SUSTAINABLE DEVELOPMENT AND WINTER VIABILITY: THE CASE OF PUBLIC MARKETS FOR ROAD SALTS IN FRANCE

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ABSTRACT

Based on the fact that some new criteria directly related to the environment have been recently introduced in the French Code for the Public Tenders constituting a new factor in the evaluation of the bids, it seemed useful to study the environmental impact of the different salt production (rock salt mines and sea salt works) and also of the transport of the salt used as road salts in France. The environmental issue of the salt production is pinpointed. From the ponderous aspect of the salt used as de-icer and from the volume of this market segment the incidence of the transport from the production sites to the points of utilization, could become a very important issue in term of greenhouse gas (GHG) emissions which can be evaluated to 5,800 tons of carbon equivalence per average year. Integrating the energy for producing the salt it reaches a total amount close to 6,700 tons. The use of a nearby source of salt and the optimization of the transport means could reduce substantially the emissions related to the transport by almost 80%.

KEY WORDS

ROAD SALT / SUSTAINABLE DEVELOPMENT / SEA SALT / ROCK SALT / TRANSPORT / CARBON EMISSIONS

1. INTRODUCTION

The road salts (nearly exclusively considered as salt – sodium chloride) represent an important market in France (3rd rank in Europe) depending very much on the weather conditions during winter. The fluctuation of the demand results to be significant. If the average consumption in the country can be estimated at about 1 million tons per year (metric ton per annum, m.t.p.a.), the actual consumption can vary from 0.4 to 1.8 million m.t.p.a., depending on the weather conditions. This variability of the needs can vary even more from one month to another. This demand remains completely unpredictable (weather forecast don't give any indication beyond 8 days), with a possibility of extreme suddenness, making clear that the supply of the material cannot be dealt in a logic of just-in-time deliveries, running the too high risk to be short of salt in times of high demand. The production of salt for de-icing purpose has to be organized with a perspective of several months ahead and the logistic for the availability of the product, at least as a strict minimum on a weekly or even more, monthly basis to be able to constitute or replenish proximity storage. The salt supplier has no option but to anticipate the needs of the coming winter based on the hypothesis of a strong winter, nearly the double quantity of an average one, knowing at the same time that the actual needs could be half of this average figure. He must integrate also the possibility to deliver within fifteen to twenty days the equivalent of the total quantity of its average year. Another characteristic of the French market is its

high concentration on the East half of the territory, where the oceanic influence is the weakest and where the mountain relief makes the winter climate more severe [1].

2. TOPICALITY OF THE SUSTAINABLE DEVELOPMENT IN THE PUBLIC TENDERS FOR THE SUPPLY OF ROAD SALTS IN FRANCE

The incentive to consider environmental criteria in the calls for tenders for the road salts in France dates back to 2006, appearing for the first time in the project for the "Guide for purchase of road salts", written by the working group "Winter Maintenance / Frost" of the Regional Laboratory of Nancy (CETE of the East). This document reminds that the French State, for its purchases, sets as a top objective to "develop the eco-responsibility settings" with a top #1 target: improve the policy of public purchase by favouring the purchase of products and services integrating environmental concerns. The possibility to consider environmental criteria is introduced in the code of the public tenders and plays a role in the evaluation of the bids.

The year 2007 starts to show this real awareness in the public tenders for the supply of road salts in France. Before that, only one market had introduced "sustainable development" criteria, for the evaluation of the bids. In 2007, two public markets introduced these criteria in their tenders. In 2008, 14% of these markets added the criteria in their tenders. In 2009, without being general, this concern has become a common definition.

In terms of considered elements, they basically focus on the request of a carbon emissions balance related to the transport of the road salt. The project of the above mentioned purchase guide shows the possibility to also include the production of the road salts, on which we shall elaborate further down, as well as both the choice of a quality, impacting the quantity to be spread and the efficiency of the de-icer.

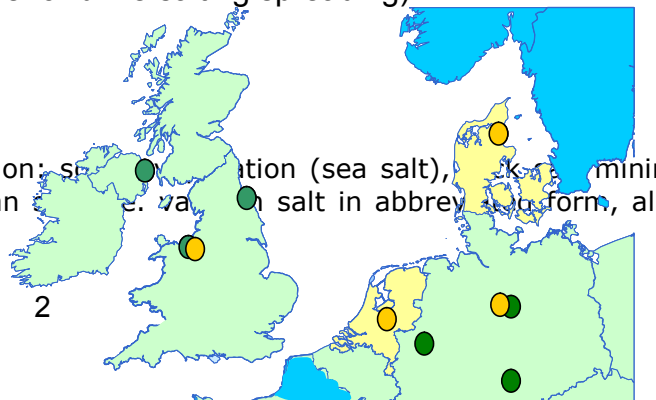
The weighting, connected with the marking determination for the evaluation of the bids, is at to-day's date extremely variable. The price factor generally remains the main issue (50 to 80 % of the final ranking) but can also have a very poor weighting (25%). The consideration brought to the environmental criteria does not count to day for more than 20% and can even go down to 4%.

3. SPECIFIC INTEREST OF THE SEA SALT AS A RESPONSE TO THE SUSTAINABLE DEVELOPMENT CONCERN

The salt used for winter viability in Europe, due to its ponderous characteristics, has, until recently, been produced on locations relatively near to the areas of utilization, excepted notably for the Scandinavian countries which don't benefit of national productions (except Denmark) (map 1). Due to this important factor, the French market has been characterized, from its development in the sixties, by an important use of sea salt which can be estimated presently at 50 % of the market in volume (with variations from one winter to the other). The other part of the French market is supplied from rock salt productions (the vacuum salt[1] being used marginally to produce brine for brine salting spreading).

Road Salt in western Europe

Productions & Main uses



[1] There are only three types of salt extraction: s[illegible]tion (sea salt), [illegible] mining (rock salt) and solution mining (vacuum pan [illegible]. Va[illegible]n salt in abbrev[illegible]form, also said evaporated salt).

Map 1 – De-icing salt in western Europe: productions and main uses (simplified)

In the context of a better concern of the environmental factors for the supply of road salts for the roads, the sea salt represents a combined interest in France.

3.1. Interest at production level:

The sea salt production is characterized by three significant environmental aspects, all presenting the exceptional particularity to be positive:

- Utilization of a renewable mineral resource – The salt, present in the sea is constantly renewed by the combined effects of the water and the earth erosion cycles,

- Utilization of renewable energies, solar and wind energy – Sea salt production is obtained essentially by using renewable energies brought by the solar radiance and the wind energy for a natural evaporation of the sea water and for the crystallisation of the salt from marine solutions saturated in sodium chloride [2],

- Creation of ecological wealth – This salt production takes place on vast territories of wet coastal areas and by creating and maintaining these remarkable natural surroundings for the fauna and flora [3]; it insures the permanence of its preservation and conservation. The wetlands, even though with a constant decline in the perimeter, constitute an inestimable patrimony. They come in second position, just after the tropical rain forests for their biodiversity and their biomass production. They play an essential role in the cycle of the water. They also constitute a genuine biological reservoir: 30% of the remarkable or endangered vegetable species are met there, 50% of bird species are directly binding on them. These wetlands are extremely threatened: during the past 50 years, nearly half of their superficies have disappeared around the Mediterranean. The disappearance process goes on because the costal wetlands often constitute the only remaining places available

for tourism or economic project developments. The sea salt production probably represents the only ecological utilization of these areas which is economically viable [4]. The stake is of importance: on the overall perimeter around the Mediterranean, it represents more than 100,000 hectares and thousands of employments [5]. In France, the sea salt production represents 45% of the whole salt production (90% in Spain!).

The vulnerability factors are many: economic fragility due to the competition with the other types of production (mine salt, vacuum salt), but also environmental fragility due to costal erosion and sea level raising.

In Camargue (South East of France), these areas have been especially distinguished by the main successive labels attributed for the protection of nature: nominated to "ZNIEFF" (Zone Naturelle d'Intérêt Ecologique, Floristique et Faunistique) (Natural Zone of Ecological, Flora and Fauna Interest), inclusion to the "Parc Naturel Régional de Camargue" (Natural Regional Park of Camargue), inscription to the "Ramsar Convention" list, nomination to "Natura 2000" sites for the application of the European directives "Birds" and "Habitats" [6].

3.2. Interest at supplying level for the road salt users

The incidence of the salt transport, for its ponderous aspect, from its production site to the place of utilization as a road de-icer, is of utmost importance both in term of cost (it can represent more than half of the final price) and in term of its global impact on the environment.

This is why any possible reduction of the greenhouse gas emissions related to the transport must be put in place. The easiest way consists in reducing the supplying distance. This statement of the obvious might not yet be so obvious for many of the purchasers because the counter examples are plenty sometimes for totally unjustified price differences. For a given shipping distance, the transport modality with the less possible emission has to be selected (in other words according to its cost as long as in the appreciation of the offers, the price aspect will be predominant on all other parameters). It seems that in France, the salt produced locally corresponds to both conditions, especially for the users located in the quarter South West of France. For example, to bring the salt to the places of consumption, both sea salt works of Aigues Mortes and Salin de Giraud, in addition to being the nearest production sites in that region, are also economically profitable by using either the waterways (Rhône and Saône) with convoys of 2 to 4,000 tonnes or the railways (full trains of 1,200 tonnes), achieving with both transport means little or even very little carbon emissions.

4. EXPANSION OF THE PROBLEMATICS TO THE FRENCH MARKET AS A WHOLE

4.1. Influence of the production process of the salt (sea/rock) in term of environmental footprints

Due to the close to nothing utilization of the vacuum salt for the winter maintenance in France, we shall only compare the environmental impacts between rock salt and sea salt productions. Under the term "environmental footprint" or "environmental impact", we mean the quantity and the quality of the direct resources necessary to these productions, as well as their consequences on the environment, with a special stress on the greenhouse gas emissions. Very few studies seem available today on that topic [2].

The environmental impact of the sea salt production, as we already saw, can be qualified as positive (creating and keeping remarkable natural surroundings). This is not the case

with the rock salt production, i.e. salt obtained through mining techniques. Indeed, the impact of this type of production is certainly much lighter compared to some other mining process of production: no professional diseases, like silicosis in coal mines, almost no creation of slag heaps, small volume of wastes with a lot less impacting effects like the low radioactive wastes produced by uranium industry. The impact of rock salt is also much less than the production of other evaporites like potassium chloride which has already generated in the past very severe saline pollution related to the storage of sodium chloride tailings (confer, for example, the case of the potash mining in Alsace [7]). In fact, its actual and quite substantial ecological impact, lays in the non renew ability of the extracted resource, contrary to sea salt production, and also in the potential consequences which are related to a mining activity, principally the hazard of mining subsidence [8] [9] [10].

If we carefully consider the emissions of greenhouse gas directly related to the energies implemented between the production of sea salt and rock salt, (disregarding the emissions due to the construction and the maintenance of the production sites, or in relation to the fabrication of the materials and means in direct or indirect connection with the production), it can be stated that, non surprisingly, the sea salt production produces notably less emissions than the rock salt production (Table 1).

Table 1 - GHG Emissions of salt production (g equivalent carbon/ton of salt)

Rock salt (Varangéville mine)		Sea salt (Aigues-Mortes saltworks)	
Explosives	101	LPG	13
Gas oil	530	Gas oil	309
Electricity	203	Electricity	102
Total	834	Total	423

The main consumption of energy for the production of sea salt resides in the use of electricity for the water pumping (sea water or brine). As the process of production of electricity in France is essentially coming from nuclear origin, it is the fossil fuel consumption which represents the first GHG emissions generator.
The production of rock salt at the Varangéville mine is consuming more fuel and electricity than a sea salt works. The process of production of the salt deposit (room-and-pillar method) explains by itself that to produce one tonne of rock salt, it generates quite two times more GHG emissions than a tonne of sea salt. Based on the same principles this very tonne of rock salt produced in Germany would generate 1,873 grams equivalent carbon, due only to the way of producing electricity in that country. This figures are based on the "Guidance for emissions factors" prepared by the "Agence des Déchets, de l'Environnement et de la Maîtrise de l'Energie (ADEME)" (Wastes, Environment and Energy Monitoring Agency) [11] [12].

4.2. Emissions of the different transport modes of the road salt in France

Taking the ADEME data as a basis for the calculation of the carbon emission [11], the following elements have been considered. In order to simplify, we are only talking about the salt in bulk which represents nearly 95% of the total market and also the most frequently used transport means. For each of them, we indicate as an example the emission corresponding to a representative distance of the transport of the road salts in France. Like any other estimates for emissions for the salt production, all the values are expressed in C and not in CO_2. They represent an average scale of sizes and no uncertainties have been indicated.

4.2.1. *Road transport:* dumper trucks of 40 tonnes of Total Permitted Weight and of 27 tonnes of carrying capacity. For "long distance" transport (usually more than fifty kilometres but sometime with a greater fluctuation depending on various parameters such as the regions, the transport companies and so on) and a rate of empty return trip of 21% (national average), the mean emission is estimated to 17.4 gram of Carbon per tonne of salt and by kilometre (g C/t.km). To show an illustration, the transport of the salt from Varangéville (North East of France, department name Meurthe-et-Moselle code 54) to the neighbour department named Vosges (code 88) for a distance of about 70 kilometres represents an average emission of 2.0 kg of C/tonne of salt. In the case of a short distance transport (trucking from a warehouse), the return trip being most of the time completely empty, the average emission is estimated to 22.8 g C/t.km.

4.2.2. *Transport by train:* full trains are loaded with 1,200 tonnes of bulk salt: 2.0 g C/t.km in average and 0.4 g C/t.km in case of electric traction. For example, for a transport of 443 km from Aigues-Mortes (code 30) to Riom (code 63) in the centre of France, it corresponds to the emission of 0.4 kg de C/tonne of salt.

4.2.3. *River transport:* by barge of 2,000 tonnes on the Rhône and Saône rivers: 5.7 g C/t.km. For example, for a transport of 277 km between Salin de Giraud (code 13) and Solaize (code 69), it corresponds to the emission of 1.6 kg de C/tonne of salt.

4.2.4. *Sea river transport:* in bulk by vessels of 1,300 tonnes: 2.2 kg C per tonne of salt and for 24 hours of navigation. For example, for a vessel of salt coming from Sardinia (Italy) and sailing up stream the Rhône to Châlon-sur-Saône, it corresponds to the emission of 10 kg of C/tonne of salt.

4.2.5. *Maritime transport:* in bulk, by vessels of 3 to 6,000 tonnes: 1.4 kg C per tonne of salt and days of 24 hours. For example, for a salt vessel arriving from Mohammedia (Morocco) and discharging in Rouen (Seine river, code 76), it corresponds to the emission of 7 kg of C/tonne of salt.

We have applied all of these emission values to a "theoretic" average situation corresponding to the following hypothesis:

Average winter, using (i.e. purchased only, no stock variations) 1 million tonnes, out of which 30% of sea salt from the southern France saltworks, 30% of rock salt from the mine of Varangéville, 20% of rock salt from imported origin and 20% of imported sea salt.

Table 2 - Emissions of GHG by the transport of the road salt (average winter in France)

Origin	Type of salt	Quantities '000 t	Emissions by transport : tonnes of C	Emissions by transport : kg C/t of salt
France	Sea salt	300	937	3.1
	Rock salt	300	699	2.3
	Sub-total	600	1,636	2.7
Imports	Sea salt	200	2,207	11.0
	Rock salt	200	1,911	9.6
	Sub-total	400	4,118	10.3
	Total	1,000	5,755	5.8

The position "transports" of the road salts in France represents a global emission of about 5,800 t carbon equivalent (21,500 t expressed in CO_2), or 5.8 kg C / tonne of salt. This average hides an important variability: the transport of the 300 kt of rock salt produced in

France (Varangéville mine) only emits 2.3 kg / t, whereas imports of sea salt emit nearly 5 times more per tonne of transported salt.

These important differences can be explained essentially by the distance between the production site and the place of utilization but also by the selected mean of transport. We have already seen that the transport by train, with electric traction, is an "all category winner" in terms of emission where the sea-river imports are strongly emitters because of the small size of the vessels used to transport the salt.

The Varangéville mine is ideally located in the centre of a region with important requirements for de-icing salt. In fact, the average distance of delivery from the mine is only 122 km and even if most of the shipments are made through road transport, the total emissions C of the salt transport is particularly low.

As to the sea salt produced in France, the deliveries are on a lot longer distances (the saltworks are not precisely very well located compared to the consumption places, for obvious reasons !) and for the shipments made in totality by truck (about 23% of the tonnage) the average distance is 200 km. The global emissions related to the sea salt transport still remains surprisingly low at 3.1 kg de C / tonne of salt, mainly from the important tonnage transported by barges on the Rhône and the Saône rivers (about 60% of the tonnage), and also by trains (18%).

Salt imports mainly come not only from Spain, Morocco and Italy but also from Germany, Tunisia, Great Britain and a few other countries representing small tonnages. The emissions of GHG related to their transport are high comparing the obviously more important transport distances, and also the trucking from the discharging ports to the final sites of utilization (nearly 2/3 of the imported salts break into France from maritime harbour).

4.3. Carbon emissions balance for the combination "supply and transport" of road salts in France

For this calculation, the emission values have been extrapolated from the values related to the road salt production in France to the imported ones, modifying only the emissions from electric consumptions, taking a basic average of 130 g of C per kWh for the imported productions (against 23 g in France), according to the above mentioned data [11]. Table 3 shows how to obtain an average value of the total emissions:

Table 3 - GHG emissions related to production and transport of road salt (average winter in France)

Origin	Type of salt	Quantities '000 t	Emissions (tonnes of C)		Total emissions	
			by process	by transport	tonnes of C	kg C/t of salt
France	Sea salt	300	127	937	1,064	3.5
	Rock salt	300	250	699	949	3.2
	Sub-total	600	377	1,636	2,013	3.4
Imports	Sea salt	200	179	2,207	2,386	11.9
	Rock salt	200	356	1,911	2,267	11.3
	Sub-total	400	535	4,118	4,653	11.6
Total		1,000	912	5,755	6,667	6.7

Concerning the productions in France, the rock salts generate finally nearly the same amounts of GHG than the sea salts. This is also what can be observed for the imported salts but with emissions more than three times higher expressed per tonne of salt, and

more than two times higher in absolute value compared to the salts produced in France. In other words, 40% of the tonnages used presently in France during an average winter are responsible for 70% of the GHG emissions.

5. PROSPECTIVE FOR IMPROVEMENTS OF THE CARBON EMISSIONS BALANCE IN THE TRANSPORT OF THE ROAD SALTS IN FRANCE

A simplistic reading of the last table could conclude that in order to reduce the GHG emissions, it is just necessary to put an end to the imports! But an important part of the imported salt are delivered in districts which are far from the French located production sites, and the surface transport may strongly impact the emission level (example of the trucks).

To get an idea of the potential target to achieve, even if very theoretical at today's date, a simulation has been undertaken on the different means of supplying the salt according to its origins in order to obtain the lowest possible GHG emission (table Nr. 4).

First we have to underline that the GHG emissions by electric train transport in France are in that respect so little that they supersede by far any other mean of transport. Even for the farthest destinations from Aigues-Mortes, (in West French Britany or in the North of the country), the substitution of one tonne imported by sea shows a reduction of the emissions of around twenty times on the primary transport only (7 to 8 kg C/t of salt for the vessel, 0.4 kg by train!). The difference is even more important if the final trucking (from the discharging port to the final destination) is added to the yield. In the case of imported salt by sea, this trucking item is in average more important than from a railway station, in the case of the transport by train, located usually in the middle of a regional department.

Table 4 - Theoretical optimization of the salt transports to minimize the GHG emissions (average winter in France)

Country of production	Type of salt	Type of transport	Quantities '000 t	Emissions by transport: tonnes de C	Emissions by transport: kg C/t of salt
France	Sea salt	Train + truck	297	374	1.26
		Truck	11	15	1.32
	Rock salt	Train + truck	644	805	1.25
		Truck	48	43	0.90
		Total	1,000	1,237	1.24

The value obtained of 1,237 tonnes of carbon, is nearly five times less than the estimation of the present emissions for the transport of de-icing salt in France which is of 5,800 tonnes of carbon. This is a very theoretic calculation (at today's date the French railways network is far to be entirely electrified) but it gives us a good idea to set the level of GHG under which it will be extremely difficult to go down. The possibilities to improve the performances are important.

For the transport by trucks, this simulation only considers the nearest destinations from the places of production, in order to remain below the limit of the emissions by combined transports (rail + road). This explains the very low volume considered (less than 6%). The

emission value of 1.32 (above 1.26) is due to the shipments to Corsica island, included in this category.

This simulation helps us also to understand that the reduction of the GHG emissions will inevitably result in the redeployment of the transport by train, even though what happens for now a decade in France shows the complete contrary. This mean of transport has in fact constantly decreased, from about 20 % (in tonnage, calculated on an average winter basis) to 5 % in 2008, due only to economical reasons.

The increase of the size of the sea vessels does not allow a significant reduction except for the big bulkers: a Handymax (40,000 t) for example only emits half of GHG per transported tonne per day of navigation than a vessel around 6000 tonnes (the duration of the navigated days will also represent a gain).

We can comment that up to now, to optimize the supply chain for the logistic of the road salts to the places of consumption, the suppliers certainly did not await any previous governmental initiatives about the environment. The rule of the game has been, more likely, dictated by economical constraints. In certain cases, the economy can meet with the environment considerations: river transport is an example, railway transport a counter example. The map 1 above illustrates the limit of repartition between the sea salt and the rock salt: This limit is not a coincidence; it corresponds to the optimization between the cost price of the salt and its cost of transport. If we want to develop the process to achieve a more significant decrease of the GHG emissions, the leverage constituted by the weighting associated to the calculation of the public offers evaluation is certainly one of the utmost mean to be taken into consideration, by increasing the importance of the environmental factors in the final evaluation and marking.

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