Feedback on white certificate on an industrial process: all-electric injection moulding machines

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Abstract

The French White Certificate (WC) program, whose goal is to increase energy efficiency in France, launched its fourth period of three years on January 1st, 2018, with a new target of energy efficiency savings of 1,600 TWhc (TWhc counts the final energy savings over the life span solution actualized at 4 %).

During the first three periods, the majority of the WC energy efficiency operations in the French industrial sector focused mainly on energy utilities with the exception of one process, the all-electric injection moulding machine. Our paper aims to analyse the impact of the WC program action since its approval in 2013. This energy efficiency operation replaces a hydraulic injection moulding machine with a completely electrified machine that produces electric savings of up to 50 %.

This article will first describe the new and the existing technologies, then analyze the number of WC obtained from this action and the WC market impact. Finally, it will evaluate the size of the operations and the percentage of CAPEX, capital expenditure), covered by the commercial incentives emanating from the WCs obtained via this action. The data used for this study comes from the national WC register, EDF (French Electricity Company), and from a survey conducted by EDF in concert with ADEME (French environmental agency) in 2017.

Between 2013 and 2017 the substitution of hydraulic machines for electric equivalents saved more than 4.7 TWhc of electricity. During this same period sales of the injection moulding machines increased by 50 %, more than half of which were all electric or hybrid models. The newer models tend to run between €50 k and €400 k while on average the WC commercial incentive provides around 5 % of the machine total cost (the purchase of the machine itself). The survey results predict a slight growth in the market over the next WC period (2018 to 2020).

Industrial operations such as the injection moulding machine represent more than 20 % of WC savings accomplished to date. The wide range of innovations in the industrial sector are an essential and rich field for new WC process operations which must be exploited in order for France to achieve the ambitious energy efficiency targets set for the WC's fourth period.

Introduction: French white certificate scheme

DESCRIPTION

The European Energy Efficiency Directive (Directive 2012/27/EU; EED) sets new targets to increase energy efficiency in the EU Member States [1]. The preferred instrument to achieve these new savings is the introduction of energy efficiency obligation (EEO), frequently applied as "white certificates" (WC) scheme (Bertoldi et al. 2010, Lees 2012, Staniaszek and Lees 2012) [2]. According to Article 7, paragraph 1 of the EED, energy distributors and/or retail energy sales companies should be committed to new annual energy-savings of 1.5 % of the energy sales by volume, averaged over the most recent three-year period prior to 1 January 2013. Paragraph 9 gives Member States the option of meeting the target using other instruments and measures as an alternative to the energy efficiency obligations. In order to implement Article 7 EED, 4 Member States rely on EEOs alone, 14 use a combination of EEOs and alternative measures and 10 Member States plan to use only alternative measures (Bertoldi et al. 2015) [3].

France indicates that almost 90 % of the 1.5 % annual savings required by this directive is achieved through its White Certificate scheme (Gazeau et al. 2014) [4], defined by the French law "POPE" enacted in 2005 and started in 2006.

The energy savings are accounted in final energy, cumulated over the lifespan of the action or service and annually discounted by 4 %. The kWh obtained with this calculation are called "cumac" which stands for cumulated and actualized (the notations "kWhc" is used).

The French government imposes upon final energy suppliers an 'obligation" of a certain number of WC to be accounted over a period of three years and determined from their final energy sales. To fulfill their obligation, final energy suppliers can:

1. Complete energy saving measures for final consumers (not limited to their own customers) or on their own assets (in all sectors and energies but EU-ETS installations),
2. Financially contribute to programs that focus on energy saving information, education, or innovation,
3. Buy or trade certificates on the national registry,
4. Delegate their obligation to other companies,
5. Pay a penalty of €0.015/kWhc,

Only certain actors, either obliged parties (final energy suppliers) or eligible parties (local authorities, social housing institutions, and companies that have received a delegation from an obliged party) can produce white certificates.

HISTORICAL REVIEW OF THE SCHEME

- Since 2006 the start of the program, three three-year obligation periods have taken place with a fourth beginning in 2018 [5–7]:
- The 1st period (July 2006 to June 2009) had an objective of 54 TWhc.
- An intermediary/transition period (July 2009 to December 2010) without an additional objective. The certificates obtained during this period were valid during the 2nd period.
- The 2nd period (2011 to 2014) set the objective at 460 TWhc. New obliged parties, fuel sellers were given a transitional obligation during this time.
- The 3rd period (2015 to 2017) had an objective of 700 TWhc. A new obligation of 150 TWhc dedicated to actions targeting energy poverty was additionally added for 2016 and 2017.
- The 4th period (2018 to 2020) has a very ambitious objective of 1,600 TWhc which includes a specific target on households in fuel poverty.

STANDARDIZED OPERATIONS

Energy efficiency operations can be accomplished by two means [8]:

1. Standardized operations: This type of operation was created to simplify the management of white certificates validation requests. The standardization of this kind of operation begins when an operation that has a high potential for energy savings is identified. A group of experts validates a standardized operation by determining the average amount of white certificates the given operation represents. The proposition is submitted to ADEME (French National Environment and Energy Management Agency) and the French Ministry of Ecological and Social Transition. Once a project is validated by these authorities, it is deemed standardized and published in a decree in the French Official Journal. A standardized request for this type of operation can then be used to claim white certificates.

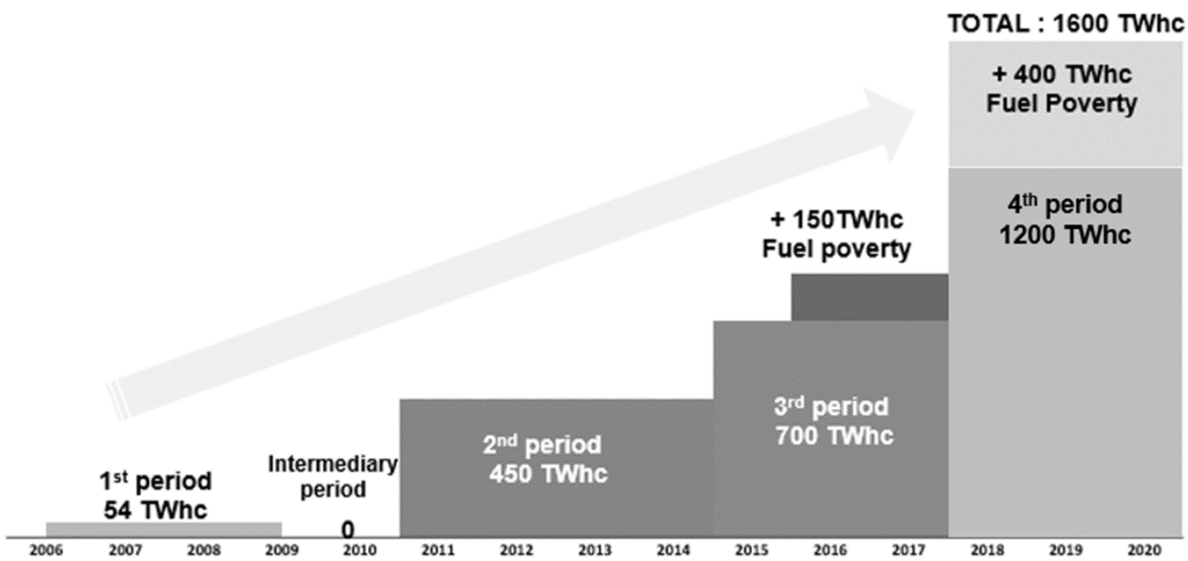

Figure 1. Chronology of the four white certificates scheme periods.

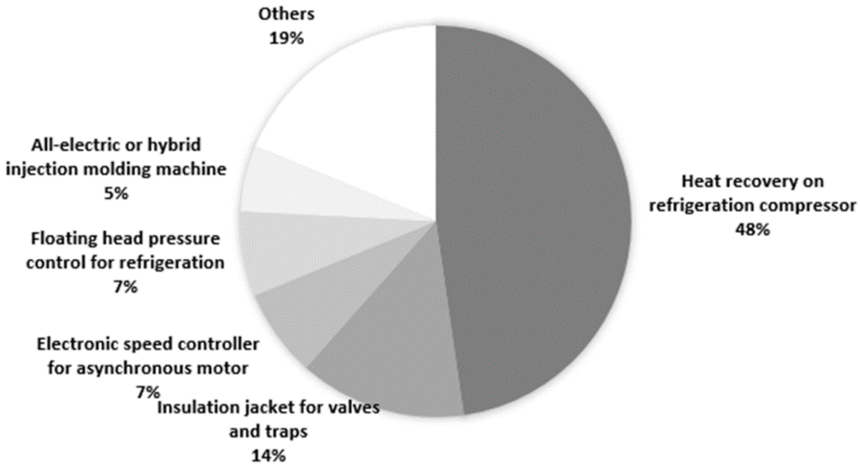

Figure 2. Issued white certificates from 2015 to October 2017 (standardized operations for industry only). Source: EMMY 2017 – French ministry of ecologic and social transition.

2. Specific operations: The savings have to be calculated by using the considered case data with an obligatory energy audit prior to the operation followed by a series of calculations following the operation. The operation and the potential savings calculated are then reviewed and validated by ADEME and the Ministry.

To date, 93 % of the white certificates come from standardized operations, 4 % from specific operations, and 3 % from funding programs.

STANDARDIZED OPERATION FOR INDUSTRY

The 22 standardized operations for the industry sector are mainly dedicated to optimization of industrial utilities:

- Motors: 6 operations
- Boilers: 4 operations
- Compressed air: 3 operations
- Industrial refrigeration: 3 operations
- Heat recovery: 3 operations
- Heating: 1 operation
- Lighting: 2 operations

Only two operations focus on process energy consumption optimization: heat recovery burner for industrial furnaces and all-electric or hybrid injection moulding machines. When studying the standardized operations eligible for the industrial sector, it is important to note that between 2015 and October 2017 of the 50 TWhc certificates validated by the Ministry, 81 % came from five standardized operations [9]. The operation highlighted in this article is the fifth of these top five standardized operations.

Plastic product sector and injection process

OVERVIEW OF THE MANUFACTURING PLASTIC PRODUCT SECTOR

Both plastic product manufacturing and processing sectors design and produce the plastic and composite products for all sectors: packaging, motor vehicles, building construction, health, aeronautics, electric and electronic and, sports and leisure [10]. Plastic processing is one of the core businesses of the future falling among the silver economy, connected objects, traceability products, implants (artificial organs) and, smart packaging economies.

The French plastic processing sector is ranked 6th worldwide by sales. The sector's sales (30 billion Euros in 2016) increased slightly, it employs 130,000 people representing 3,500 companies. Between 2012 and 2017, the research and development expenditures increased by 23 %. Of these 3,500 companies, 73 % are looking to go on investing in the sector.

This sector, made up largely of SME's with an average of 30–50 employees, is the interface between the manufactured goods groups (consumers) and the organic chemical groups (suppliers of the plastic product). Isolated due to their size and their position, they are on the lookout for any external economic and regulatory signals that could influence their potential for growth.

The plastic processing sector consumes 8.2 TWh per year (2014) [11]. The cost of energy (roughly 1 billion euros) accounts for 3 % of their annual sales. The energy mix of the sector is 70 % electric and 30 % fossil fuels, it may thus be designated as an "electrophile" sector. The distribution of the types of electricity usage shows 64 % consumption in the process (essentially injection), 12 % cooling, and 9 % compressed air.

THE MOULDING INJECTION MACHINES MARKET

The current French fleet of injection moulding machines is evaluated by the ACDI (Association des Constructeurs, Distributeurs et Importateurs de la plasturgie) at about 18,000 machines. In 2017, sales were estimated at around 1,000 machines.

The annual sales sharply decrease in the beginning of the 2000s. They remained under 800 units for more than ten years with a low of 400 in 2009. Between 2013 and 2017 however, the sales gradually increased reaching approximately 1,000 units according to the ACDI's first estimate for 2017, a level not seen since 2001. The influence of the creation of the WC scheme standard operation, approved in 2013, on this growth thus seems to be credible.

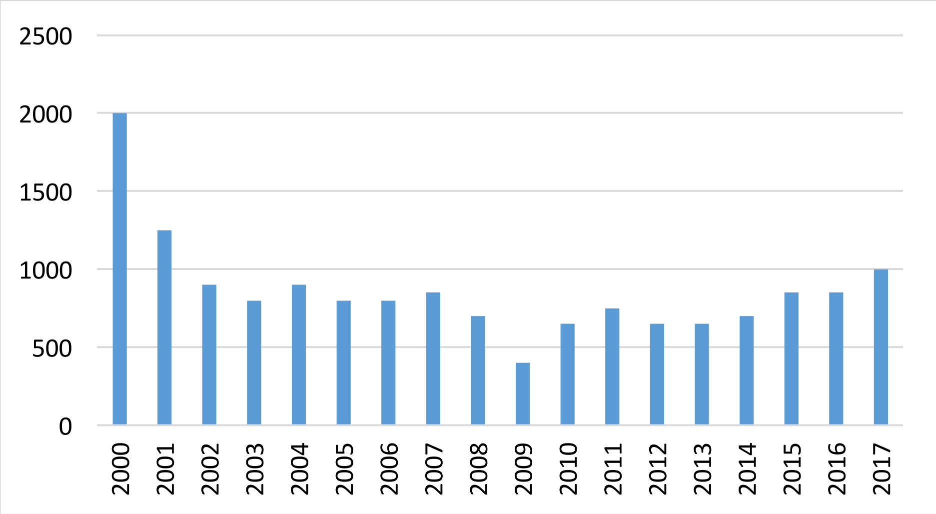

Figure 3. injection moulding machines annual sales. Source: Fédération de la plasturgie, ACDI.

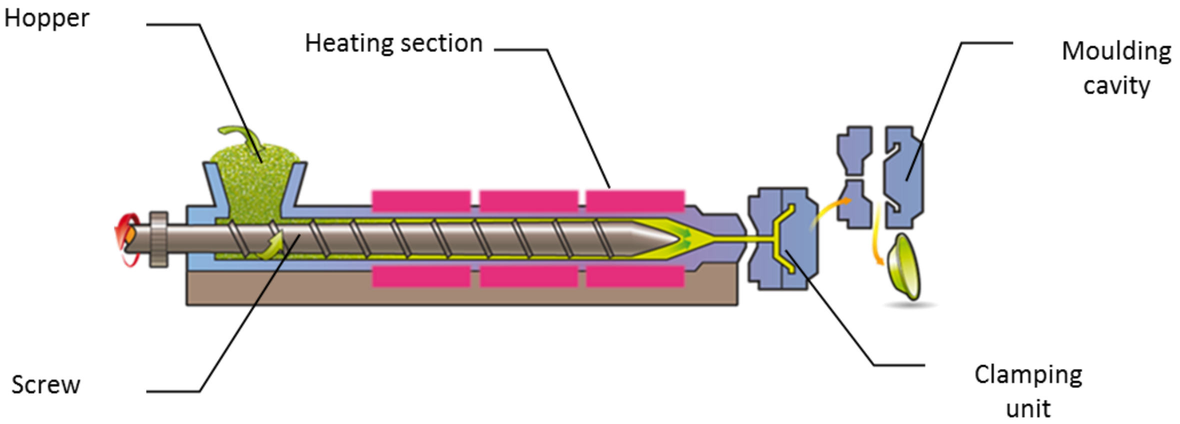

Figure 4. Working principle of an injection moulding machine.

WORKING PRINCIPLE OF AN INJECTION MOULDING MACHINE

The injection moulding process is generally used to achieve high speed moulding of thermoplastics [12]. It works on the principle that the molten thermoplastic is injected into a moulding, a high amount of pressure is then applied to obtain a desired shape.

The material used for moulding is loaded into hopper from where it is transferred by a feeding device, where the temperature is about 150 °C–370 °C, to the heating section. The material is then melted and injected through a nozzle into a closed moulding by either an injection ram or a plunger.

The injection unit consists of hopper, screw and the heating section. The moulding cavity is present in the clamping unit. The pellets are first fed into the hopper. The resins are then pushed along with the reciprocating screw located in the heated condition. The screw is moved forward to push the plastic material into the moulding. The screw itself then moves backward and allows the accumulation of enough material to fill the moulding. The rotation of the screw encourages the plasticizing action through frictional and shearing effects. The axial motion of the screw provides the filling action.

The longitudinal and rotation movements are generally carried out with the help of a hydraulic circuit where the oil is brought up to pressure to move the hydraulic cylinders. This solution has very high clamping forces while remaining cheaper than its competitors. However, due to the power of the shear forces used during the process the oil can heat up and must then be cooled, this necessity impacts the process's net energy consumption.

Through the substitutions of the hydraulic circuits by servomotors, it is possible to reduce energy consumption during the injection process by about 50 %. The generation of the movements is different but the working principle remain the same throughout these two technical solutions. This substitution is referred to as an all-electric injection moulding machine. It allows for increased accuracy, repeatability, and consistency while having higher part quality, lower cost per part, and lower operating costs. It also increases speed (5 to 50 % faster) and precision. Comparatively however, the all-electric version is more expensive than the hydraulic equivalent and is not compatible for very high clamping forces.

Feedback on White Certificate on all electric injection moulding machines

WC STANDARD OPERATION CALCULATION METHOD FOR THE ALL-ELECTRIC INJECTION MOULDING MACHINE

To be eligible for standardized operation, there are three scenarios:

- One direct motorised electric movement (dosage) with an energy efficiency gain of 27 %,
- Two direct motorised electric movements (two of three possible movements; injection, dosage or opening and closing) with an energy efficiency gain of 40 %,
- Three or more direct motorised electric movements (of the three listed above or more) with an energy efficiency gain of 54 % [13].

Energy consumption can be reduced by electrifying the movements of the machine and also during the cooling process of the oil. The amount of savings can be calculated using the formula below.

The direct savings related to the overall improvement of the injection moulding machine which uses less or no more hydraulic energy can be determined as:

$$\Delta E_{direct} = Gain_{motor} \times P_{Hydraulic\ injection\ molding} \times t_c \times D_{use} \quad (1)$$

The indirect savings via lower energy cooling needs from the cooling unit due to the decreased level of heat that needs to be remove from the hydraulic oil circuit can be determined as:

$$\Delta E_{indirect} = Gain_{motor} \times \frac{H_{Heat\ to\ be\ removed}}{COP} \times P_{Hydraulic\ injection\ molding} \times t_c \times D_{use} \quad (2)$$

These two calculations allow for the formula calculating overall energy savings:

$$\Delta E = Gain_{motor} \times (1 + \frac{H_{Heat\ to\ be\ removed}}{COP}) \times P_{Hydraulic\ injection\ molding} \times t_c \times D_{use} \quad (3)$$

Where:

ΔE_{direct} direct energy saving (kWh).

$\Delta E_{indirect}$ indirect energy saving (kWh).

ΔE total energy saving (kWh).

$Gain_{motor}$ energy savings achieved by an all-electric or hybrid injection moulding machine compared to its hydraulic equivalent. On average the substitution of one movement leads to savings of 20 %, of two movements of 30 % and three or more movements lead to savings of 40 % (no unit).

$H_{Heat\ to\ be\ removed}$ the share of the energy of the injection moulding machine that is converted into heat and is then removed using a cooling unit. The average value of 70 % was selected with the figures from our study detailed below (no unit).

COP the annual average coefficient of performance of the cooling unit. An annual average COP of 2 will be kept as in the IND-UT-117 WC operation “Heat recovering on a cooling unit” ($kWh_{electric}/kWh_{thermal}$).

$P_{Hydraulic\ injection\ moulding}$ the electric power of the hydraulic injection moulding machine (kW).

t_c the average rate of the injection moulding machine during its operating hours. It is estimated at 80 % by the professional union of plastics processing and construction (Syndicat de la plasturgie et constructeurs) (no unit). That number corresponds to an average oversizing of 20 %.

D_{use} the operating time of the factory (1×8 h, 2×8 h, 3×8 h stop and non-stop over the weekend) (hours/year).

DATA USED FOR THE STUDY

For our study we used data emanating from the national register, EMMY and EDF’s own databases.

EMMY registers the number of WC energy savings in MWhc by year and operation type. These MWhc are derived from the number of WC from standard and specific operations approved and then allocated by the public authorities by the date of the acceptance and signature of the quote/order for the WC project, called the engagement date.

EDF databases similarly trace the number of WC energy saving in MWhc by operation type as well as the commercial incentive per WC registration request,[1] and by the engagement date. Behind each registration request there are supporting documents available that are also saved in EDF databases such technical documents and references (the installed power of the equipment, the make and model, etc.), as well as the price for the installed equipment and the payment invoice.

VOLUME OF WHITE CERTIFICATES ISSUED BY THE PUBLIC AUTHORITIES

Since the standardized WC operation went into effect at the beginning of 2013, 4.7 TWhc of WC have been approved and allocated by the public authorities. During this same period 3,050 injection moulding machines were sold, of which 35 % were all electric and approximately 15 % were hydraulic.

A year after the publication of the standardized operation, it was one of the top 5 of industrial WC operations realized in France. After reaching a maximum of 2.4 TWhc per year in 2014, the per annum rate fell. Despite this tapering off, the sold per annum units continued to increase. This leaves us with a number of outstanding questions: Are the machines currently being sold without the aid of the commercial incentive of the WC? Are these machines ineligible for the program? Are they rented as opposed to bought outright, which leads to a smaller amount of WC because these are calculated only over the duration of the contract?

Figure 6 compares the price of the injection moulding machines with their installed power capacity.

1. WC registration request is the official document sent to the government for validation of one or more WC operations.

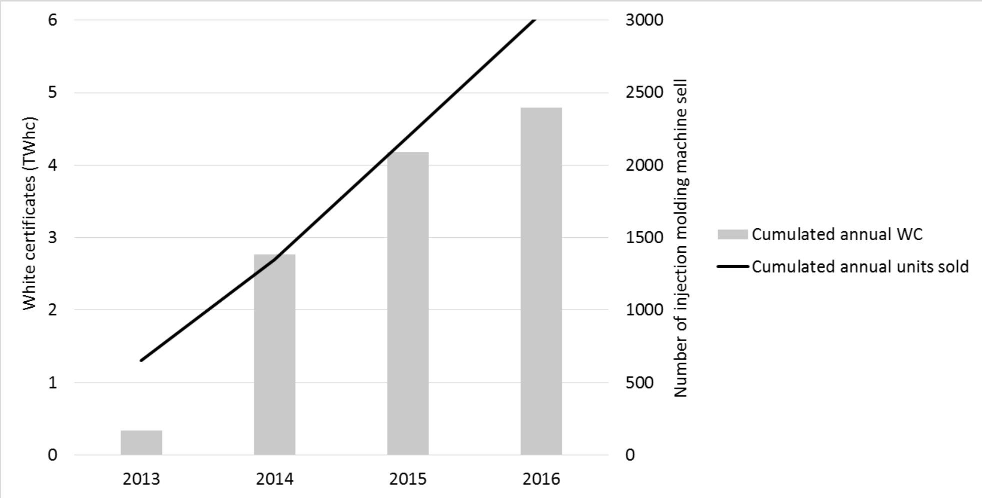

Figure 5. Cumulated WC and the cumulated number of units sold. Sources: EDF and ACDI.

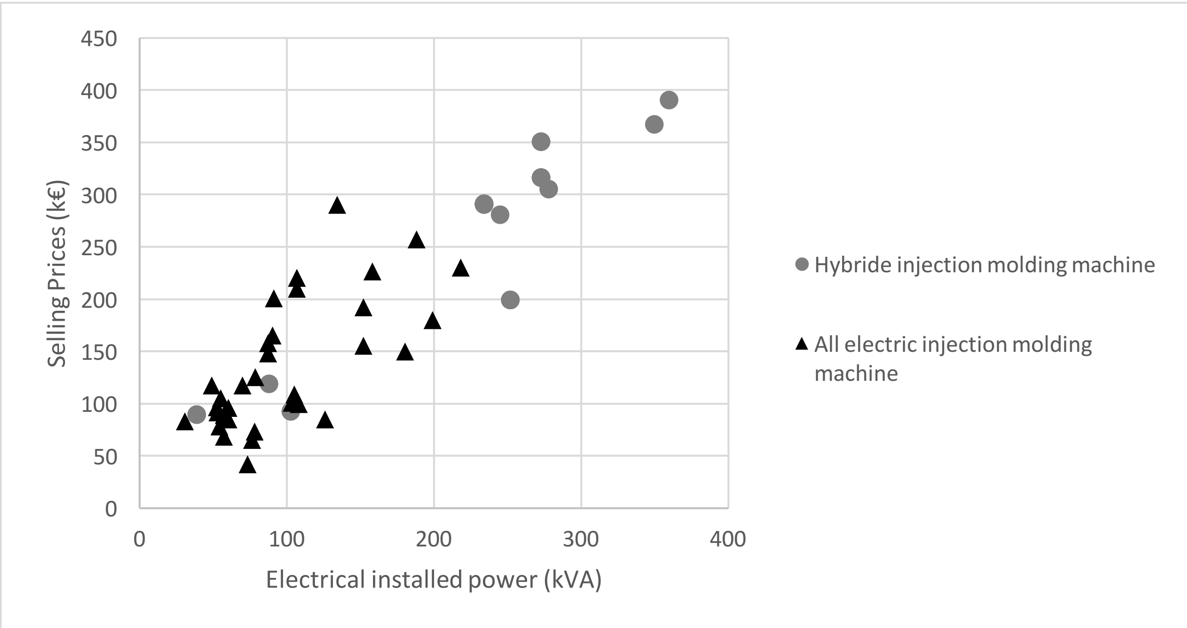

Figure 6. Electrical installed power versus selling prices of the injection moulding machine WC operation. Source: EDF database.

The all-electric injection moulding machines have a maximum installed power of 220 kVA. This maximum is due to the maximum clamping force of around 500/550 tons, to date the technology is unable to reach more force.

The hybrid injection moulding machines have an installed power above 230 kVA and are thus employed when a higher clamping force is called for. The few buyers who opt for the lower priced hybrid model do so because the all-electric model is at too high a price point.

The average cost of an eligible WC injection moulding machine is €1,229 per kVA.

$$WC\ coverage\ rate = \frac{Commercial\ incentive}{Selling\ price\ of\ an\ injection\ molding\ machine} \quad (4)$$

The first and the ninth decile are respectively 2.4 and 7.4 %, indicating that the coverage rate, while comparatively moderate, is still important. The professionals of the plastic processing industry suggest that this WC operation is important for two reasons. The WC incentive reduces the gap price between all electric or hybrid and hydraulic injection moulding machines, which are 15 % to 25 % more expensive. Secondly, the support of the WC operation itself sends a strong signal from the public authorities to the sector.

SIZE OF THE FOLDERS CONTAINING THE INJECTION MOULDING MACHINE WC OPERATION

Figure 8 shows the size of 126 WC requests analysed. On average, the median requested energy savings are 5.9 GWhc. The first and the ninth decile are respectively 2.2 and 16 GWhc. The minimum and maximum are respectively 0.7 and 104 GWhc (this maximum contains the installation of several units).

On average, for the third period of WCs, the commercial incentive was €2/MWhc. As the figure shows, the order of magnitude is sufficient to make production profitable. Between first and ninth decile (€4.4 k and €32 k of commercial incentive), the absolute numbers (CI) also show a high commercial incentive.

OUTCOME OF MANUFACTURER SURVEYS

EDF's most recent survey, conducted in June 2017, analysed 4 injection moulding machine manufacturers. This survey aimed to provide a concise evaluation of the third WC period and to provide feedback for the fourth WC period since the all-electric and hybrid injection moulding machine is one of the main WC standard operations in the industry. Four out of seven manufacturers replied to the questionnaire, their responses are summarized in the two radar diagrams below.

The survey results were compared with a previous survey conducted in the 2015 EcoCEE study in order to highlight the evolutions over time [14].

Items included in the first part (dedicated to the third period of the French WC scheme) of the survey conducted June 2017:

- Eligibility: which parts of the company's activities were eligible for WC;
- Impact of the WC commercial incentive: an evaluation of the importance of the WC commercial incentive in the decision making process of the beneficiary (the company);
- Impact of the regulation surrounding energy audits: an evaluation of the impact of the audit scheme included the decree-law n°2013-619, which required an energy audit for all factories with more than 250 employees, with net sales of €50 M, or with a net revenue of over €43 M on WC production;
- Impact of the ISO 50001: an evaluation of the impact of ISO 50001 certification on WC production;
- Impact on the sales revenue: how much additional sales revenue thanks to the activity carried out in the WC program;
- Potential of improvement on WC: what if any potential improvement of the company occurred or could occur compared to 2014 (with a view towards potential energy savings operations for the fourth WC period's national obligation);
- Reinvestment of benefits: what if any of the commercial incentive related to the installation of equipment eligible for

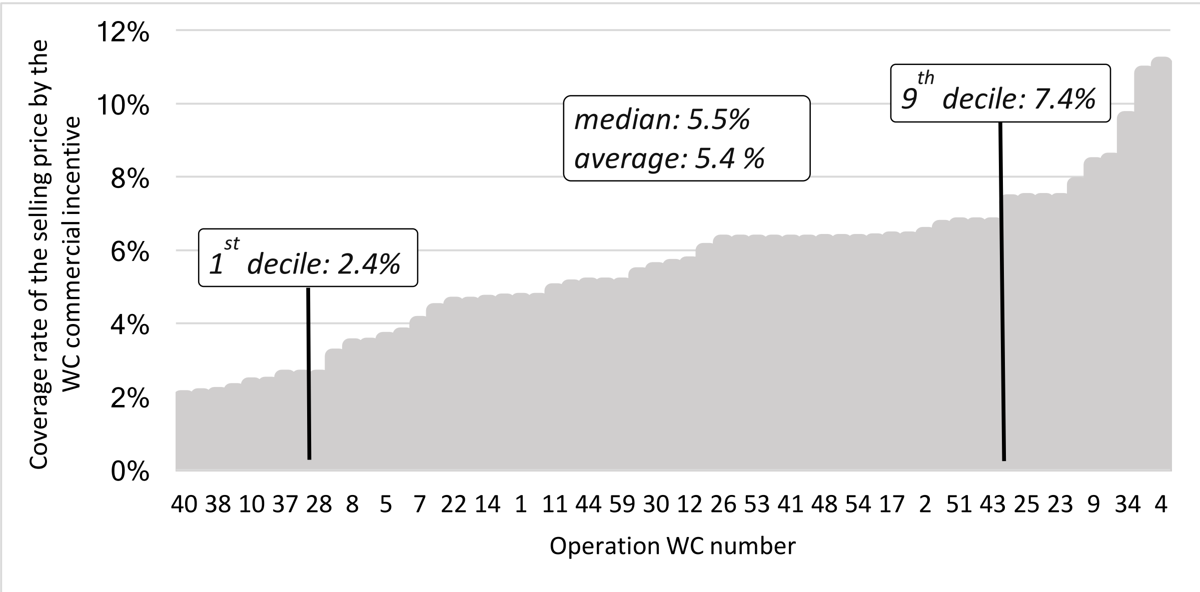

Figure 7. Ranking of the coverage rate of the selling price for 59 WC operations. Source: EDF register.

Figure 8. Distribution of the WC registration folders that contain the injection moulding machine WC operation. Source: EDF databases.

Table 1. Evaluation of the criteria to assess the third WC period and survey items.

Impact level	Null = 0	Low = 1	Medium = 2	High = 3
Eligibility	0 %	0–25 %	25–50 %	50–75 %; 75–100 %
Impact of the WC commercial incentive	No impact	Financial lever, +1; decrease of the payback return thanks to CI payment, +1 ; CI low impact, +0.5; CI deciding factor, +1		
Impact of the audit scheme	No impact	Impact audit beneficiary, +1.5 ; Impact audit manufacturer, +1.5		
Impact of the ISO 50001	No impact	Impact ISO benificiary, +1.5 ; Impact ISO manufacturer, +1.5		
Impact on the sales revenue	No margin	Yes, ×1.2	Yes, ×1.5	Yes, ×2
Potential of improvement on WC	No impact	Less than 5 %	Between 5 and 20 %	More than 20 %
Reinvestment of benefits	R&D Investments +1, New hiring +1, Lower the prices +1, to explore new market +1			
Non registered folders	No	Yes, without justification, +2 Yes, with justification, +3		
Structuring of the offering	Nothing	Engineering and research, +; Production, +1; Marketing, +1; Communication, +1; the 4, +3		

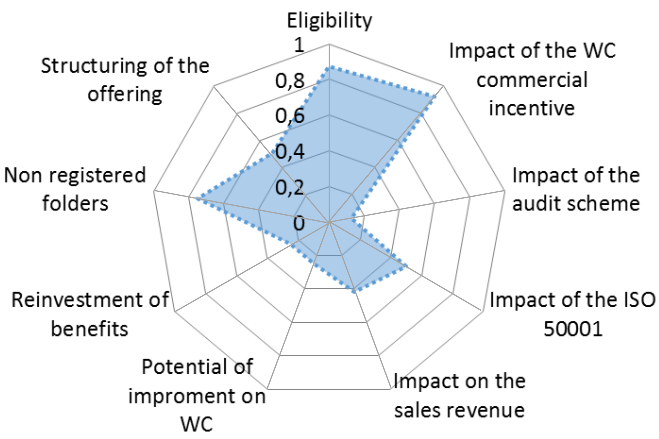

Figure 9. Overall result of the WC scheme – injection moulding machines, normalized scale from 0 to 1. Source: EDF.

WC was reinvested in the research and development of other energy efficient solutions, increased/decreased employment (more/fewer hires), the price (decrease of the price of products), and the discovering of new markets;

- Non registered requests: part of the WC operation that were not submitted/requested;
- Structuring of the offering: the impact of the WC on the product equipment level, internal and external communication, marketing and engineering and, research;

In order to graphically represent these results and compare them with the 2015 study results, each criterion is evaluated on a scale of 0 to 3 according to the answers given by the manufacturers or installers. If the respondent did not wish to transmit his answer or was not asked about this question, the notation is arbitrarily set at 0.5.

A large part of the activity of the injection moulding machine manufacturers is eligible for WC. The interest that EDF and the public authorities have shown in the creation of the WC all-electric injection moulding machine standardized operation and its extensive use thereafter has stimulated the plastics manufacturers. They consider that the payment of the commercial incentive as well as the implementation of an Energy Management System (EMS) within the framework of the ISO 50001 standard to be two decisive levers in the decision to install a unit.

The second part of the survey aims to provide feedback for the fourth WC period.

Evolution of the WC scheme with a view to its 4th period (second part of the survey conducted June 2017):

- Change in strategy by obliged parties in the last two years: decrease of the commercial incentive, increase of the commercial incentive, development of new WC operations, lack of interest for the proposed WC operations;
- Potential of existing standardized WC operations;
- Potential of allowing WC operations for EU-ETS installations (installations submitted to greenhouse gases quotas) (currently ineligible for WC operations);
- Acceleration of the diffusion of existing WC operations;
- Increasing information about WC operations: organizing informational meetings, raising awareness about the WC;
- The establishment of formal partnerships between obliged parties and eligible parties to acquire WC;
- Creation of new WC operations;
- Simplification of administrative procedures.

The current projections of eligible machines sales during the upcoming 4th period remain at the level of 2014–2015, to date the highest level. The plastics products manufacturers noted that some eligible operations were never submitted due to complexity of the administrative process, but also because some of the obligated parties had already achieved their WC quota. It remains a great potential in the 4th period for the currently approved standardized operations. They also want an increase in the communication by the obliged parties on the WC scheme and its opportunities for the stakeholders.

Table 2. Criteria evaluation for the evaluation of the fourth period of the scheme (the normalized scale from 0 to 1 was used to be able to compare with the previous study).

Impact level	Null = 0	Low = 1	Medium = 2	High = 3
Change in strategy by the mandatory participants	CI drop +1, CI growth +1, New WC operations development +1, Disinterest in proposed WC operations +1			
Potential of standardized WC operations	No demand	Decreasing demand	Constant demand	Growing demand
Potential of ETS installations	No potential	Low potential	Average potential	High potential
Increasing information on WC system	No	Organize information meeting, +1.5 Awareness on the WC system, +1.5		
Creation of new WC operations	No	New operations development CEE, +1.5 Create new WC operations, +1.5		
Simplification of administrative procedures	No	Yes, +3		
Establishment of a partnership agreement	No	Yes, +3		
Acceleration of the diffusion of existing WC operations	No	Yes, +3		

Evolutions between two surveys 2015 and 2017

Two injection moulding companies had been previously contacted for the 2015 study. The two studies used five similar criteria to judge their evolution between 2015 and 2017.

It is noted that for manufacturer 1, the share of its activity eligible for the WC scheme increased, as well as its turnover directly related to the WCs, while for manufacturer 2, a decline in these two parameters is conversely observed. The latter also mentions that the all-electric and hybrid injection moulding machine WC operation should be extended to moulding machine with a closing force of more than 400 tonnes, which would enable this manufacturer's machines to be once again eligible for a standardized operation. On the other hand, the two manufacturers continue to structure their company around the WC program and consider the commercial incentive as a determining element.

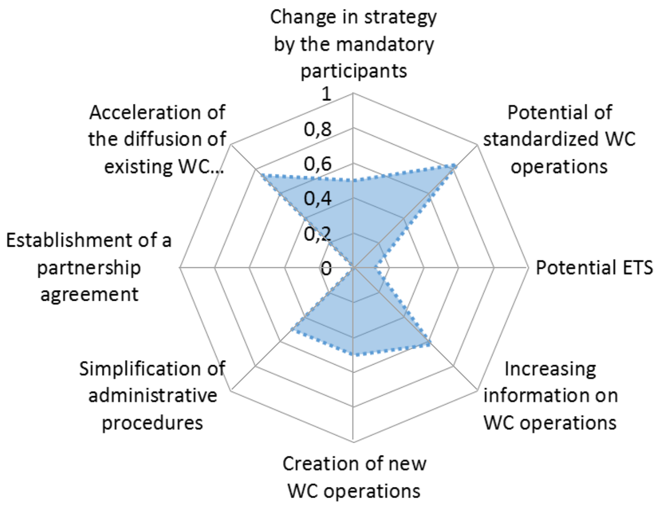

Figure 10. Revision of the WC scheme – injection moulding machines, normalized scale from 0 to 1. Source: EDF.

Conclusion

Since its approval in 2013, the WC standardized operation targeting the installation of a hybrid or all electric injection moulding machine has been highly successful. Despite this success, hybrid units which have a higher installed power still outpace their all-electric counterparts. This uneven success is explained by the technological difficulty in electrifying moulding machines with very high closing forces.

The commercial incentive paid by obligated parties in exchange for the WCs helps to cover a portion of the extra cost associated with the choice to buy an all-electric unit over a hydraulic one. The existence of the WC standardized operation is interpreted by the profession (mostly comprised of small and medium-sized enterprises) as a signal of strong public interest to this sector. This support is underlined by the important volume associated with a standardized operation (number of MWhc for this standardized operation) and the commercial incentive that provides a significant amount of financial assistance for the installation of the machine.

Manufacturers of injection moulding machines credit a large part of their activity eligible to the WC scheme. They consider that the payment of the commercial incentive as well as the implementation of an Energy Management System (EMS) within the framework of the ISO 50001 standard are two decisive levers in the decision to invest. They do however indicate that the annual sales will remain stable in the short term and comparable to these of the last three years. In order to encourage sustained growth in this sector, intensive communication about the WC scheme and its environment is and will remain critical.

In order to further optimize the energy performance of this highly electrically dependent industrial sector it is recommended that the WC standardized operation for the injection moulding machines should be extended to include high electric power one movement hybrid moulding machines.

This impact study shows that industrial processes can be successful targets for WC operations. It should be seen as an encouragement to develop similar new standardized WC operations. Furthermore, it shows the importance of allowing similar industrial processes, currently excluded of the French WC scheme due to their belonging to EU-ETS installations, to benefit from the financial support available for other processes both in France and abroad (such as in Italy where similar processes are eligible for Italian WCs). These actions would not

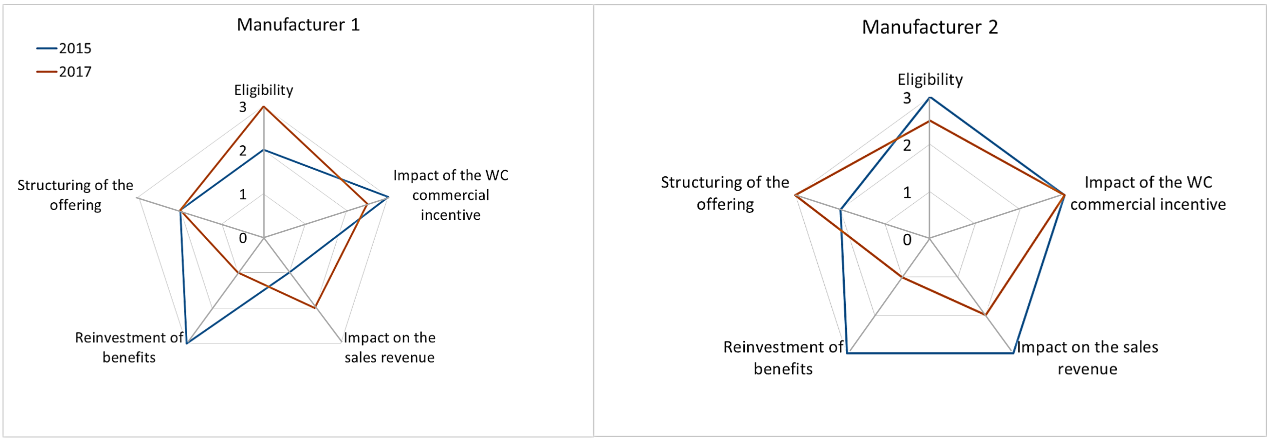

Figure 11. Comparison between 2015 and 2017 for two manufacturers. Source: EDF.

only increase energy efficiency in France but would also be a strong signal that the French government encourages and actively supports French industrial competitiveness.

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