described. First, 2020 is the deadline for efficiency and renewable energy commitments in the EU. In many cases, adoption of this potential presents economic gains in less than three years. For the second, 2050 corresponds to the heavy cuts in carbon emissions the EU and other powers have committed to in the climate negotiations. This was considered to take too long and not be practical enough. Most industrial equipment will have been replaced earlier. Also, by this time, techniques will have evolved significantly. Thus we employed the less precise notion of "long term", a sufficient timescale to adopt all achievable potential. For example, many new processes in heavy industries will be at least partly implemented before 2030.

One first step is to split energy uses between branches as much as possible and estimate the present efficiency of productions, recycling and import-export balances.

For most sectors, it was decided to use a "frozen demand" so as to be able to discuss potentials of "pure" efficiency. Only two factors were modified:

1. EACEI: Enquêtes Annuelles sur les Consommations d'Energies de l'Industrie.
2. CEREN: Centre d'Etudes et de Recherches Economiques sur l'Energie.

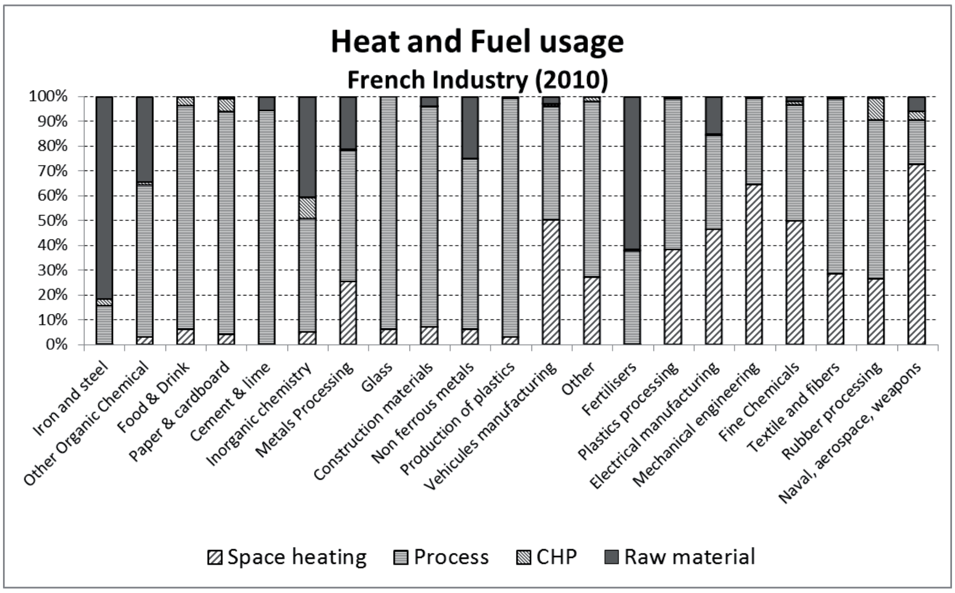

Figure 2. Heat and fuel usage in French industry (2010).

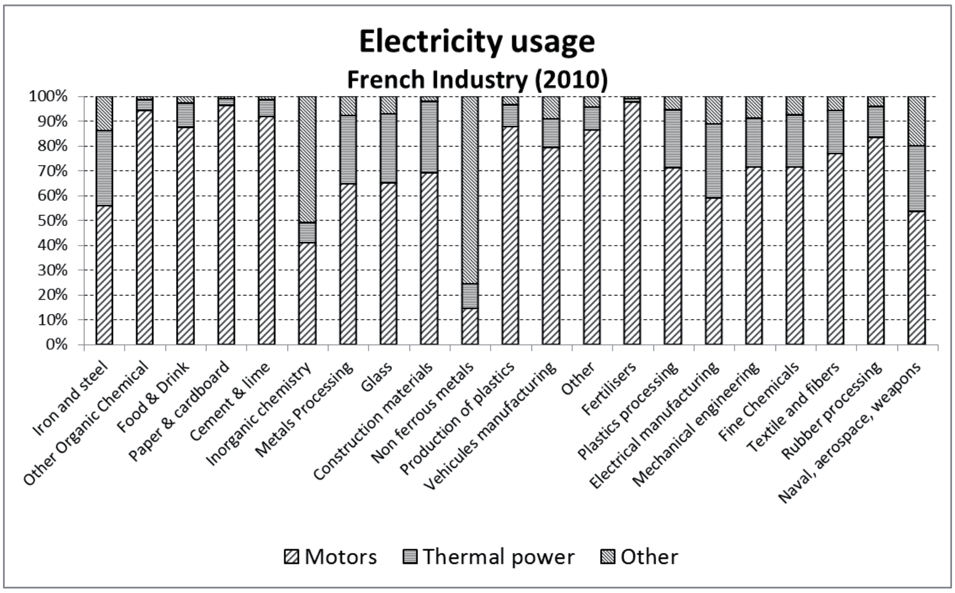

Figure 3. Electricity usage in French industry (2010).

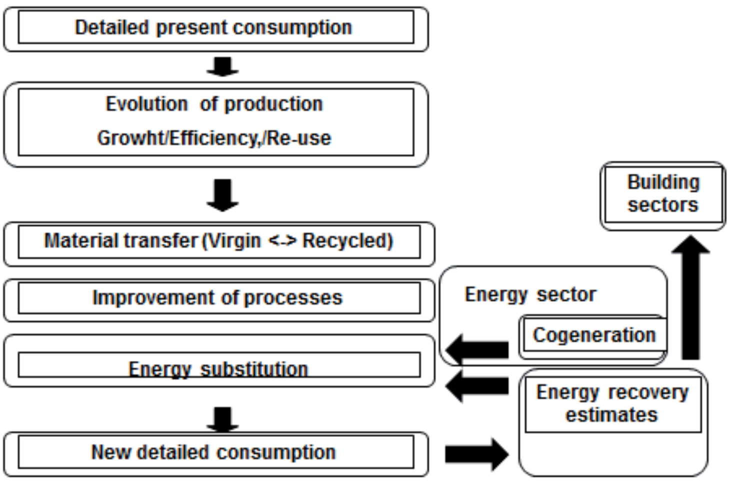

Figure 4. Long term changes in French industry.

- Recycling rate increase (metal, paper, plastics) leading to a decrease of primary material production and an increase of secondary material production.
- Reuse of packaging such as bottles or boxes, with part of the single-use glass and plastic bottles progressively replaced by reusable bottles. The impact on the glass and plastic production is taken into account.

Once the demand is described, available technologies are applied to sectors and usages. We consider common utilities, process industries, and recovery or cogeneration of heat and power between sectors. Energy savings depend on the present state of processes in use, and also of the best available technologies. The study is limited to technologies that exist at least in an advanced development stage, i.e. where industrial pilots exist.

For reasons of statistical availability and compromise of modeling the base year is 2008. This was chosen as the best average between the crisis in the last three years and the previous years of economic boom.

EFFICIENCY IN UTILITIES

This section presents savings made on utilities which are the cross-functional uses which we find in every branch: lighting, compressed air, space heating, water pumps and so on. The work was based notably on a study by CEREN (CEREN, 2010) and employs the same branch divisions. These general uses represent 80 % of industry's demand for electricity.

An additional opportunity for efficiency is the adoption of standards for boilers or electrical equipment, particularly for the motors. The EU began this process with progressive passage of the IE2/IE3 standards after a first step called IE1. The United States have adopted a more stringent and comprehensive standard (IE4) to be effective by 2016–2017. The study considers its adoption before 2020, because electrical equipment manufacturers have already begun diffusing such high performance equipment in Europe. Such standards are very beneficial since the investment in the motor itself represents only a tiny proportion of the lifetime cost of motors. Even with a low cost of electricity, a slight increase in investment costs will pay back generously. This justifies strengthening standards (Waide 2011).

Electric motors represent more than 70 % of uses in industry through pumps, ventilators, mechanical conveyors, machine-tools, or the production of cold. A low efficiency comes from oversizing (Wikstroem 2007); from lack of speed control (ZVEI, 2006); from poor maintenance of the motor itself or of components such as belts, transmissions, and gears, for example. These problems represent a much larger saving potential than the new standards on motors. A combination of all these improvement is in order.

For fluid conditioning (compressed air, pumps etc.), efficiency gains derive from the integration of components beyond the motor itself; from the optimal design of circuits; from the limitation of losses and the cleaning of filters. The report estimates the economic gain solely for electric machinery at 35TWh – of which 14TWh in 2020 – or a potential equivalent to the production of five nuclear reactors.

Beyond electric motors, large gains are also possible in other cross-sectoral uses:

- Lighting can benefit from still more efficient technology and also the optimisation of work places to benefit from natural lighting.
- Air conditioning and refrigeration can also benefit from better motors but also a limitation of losses and the recovery of compression heat.
- Space heating is often far from optimal in industrial buildings and could use recovered heat and better boilers.
- Industries use power transformers that often employ obsolete technologies. In many cases, electrical losses could be halved.

For all these cross-sectoral uses, CEREN estimates a 43 % efficiency improvement potential (or a 30 % saving of all electricity used in industry), of which more than half have a return on investment (ROI) under three years. The total possible gains stand at 64 TWh, or as much as all hydro production in France (or 9 nuclear reactors).

Table 1: Saving potential in cross-sectoral uses (CEREN 2010).

	Present consumption		Efficiency potential		Short term (ROI < 3y)	
	TWh	Share	TWh	Gain	TWh	Gain
Boilers (ancillary)	10,0	7%	7,7	77%	6,4	64%
Grids	7,6	5%	5,1	68%	3,8	50%
Space heating	24,6	17%	12,2	50%	11,2	46%
Motors	51,4	35%	18,6	36%	5,6	11%
Compressed air	8,8	6%	2,9	33%	1,7	19%
Cold	8,8	6%	3,2	36%	1,6	18%
Ventilators	15,6	11%	5,8	37%	2,9	19%
Pomps	14,4	10%	3,9	27%	1,8	13%
Transformers	1,8	1%	1,3	71%	0,0	0%
Lighting	5,0	3%	3,2	64%	1,8	36%
Total	148,0	100%	63,9	43%	36,8	25%
Source CEREN 2010						

EFFICIENCY IN PROCESSES

Evolution in steel processes

This sector bases about half of its production on recycling scrap metal. The main blast furnaces in Dunkerque and Fos-sur-Mer produce the rest from iron ore and coal. This kind of equipment has a very long life but short term improvement is possible. This includes electric motors (ventilation, crushers, conveyors etc). On top of that, several ways are being developed to improve the efficiency of the process. We chose the HIsarma technology because it is already deployed on a small scale in the Netherlands with an efficiency improvement of 20 %. This is far from negligible as steel is the most energy consuming industry in France.

One advantage is that coal is used directly – not as coke – and in lesser quantities. It can also facilitate the inclusion and partial use of biomass, natural gas or hydrogen. Other processes, explored in the Ulcos project, could go further in the future but were not considered.

All of this is complemented by the share of recycling, a very potent way towards efficiency and reducing emissions. The study considers that recycling will have reached a 60 % rate by 2020 and a 90 % rate in the long run.

Paper and cardboard industries

France produces only 88 % of the paper it consumes and imports the rest. As well as this deficit, it imports 40 % of its virgin pulp. At the same time, it is a net exporter of recovered paper for the production of recycled paper.

We considered pulp production and paper machines. In Europe, the first ones used mainly wood as feedstock. The process can be mechanical or chemical, with both types of plants being net exporters of energy. The black liquor derived from chemical processes contains half of the energy content of the wood. It is used for cogeneration. In mechanical processes, the heat from the friction can produce steam. In addition, the bark of trees, used as feedstock can be burned and produce more steam.

In France, pulp is made from 60 % of recovered paper, which simplifies the process and uses less energy. But efficiency depends on the quality of collected paper and on the final use of the product. In the process, pulp is spread on fabric, drained, compressed and dried through a series of rolls heated by steam. By combining the pulp and paper processes in an integrated plant, the energy use is reduced: the extra energy created by the pulp process is used in the paper making and one step of drying is avoided. Much water is also saved. 60 % of European production is done in such sites.

In comparison to the best current technologies, important savings can be obtained. They are estimated at 25 % on fuels and 30 % on electricity. By 2020, given the long lifetime of paper machinery, only 10 % of gains are retained. Nonetheless, vapor compression for drying should improve efficiency in the long term by up to 80 % on this part of the process. We consider adoption of this process in the 2030s for a 60 % saving on thermal energy.

Cement processes

In the statistics, the making of cement is often added to that of lime and plaster. The study concentrates on cement, which represents 60 % of the sector. In this sector, minerals are crushed and decarbonated in kilns at around 1,500 °C. The product (the "clinker") is ground and mixed with other ingredients. Potential remains significant, mostly by generalising dry processes – leaving aside wet and semi-wet processes still in place. Grounding processes can also be improved by using more efficient mills. In both cases, French equipment consumes more than its counterparts elsewhere. But the main change could come from the adoption of new bases to replace Clinker. These could be manufactured in a low temperature kiln at 700 °C or even an autoclave. Teams from Imperial College and the University of Karlsruhe have developed "Novacement" and "Celitement", respectively. These processes exist at the pilot stage and were integrated in the long term potential, with improvements in efficiencies of over 50 % and even more in terms of CO_2 for the use of such cements. Other promising processes, such as Calera originating from the University of California, are in development (WBCSD/IEA 2009).

Other sectors

Some gains in efficiency require a change of energy vectors. In particular, some uses of electricity as a substitute to fuel allow interesting savings. There are two main examples: mechanical vapour compression and electrical induction heating.

Vapour recompression can be used for the evaporation and concentration of liquids as well as the drying process in food processing (Dupont 2009)and chemical or paper industries (see § paper cardboard industries). Typical improvement is around 80 % (final energy).

Electrical induction furnaces can be used in metal and even plastic transformation or treatment instead of combustion furnaces, with an improvement of around 50 % (final energy).

For such innovations, net gains have to be significant as expressed in primary energy (the actual primary/final ratio for electricity in Europe is around 3). The use of heat pumps instead of boilers, especially in the food industry, is another way of energy savings. (BREF 2005, 2006)

RECYCLING AND RE-USE

There is significant potential through recycling and re-use in both the short and long term. One key example is the sector of glass packaging which represents more than half the weight of the glass-making products. It is possible, according to the scenario, to divide its use by three or more times for the same service provided.

Recycling

The levels of production were defined and then the objectives for recycling rates were determined. In every branch where recycling saves significant energy, recycling rates are taken into account. The ratios of final energy use between primary and recycled production vary from 12 (aluminum) and 5 (steel) to a lower 2 for paper and 1.3 for glass using final energy consumption between primary and recycled products. The ultimate recycling potential was determined with the literature and discussions with recyclers.

These increases may be slow because the higher rates depend strongly on the implementation of eco-design principles to impose easy dismantling of products. This is illustrated by the example of the seats and plastic parts of cars: the present flow of scrapped vehicles is far from adapted to ambitious recycling objectives. In the longer run these rates could be much higher

Table 2: Recycling rates (source BREF/IPPC, E&E).

Materials	Present rate of recycling	Energy ratio of recycling	2020	2050
Aluminium	30%	12	50%	86%
Steel	49%	5	60%	90%
Papier-Carton	60%	2	75%	80%
Plastics thermo-mechanical*	6%	1.3	15%	30%
*Does not include chemical recovery				

with improved design (Santini 2011). Such constraints are not yet in force with Eco-design regulations of the EU which focus more on energy use of products.

The rates used in the study can be found in Table 2.

Metals allow very high recycling rates with limitations resulting from oxidations and from single use products. For papers and cardboards, the recycling and its use in the manufacturing process depends on products. Going from one extreme to the other, it is difficult to recycle hygienic papers, but very easy for newspapers. Unlike with metals, the recycling of paper is limited because the breaking down of fibres requires a proportion of virgin material for mechanical properties (Baeyens 2010).

As for plastics, recycling is mainly done in a degraded mode. Plastic is used in less noble products such as plant pots or bottle crates (thus saving in the plastics sector) through so-called "mechanical recycling ". Alternatively, it is incorporated as a raw material used upstream to the processes of elaboration (thus saving in the chemical base industry). In our projection, 30 % is used in thermo-mechanical recycling. It was considered that an additional 30 % can be used as feedstock in industries: chemical recycling, injection in steel, transportation fuels etc. This does not bring gains in efficiency to the receiving sectors but a good substitute to fossil fuels. In terms of emissions it is much better than heat recovery in the low efficiency waste incinerators used in France (Al-Salem 2009).

As for glass, recycling brings little net energy savings with regard to the primary production of virgin material. Instead of modelling the evolution of the process we evaluated the re-use of packaging, allowing the limitation of hollow glass with important gains. Plastic containers got the same treatment.

Re-use

In the case of glass, the re-use of packaging at a regional scale seems a promising way to divide the needs of virgin products and to substitute part of containers for food, drinks, yoghurts etc., in plastic or even cardboard or steel. Such an evolution is technically and politically feasible on a significant scale. It is already a practice in Germany, Denmark, Switzerland, Belgium, and even in French cafés. Part of plastic bottles can also be substituted. This evolution comes at several conditions:

- Containers are standardized at least by region or by group of regions, or better at the European level;
- Return transport is optimized
- Filling is regional or local, and linked to more local production to limit transport
- Savings on emissions should be rewarded and return schemes may become mandatory for some products.

The benefits and costs to be considered are on several levels, and concern first the manufacturers and the bottlers, then the organization the food-processing industry (relocation of productions, return trips). A reference study for ADEME suggests a lifetime of 8 to 30 uses (RDV-Environment 2008). On this base, re-use brings a decrease in feedstock, but also an increase in the weight of containers to compensate for more handlings (Pilz 2010).

On balance, benefits are important for consumption inside a radius of about 200 km even by the 2020 deadline. Returning 10 % of bottles may save a net 0.4 million tons of glass per year, even accounting for heavier containers. On the single segment of packaging, consumption is divided by three.

Substitution of plastics

Such a gain is also attainable by substituting plastic bottles and containers by glass, steel or aluminium. Although glass is heavier (by a factor of 12.8), there is still a good net saving at the condition of a more local production. A switch of 30 % to 50 % of flasks and food containers and the reuse of other plastic items would save 25 % of plastic packaging, which is considerable. The net gain is 0.3 Mt (or 8 % of all plastic consumption of France). This result suggests that this path should be further explored in addition to programs aimed at limiting wasteful packaging (not included in the study).

SYSTEM WIDE RECOVERY

An additional iteration was also calculated so as to estimate the remaining recoverable heat after the best available technologies are applied. This is combined with the substitution of thermal electricity generation by cogeneration. These two additional potentials were identified then quantified in a simplified way.

Energy recovery

Many processes, even optimised, still reject warm effluents (smokes, cooling water). Heat exchangers can tap this energy source, and feed it into heat networks. That heat is fed into other industries or into the building sector.

Recovery of heat is limited in the study to 75 °C or 90 °C. This level of temperature is important because it fixes a physical limit to keep a gradient of temperature large enough with the heat network. This potential could be increased by the use of heat pumps.

In this estimation it is necessary to have in mind that recovery decreases in time with improvement of the processes. In many cases, efficiency gains come precisely from the use of waste heat. But recovery is still possible in high temperature processes in the heavy industries such as steel, metal, chemical or cement production (Eichammer 2009). At the opposite end of processes, industries using low temperatures can be supplied by the networks, with heat pumps if necessary.

The study does not consider the conversion of the heat into electricity by thermodynamic cycles. These do exist for example in cement plants, but are seldom economic in Europe. Improved processes of production will decrease the temperature of effluents and limit this potential even more. Sugar mills, for example, have strongly limited their warm effluents. Although new technology may appear in this field (Kalina cycle, ORC, thermo sensitive materials etc), it is at present better to use this heat directly near the site.

Overall, over 10 % of industry's energy is lost through warm effluents. But a realistic potential for heat recovery is estimated at 2TWh in short term and 9TWh in the longer term, for an extra saving of respectively 0.5 % and 3.5 % of total industry use.

Cogeneration

This takes advantage of industrial process needs of heat or steam to produce electricity in parallel with a high global efficiency. This economy can be deducted from the energy sector. An optimisation of these productions along with power demand and the need of generating fossil fuel could also produce gains in emissions.

Cogeneration produces 6 to 10TWhe in France – depending if outsourced production to specialised energy firms is included – or 5 to 8 % of electricity use (MEEDDM, 2010). Estimated potentials from heat needs at low and medium temperature can be as high as 120TWh (CEREN, 2002, MEEDDM, 2010), of which about 20 % is considered economically the study. In particular, load factors have to be high enough for the machines to be economical. Steam turbines and combustion engines or turbines are considered with their efficiency and technical characteristics in branches. This brings a net potential (excluding existing cogeneration) of 25TWh in the short term. Later this figure decreases to 21TWh because improved processes use less heat.

In theory this potential is significant. But in reality the situation is dire for cogeneration because most present installations were built in a rush created by a feed-in tariff in the late 90s whose contracts are soon over. This ill-calculated tariff does not include any optimisation for carbon emissions and industry production. Thus, many good cogeneration projects do not receive support even when they would make more sense than building new gas centralised plants (CCG). France has authorized 34 such plants (at 450 MW a piece) with no request or incentive for heat recovery. They represent up to 16,000 MWe of new gas construction and threaten France's commitments to carbon emissions. At least 12 new gas plants could be viably replaced by new or refurbished cogeneration ones with the same contribution to peak power and much fewer carbon emissions. Moreover, cogeneration could be a resource for peaking power if combined with heat storage and the modulation of production in affected branches, bringing both an economic resource to industries and a contribution to future electricity grids. But this issue is not in the least taken into account by EU directives currently being discussed.

RESULTS OF THE STUDY

Overall, savings by 2020 amount to a gain in efficiency for industry as a whole of 18 %, with potential for more than 42 % in the next decades. These gains comprise a 20 % reduction in heat use and 12 % electricity use by 2020, and future energy savings of 46 % for heat and 49 % for electricity. The difference in totals stems from system-wide energy recovery and cogeneration.

The next table presents energy saving potential in final energy usage (in TWh or Billion kWh), first for heat then for electricity in industry sectors.

Process heat savings

The main gains in the short term are in sectors where more recycling or re-use is possible such as steel, non-ferrous metals, glass, paper and cardboard. New processes – e.g. in the cement industry – will later have a large impact.

For base chemicals, and to a lesser extent the food processing industries, diversity of processes and limited transparency of data lead us to project smaller gains than in other branches. This bias is significant and the modelling of these two industries shows they become the heaviest consumers by 2050. This is obviously an artefact of the study because these branches have as many opportunities for improvement and are also quite dynamic.

Electricity savings

This is a much more dispersed potential than heat spread among all sectors. Some of it will be achieved through the present wave of standards in lighting, motors, or heating equipment. Others will need pro-active policy that is not yet in place.

For electricity, global potentials are lower than for heat. This is partly due to a conversion to more recycling facilities which tend to use more electricity than fuels, as shown in the example of steel. There is also a substitution of some fuel uses by efficient electric processes (induction, vapour compression) for drying, evaporating or heating.

EMISSIONS REDUCTIONS POTENTIALS

The study calculates the CO_2 abatement in a simplified manner, based on energy CO_2. Beyond the gains obtained directly from energy efficiency and recycling, three measures are taken into account:

- extra use of plastic waste as transport fuel and in the steel process as a replacement for coal;
- recovery of low temperature heat for neighbouring industries and use in buildings;
- use of renewable energies, and notably biomass, for heat, based on the rates for industry France committed on at the EU level (MEDDM 2009).

The last choice is an underestimate. There may be a more important potential for RE such as thermal solar and geothermic heat. Moreover, substitutions with biogas or natural gas, biomass and/or solar energy depend on other sectors (transport, residential, tertiary, energy) to determine the optimal distribution of the resources. This estimate is conservative and mainly includes the use of biomass. It is considered that by 2020 about 5000 ktoe of renewable heat could be mobilised by industry. The long term estimate for biomass is double.

By simplification, the carbon content of electricity is considered constant. Emission factors are those of IPCC in 2006. Biomass is considered neutral.

Table 3: Heat and fuel savings potentials in French Industries.

	Energy consumption (TWh/a)			Gains (%)	
	2008	2020	Long term	2020	Long term
Iron and steel	71.4	57.9	21.4	19%	70%
Other Organic Chemical	57.3	49.6	39.5	13%	31%
Food & Drink	37.7	28.5	22.2	24%	41%
Paper & cardboard	34.2	24.9	12.5	27%	63%
Cement & lime	26.2	22.4	13.8	14%	47%
Inorganic chemistry	19.8	17.7	15.7	11%	21%
Metals Processing	13.3	10.0	8.4	25%	36%
Glass	11.9	6.9	2.7	42%	77%
Construction materials	11.9	10.5	8.9	12%	25%
Non ferrous metals	5.7	4.4	3.3	22%	42%
Production of plastics	10.1	8.1	6.0	20%	41%
Vehicules manufacturing	5.7	3.7	2.8	35%	50%
Other	6.9	5.6	5.4	19%	22%
Fertilisers	9.2	8.2	7.3	11%	21%
Plastics processing	3.0	2.1	1.7	31%	44%
Electrical manufacturing	3.6	2.7	2.6	25%	28%
Mechanical engineering	3.1	1.9	1.5	39%	52%
Fine Chemicals	3.2	2.1	2.0	32%	37%
Textile and fibers	2.9	2.3	2.2	21%	24%
Rubber processing	2.7	2.2	2.2	16%	18%
Naval, aerospace, weapons	1.9	1.1	0.9	44%	49%
TOTAL	341.7	272.9	183.2	20%	46%

The achievable potential, based on emissions in 2008, is estimated at 32 % by 2020 and at 78 % in the long run, of which over half is gained through energy efficiency.

Beyond this potential, extra gains could be made, first with more renewable energies as previously mentioned, but also with the evolution of consumption and the evolution of material uses. For example, new models using less steel but more glass are a popular trend. Another present trend is a slight decline in car use in term of yearly distance, with vehicles kept longer by their owners.

The study has used the year 2008 as the reference for production, but it is less telling for emissions. If we use 2005 or 1990 as base years, the decrease in emissions by 2020 become -34 % and -40 %, respectively. In the long term the figure is 76 % and 78 %. These results were fed into the debate in France about the opportunity for the EU to commit itself to -30 % of emissions, as an argument that industry could and should take its part in this commitment (Réseau Action Climat 2011, De Perthuis 2011).

Policy discussion and conclusions

This paper has shown the significant efficiency potential remaining in French industries. This information by itself differs from the traditional views held by policymakers and industrialists. It would be a paradox if the adoption of a carbon tax at the borders of Europe for products such as cement, fertilizers and solar cells backfired with competitors from emerging countries using more efficient technologies.

French industry is rather polarised between large industries and many smaller units. For example, only 970 units (owned by 570 firms) are subject to the European Trading System (ETS) for carbon quotas, compared with hundreds of thousands of medium and small firms. The large units represent about 5 % of units, but use 80 % of the total energy used by industry. Two issues stand out for this category: carbon quotas have been over-allocated due to bias in the projections, and electricity has been wasted due to a lack of attention towards efficiency. In small firms, knowledge and awareness are missing.

A third policy issue was discussed already: the lack of political focus and stability in cogeneration. With the low carbon content of its electricity, France has still to design a system where cogeneration contributes to the peak load and to the stability of the system, also bringing economic gains to industries willing to contribute to the future decentralised grid. The present methods measuring carbon emissions only take into account averages based on the French perimeter and not marginal emission rates. A pricing using marginal calculation including fossil fuel emissions and electricity imports at peak times would be helpful for efficiency and optimal use of resources (Bonduelle 2007).

Table 4: Electricity saving potentials in French Industry.

	Energy consumption (TWh/a)			Gains (%)	
	2008	2020	Long term	2020	Long term
Iron and steel	12.9	11.9	11.7	8%	9%
Other Organic Chemical	8.0	7.2	6.6	10%	18%
Food & Drink	19.6	18.0	14.5	8%	26%
Paper & cardboard	11.2	9.1	8.8	19%	21%
Cement & lime	3.6	3.0	2.3	17%	36%
Inorganic chemistry	9.9	8.9	7.3	10%	26%
Metals Processing	9.3	8.5	6.8	9%	27%
Glass	3.4	2.9	1.2	15%	64%
Construction materials	2.9	2.6	2.1	11%	28%
Non ferrous metals	8.4	7.0	3.5	17%	59%
Production of plastics	2.8	2.3	1.5	18%	46%
Vehicules manufacturing	5.6	5.0	4.0	10%	28%
Other	4.4	3.7	2.7	15%	37%
Fertilisers	0.9	0.8	0.6	14%	37%
Plastics processing	6.1	5.2	3.8	15%	38%
Electrical manufacturing	5.1	4.5	3.5	13%	31%
Mechanical engineering	3.3	2.9	2.4	11%	28%
Fine Chemicals	2.7	2.3	1.7	15%	37%
Textile and fibers	1.9	1.7	1.3	13%	33%
Rubber processing	1.8	1.6	1.2	15%	35%
Naval, aerospace, weapons	2.2	1.9	1.5	13%	32%
TOTAL	125.8	110.7	88.8	12%	29%

Table 5: Evolution of CO_2 emissions from 2008.

Million tons of CO2	2008	2020		Long term	
Efficiency potential	90,6	74	-18%	47.7	-47%
+ recovery of plastics'		72.7	-20%	44	-52%
+ heat recovery'		72.2	-20%	42.1	-54%
+ RE substitution		62.1	-32%	19.7	-72%
E&E Consultant 2012					

BRINGING BACK EFFICIENCY POLICY INTO LARGE FIRMS

As mentioned in the introduction, French political attention has been focused on the production of electricity but not much on its efficiency. With relatively low electricity costs and lower taxes on fuel in comparison to Sweden or Germany, for example, there have been few incentives for action or even to commit to future action that could be triggered by the promise of a combination of sticks and rewards (Tanaka 2011). There are also few incentives to adopt radical technologies because that would diminish the value of existing plants, as illustrated by the case of cement. French cement firms have used the Kyoto mechanisms, such as Joint Implementation (JI) and Clean Development Mechanism (CDM) in the Czech Republic or in China, while keeping old-fashioned plants in France running and keeping shy of new processes.

Recently, firms have awakened to the sting of higher prices of oil and gas, or to their growing electricity bill. The state has also injected important funds into "technologies for the future". Fixing the ETS system has also started at EU level.

But a large bias in the projections for demand in industry remains. A telling example has been the allocation of quotas for industry[3]. In this process, representatives of each branch

3. Disclosure: one author was an NGO representative in the French Commission allocating quotas.

of industry gave their – generous – perspective for activity and limited efficiency, with the reward of free or near-free tradable permits for their members in mind. Such bias is understandable because industry has to shield itself from possible costs. But in this process official representatives did not intervene, and the details of such previsions/prospects were not even available to NGOs and their experts. Even state-funded studies such as CEREN's are not generally available but this time officially for copyright reasons.

Another bias is the twist in the electricity demand projections, where official projections have erred regularly, in largely overestimating industry demand. According to Benjamin Dessus, a former researcher and official in the French Energy Agency, this also stems from the lack of participation of civil society and the administration's sole focus on the supply side (Dessus 2010).

One interesting way to obtain a more independent view has been the construction of long term views of industries and their energy needs by researchers and industry representatives. Such work was done in a less defensive context (CIRED, LEPII 2008). But this study did not include branches that fear for their short term future such as the automobile industry.

HOW TO HARNESS EFFICIENCY IN SMES?

Large industries are aware of efficiency potential. They have designated staff for maintenance or efficiency budgets. They have suppliers of equipment and consulting firms, ready to follow their requests. Even if their priority has been up to now to reduce process energy, they have access to all the conditions to improve electrical efficiency in utilities. This is starting to happen with recent increases in electricity bills. In particular, suppliers of electrical equipment offer their services for ventilators, compressed air and electric motors. Their unions such as GIMELEC now defend aggressive efficiency policy (GIMELEC 2010).

On the opposite side, small firms are far from their optimum efficiency. There are often no maintenance or efficiency personnel. Suppliers shy away from visiting them. Managers, often on their own, have no time to allocate to the modification of their systems. Public energy agencies have focused on other issues and often have out-dated information. In recent cases, free audits for SMEs did not even manage to fill the targeted numbers. French SMEs do not differ in this respect with other European cases such as Italy (Trianni 2012) or Germany (Grüber 2011).

One more specific feature in France is the weakness of professional organisations defending SMEs. Many defend above all their larger members and neglect smaller ones. As previously mentioned, they have a strong bias in underestimating the efficiency potential. Small firms are also represented by the local Chambers of Commerce and by Professional Technical Centres. These organisations are rather dispersed but have recently added timid efficiency goals to their missions with only limited success.

More barriers are specific to France. For example, one of the contact SMEs have with the outside world is the local distribution grid whose main concern is to avoid excess reactive power or flickers and may impose fines. Thus a manager of a SME will fear the grid and will not expect it to help with efficiency. The same problem arises with insurance audits which can be rather conservative agents in France. For example they imposed the late use of asbestos or PCBs. This culture of written rules, and not of best available technologies, remains to this day.

But at present, the most powerful barrier for medium and small firms comes from the lack of precise information on economic potential and on possible solutions. Neither the suppliers nor the managers or even the public agencies in charge of efficiency have precise knowledge.

Suppliers are not yet interested in proposing up-to-date equipment and services for firms whose demand is not yet formulated. They focus instead on larger units which are mostly part of big groups. There, the economics of efficiency gains are clear and dialogue is easier with banking institutions, budget officers, maintenance and engineering departments, and managers. In addition, this is where the limited means of public agencies has been focused. In firms such as paper production plants, the size and number of motors justify the time engineers spend on tailoring the best solutions.

In SMEs, managers have limited knowledge of efficiency possibilities. They have little awareness of the latest motors, speed variation or other efficient equipment. As savings will be more limited than in bigger units solutions should come ready-made or with very limited engineering time. They lack time, dedicated and trained staff, and available credit with their bank. Thus they probably have limited use for interest free loans – such as those offered by the OSEO public bank – because these are triggered only as a supplement to traditional banking.

The picture is not entirely bleak. For example, industry is entitled to tradable certificates from a list of efficient equipment such as variable speed transmissions or transformers. This represents a total of 9.2 % of French certificates, and an annual saving of about 6 TWh (MEDDTL 2011). But the majority of this market is opportunistic and takes place in the larger firms.

To break away from this difficult situation, the first condition is to describe precisely where the efficiency gains are, and to what extent they bring economic gains in the smallest units. Supply of equipment is not well organized; electricity rates stand lower that in Belgium or Germany where in some sectors economic gains are more obvious. Available data is based only on firms with staff over 20; it does not give much information on the existing stocks of electric motors and the duration of their use. In the last decades, many French firms have downsized their activity while keeping the same buildings, have merged or moved. Many workshops are not optimised for heating and ventilation, compressed air, or electricity circuits. A large scale census of energy use in the small firms – and maybe other professionals such as bakers – is needed. One objective could be to deliver efficiency-cost supply curves for each sector and size group, in the model of Industrial Energy Analysis in Berkeley (McKane 2011). Combined with a discussion on the evolution of French electricity rates, this should lead to the formulation of renewed policy, associating suppliers (GIMELEC 2010) and sectors.

Conclusion

Contrary to a long held belief, French industry retains a large potential for energy efficiency. More independent and transparent processes for quota allocation, more stringent objectives for policy, and a development of finer knowledge of potential and improving awareness in SMEs: all of these could help harness this potential. These efficiency gains are important enough for industry to play its part in climate protection in the short and long run, and to be part of a strategy to improve the competitiveness of industries.

Beyond this renewal in policy input some issues could be changed rapidly. More innovative rates for cogeneration in industry with real time management could benefit both the electrical system and the concerned industries.

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