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ENVIRONMENTAL IMPACTS IN RURAL AREA OF A HV UNDERGROUND LINK

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ABSTRACT

This paper gives an overview of an environmental study dealing with the implementation a HV underground cable (UGC) in a rural area. This study has been carried out looking at the before, during and after construction stages: from 2003 to 2004 for the initial report and during the construction, and from 2005 to 2006 for the environmental study after the construction had finished. The following article discusses the findings of this study.

KEYWORDS

Environmental impacts, recovery

INTRODUCTION

From historical reasons, RTE underground cables were dedicated to urban centers. Nowadays, because of the increasing environmental and social pressure, the general public acceptance of new overhead lines is more and more difficult, even in rural areas. Therefore, RTE use of underground cables in rural areas may increase in the near future.

The cost of an underground cable is partly linked to its length. Hence, RTE is expecting these lines to use a direct path in rural areas.

RTE decided to have a special focus on a new underground link to be built in a rural area (from July 2004 to commissioning in March 2005). This around 20 km 63 kV underground cable pathway is going through grasslands and cultivated areas for half its length. The main goals of this three years study were:

- Understand the actual impact of a High Voltage underground cable on the physical, natural and farming landscape;
- Study the behaviour of the vegetation situated above the UGC;
- Determine what impact limitation measures are needed, as well as the best guidelines for a worksite of this type.

RTE therefore instructed an Environmental Impact Assessment consultant and an agricultural and forestry expert to carry out a 2-stage environmental study:

- Initial pre-works report (2003-2004)
- A during- and post-works environmental study (2005-2006)

DESCRIPTION OF THE WORK SITE

The 63 kV line is 18.2 km long and passes entirely through rural areas, with no major railways or roads. Over half of its length crosses fields and meadows, and it also passes through streams, wet areas, hedges, stands of trees, Natura 2000 sites and other natural zones of national interest.

The construction works lasted from July 2004 to March 2005.

Laying method:

The two laying methods chosen for this project were:

- In rural areas where no specific type of feature had to be crossed, which was the case along the majority of the route, the cables were laid in HDPE (High Density PolyEthlyene) pipes placed directly into the ground;
- for crossing brooks, one large HDPE tube (Ecopal) containing groups of pipes was laid in order to reduce the time needed to be spent working in the area.

The cables were laid in sections of approximately 3 km using a new water bearing technique, and connected inside underground junction chambers

Along the route, the worksite covered a band of land approximately 12m wide (up to 15m in wet areas), and the width of the trench varied from 0.80m to 1.40m:

- traffic lane: 4/5m
- topsoil deposit: 2/3m
- deposit of matter removed from the trench: 3m
- trench and immediate area: 2m

ENVIRONMENTAL STUDY REQUIREMENTS

Points considered by the Environmental Impact Assessment consultant

Hydrology

A description of the aquatic environments was needed, mainly in the form of a biological inventory of the species directly affected by the work, as well as possibly an on-site measurement of the physico-chemical parameters (dissolved oxygen, temperature, conductivity and pH), both upstream and downstream of the crossing.

Pedology

A description of the soils and their behaviour was required. Aimed at studying the possible impact of the underground line, the main purpose of this description was to discover any changes in the flow of water through the soil.

The main factors taken into consideration when describing the soil units were:

- type of substrate,
- hydromorphism,
- the succession of soil horizons (strata),

In 2004, 1.2m boreholes were made at 100m intervals in order to obtain a soil profile for the whole of the route.

Vegetation

The study looked at different types of vegetation: wet meadows, sedge meadows, willow plantations, wooded slopes (border vegetation), embankment vegetation etc.

Odonata (fauna)

Regarding fauna, the inventories concentrated on small species that would react to very localised changes in the biotopes: odonata.

Although they adapt very easily and are able to travel long distances, odonata should nevertheless be seen as good biological indicators.

Points considered by the agricultural and forestry expert

Wooded areas

The study of the impact of UC on wooded areas looked at:

- short and long-term physical integrity (sustainability or disappearance),
- impact on the landscape and in particular healing process,
- environmental impact, in order to determine the extent of disturbance in the area and its ability to recover.

Farmed areas

The study of the impact of the underground cable on farmed areas looked at:

- the physical integrity of the underground cable

Actual and foreseeable effects of the construction process and presence of underground cable:

  - disturbance of soil horizons,
  - disturbance of soil structure (subsidence),
  - microdrainage effect,
  - macrodrainage effect,
  - rising of stones and boulders to the surface.

- the type of agricultural production

Does the impact of underground cable and the related work change depending on type of agricultural production:

  - large-scale farming,
  - open air animal husbandry,
  - specialised crops.

- the type of farming and intensity of production

The impact, in particular the medium and long-term effects, differs depending on the type of farming:

  - Leading edge farming,
  - intensive farming,
  - traditional farming,
  - extensive farming.

FINDINGS AND ASSESSMENT

During construction

During construction, a certain number of differences were found between the Environmental Impact Assessment (carried out before the construction and which predicted the effects of the construction and future works on the area) and the actual conditions at the work site.

In particular, there was a significant difference between the surface area estimated in the Environmental Impact Assessment and the actual area required: 6m with a 0.35 m ditch was predicted, whereas the 'optimal' strip of land occupied by the worksite was 12m (up to 15m in wet areas), and the width of the trench varied from 0.80m to 1.40m.

Similarly, the study said that a geotexile and metal plates should be used in order to avoid the construction machinery sinking into weak soils. However, deep ruts were still seen in the wet areas during construction.

The company must therefore take heed of the environmental information contained in an impact study, which should as far as possible predict the likely conditions at the worksite (use of public works machinery, likely width of the worksite area, warnings for crossing brooks, measures to avoid polluting brooks etc.).

Special care when filling in the ditches and restoring the land will help speed up the healing of the areas and will therefore mean any disturbance caused during the construction is soon forgotten.

Post-works environmental study report (2005-2006)

Hydrology

Work carried out on brooks resulted in physical changes to the habitats of aquatic fauna. The disturbance of the physical environment appears to have caused a clear improvement in the quality of the habitat, leading to an increase in the number of invertebrates recorded at all sites. By digging into the riverbeds, the construction work created new conditions and new attractive environments for the fauna.

The physico-chemical analyses carried out in situ, in particular of temperature, pH, conductivity and dissolved oxygen levels, showed that the water in the rivers and streams had not been affected by the presence of the electric line. In fact, no significant difference was recorded between the upstream and downstream sections of where the electric line crossed the brooks.

In conclusion, although significant localised disturbances of the environment, and therefore of the fauna, were seen whilst the construction works were being carried out (harsh destruction of habitats, salting-out of substances in suspension, downstream silting), these appear to have been beneficial for the area post facto and in the short term.

Pedology

- **Sound land (good drainage):** Trenches that were not very wide (approx. 50cm) and about 1.50 m deep had barely any impact, provided that the work was carried out in favourable meteorological conditions (no rain). In wet conditions, when machinery needed to pass over the same place several times (e.g. junction boxes) there was a significant risk of the layers under the topsoil subsiding.
- **Naturally wet and drained land:** It was essential to reform the drainage network quickly in order to allow water to drain away if it rained (work to be carried out in summer before the first major autumn rains). Otherwise, there was a high risk of the soil subsiding under the site, which can often lead to an asphyxiated area and/or an excess of surface or sub-surface water which causes problems for root development and a limited filtration of water down to deeper layers.

In order to reduce the risk of vegetation (wild or farmed) not taking well to the soil, it was essential to respect the original order of the soil horizons (strata) when filling in the ditch and the areas around it. The matter used must be dry enough and the work must not be carried out during rainy periods. For wet or swamp areas, it is much harder to reform the area due to the higher water content of the excavated matter (in marshy areas, spreading the matter over an ample area and drying it in the sun to remove

excess water should be anticipated).
The precautions should take into account both the ditch as well as the whole work site, which can extend to 6-10 metres on either side of the ditch.

Favourable meteorological conditions and well-dried matter will increase the chances of successfully integrating the ditch into the natural environment.

Vegetation

The vegetation grew back quickly in the valleys studied, and two years after the work finished, over 50% coverage was observed along the trench area.

- **Aquatic vegetation** and vegetation along the riverbanks grew well after the work (from the first 8 months), especially when it had originally been in a shaded area. However, a significant increase in light sometimes leads to an 'explosion of flora', which can reduce the flow of water. When the work causes a decrease in the gradient of a sloped area compared with how it was at the start, this helps vegetation to develop and can cause the wet part of the brook to shrink, at least during summer periods. These new habitats were soon colonised by strictly aquatic invertebrates or those that spawn on plant matter (e.g. some dragonflies).
- **Meadow vegetation** along the valley floors grew back quickly. During the first year, a natural pioneer stage was observed. Because the wetness level had been increased by the passing through of the construction machinery, this involved bare- and wet-ground annual species. Cattle grazing can sustain this pioneer stage, as the hooves repeatedly walking over the land make small depressions that quickly fill with water. For peat substrates, the fact that they were stripped bare by the construction work meant that a nationally protected plant species was able to germinate there (Drosera intermedia). Perennial plants in meadow areas, in particular poaceae (gramineae), grew back quickly, giving the vegetation a meadow-like appearance.
- **Forest vegetation** underwent radical rejuvenation and it quickly returned to the initial stage of vegetative succession. Over 18 months the initial pioneer stages developed into more closed green formations, in which young ligneous plants developed, signs of later stages to come (thickets, sometimes heaths then afforestations). An edge effect was seen along the borders of the wooded areas affected, with the appearance and/or clear growth of forest edge plants or post-cutting species.

In general, the construction led to localised diversification of the vegetation, with rejuvenation and a local increase in wetness levels, which proved positive from an ecological point of view. However, the introduction of external matter in order to fill up some of the very wet areas or stabilise some slopes led to a generalisation of the flora.

Odonata

In general, the dragonfly population of the various brooks studied was fairly uniform (same dominant or partly represented species), which is to be expected as it involved similar geographical, geological and hydrological contexts.

The plant structure along the riverbanks had a lot of influence, as seen in the different results noted. The population was lower in shadowed areas with many willow trees. Sunny areas (with palustrine and aquatic plants) were colonised by several small species, in particular the Southern Damselfly (a nationally protected species).
The area that was most changed by the works was an open area of wild land that replaced a densely wooded area. This seems to have been mostly favourable for the local entomological biodiversity, because the open areas have been colonised by heliophilous species (dragonflies and other insects such as butterflies and hygrophilous orthoptera) which are absent from the neighbouring undergrowth. The area even seems to have favoured the development of a small Southern Damselfly population coming from the neighbouring river.

Therefore, the opening up of the area mostly led to the appearance of favourable micro-habitats but could also possibly cause the destruction of protected species and their habitat if care is not taken.

Wooded areas

- During the construction, all wooded structures were destroyed over an area 12-15m wide for wood forests and groves, and 4-5m for hedges.
- After the work finished, the wooded areas regenerated. Maintaining the felled trench limits the development of forest vegetation.

Underground cable has a major physical impact on wooded structures, both in the short- and long-term. As with aerial lines, deforestation needs to be considered.
In general terms, the countryside impact of UC on wooded structures is well balanced:

- the choice of route is essential: large wooded structures are very sensitive to change (forests, woods), unlike more sparse structures (groves, boundary hedges) which are much less affected (the line becomes almost invisible in an enclosure)
- In natural sensitive areas, or where there are plant formations growing along a riverbank, the underground line remains visible. However, in some aspects the opening up of the environment can be positive.
- During construction, the aerial and underground sensitivity of bordering forestations is proportional to the age of the trees, including when the line is installed under roads. Conifers are more sensitive than deciduous trees.

Farmed areas

- **The physical integrity of the soil**

Disturbance of soil horizons:

Agricultural soils are arranged in layers over depths of about 0.3 to 0.5m. A 1.30m deep ditch affects the deep sub-soil layers.

The surface layers, which are rich in organic matter, are the most important as well as the most fragile. They include the "topsoil" which is where seeds germinate and so it must ensure a food supply for the plants.

Deeper layers become colonised by roots as they search out water, particularly in summer periods. These deep layers often contain large particles of rock or gravel.

During construction, the topsoil must be stored separately so that it can be re-spread over the surface after the work is finished. Soil horizons should be mixed as little as possible (differences in colour will aid visual identification) and the raising of large particles (stones and boulders) to the surface should be avoided.

At the Locmalo-Plouay site, the topsoil was treated correctly. Mixing of horizons was limited to a few traces of lower layers that mixed with the topsoil. However, the raising of large particles (stones and boulders) to the surface affected over 25% of the area worked.

Disturbance of soil structure (subsidence)

Soil is living matter. Its structure is related the organisation of the elements that it contains: mineral elements (sand, clay, silt, gravel), organic elements (crop residues, manure etc.), but also water and especially air.

Subsidence affects the circulation of air and therefore the life of the soil.

Although the soil in Brittany (sand-clay) is averagely susceptible to subsidence, the study of the Locmalo-Plouay link confirmed the importance of this point.

The negative effects of soil subsidence were amplified by the water content of the soil at the time the work was carried out.

The junction chambers, which is where heavy work is carried out, were more susceptible than along the body of the line.

Microdrainage effect:

The underground cable had a microdrainage effect that clearly affected large-scale crops harvested in summer (corn). The effect diminishes after more than two years (length of the study).

Raising of stones and boulders:

Over time, the people working the land have removed stones and boulders from the topsoil. Subsidence work involving the subsoil caused large particles to rise up to the surface.

Along the Locmalo-Plouay cable, despite the quality of the work carried out by the earthwork companies, there was significant raising of stones and boulders to the surface which affected over 25% of the area involved.

- **Type of agricultural production**

About a hundred plots of farmland were studied along the route of the work.

The results according to type of agricultural production were as follows:

For large-scale farming, which made up 50% of the farmland affected (mainly corn, followed by peas, wheat and barley), during the year following construction, crops were affected by the presence of the line in different ways:

- crops sown in autumn hardly showed the presence of the line and production losses were immaterial.
- crops sown in spring (some barleys, some peas and especially corn) clearly showed the presence of the underground line. Losses in production, which were visible over a width of 8-10m, can be estimated at 25-50% of the remaining yield of the plot.

The impact lessened the following year (n+2). It took three years for the situation to return to normal. This impact can be explained by a microdrainage effect connected with the disturbance of the soil structure. The impact duration is in agreement with the indemnification paid by RTE to the farmer (2,5 harvests paid).

For open-air animal husbandry, which made up 40% of the area affected, permanent and temporary sown meadows are the most frequently used for feeding cattle.

During the year following the work, fodder production was affected in the same way as large-scale crops. Crops sown in winter and harvested before summer were not affected very much, unlike those planted in spring and harvested in summer.

On the other hand, the construction had a direct impact on how the grazing was organised, both during the construction due to disturbance of the animals, and afterwards whilst the soil was still stabilising (12-18 months).

Specialised crops

These cover 10% of the farmed areas affected by the Locmalo-Plouay underground cable , and involve open country vegetable farming (spinach, turnips, green beans etc.) and seeds (mainly fodder). For the Locmalo-Plouay underground line, the impact was tempered by the sandy-clay nature of the soil, which is relatively insensitive to heavy works and use of technology (see section on types of farming).

The impact of underground cable on agricultural production depended on the period during which the crop is grown, as well as the temporary effects of microdrainage caused by disturbance of the soil:

- *crops sown in autumn and which benefit from spring rains are very tolerant,*
- *crops sown in spring and harvested at the end of autumn (mainly corn) suffered significantly reduced yields.*

- **Type of farming**

Because it crossed an interesting selection of farming methods, the Locmalo-Plouay line was very useful for analysing the impact of underground cable.

Leading edge farming

Paradoxically, along the Locmalo-Plouay line, modern farming is the type that was least affected by the UC, although the financial stakes were high (very high added value per surface unit). The impact is lessened by the very good condition of the soil and the skill of the farmers.

Only the areas around the junction chambers suffered from excessive subsidence of the soil.

Intensive farming

The effect on intensively farmed areas was comparable to that of large-scale farming or open air animal husbandry. Summer crops (corn) were affected by the destructuring of the soil and the resulting microdrainage. Fortunately, good condition soil and the skill of the farmers lessened the

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impact.

Traditional farming

There are contrasting situations along the route of the Locmalo-Plouay underground cable due to the influence of the Brittany climate:

- permanent, grazed and mown meadows regenerated with surprising speed, provided the soil was left to stabilise.
- spring crops were clearly affected by the micro-drainage of the construction site area.

Extensive farming

Extensively farmed areas were the most affected by the Locmalo-Plouay underground cable passing through. However, the financial stakes were low (low added value per surface unit). The impact was aggravated by the poor condition of the soil and extensive farming after the work had finished.

GUIDELINES AND IMPACT LIMITATION MEASURES

Before the construction starts (upstream stage)

Environmental Impact Assessment

This is a very useful environmental assessment tool for construction and development projects. It should be as exhaustive as possible and will help:

- list the areas affected and determine their sensitivity in relation to the project: populations of protected species, wet areas, soils or ground water likely to be affected etc., taking into account available inventories, and ending with a land analysis, giving the susceptibility of the area to impact.
- not underestimate the work footprint, the impact during construction, the more or less long-term effects (drainage of wet areas, soil subsidence, disturbances to riverbanks, rejuvenation of vegetation etc.).

Scheduling the work

Natural environments: the best times if possible seem to be the end of summer for the destruction of vegetation and construction along brooks (low water level periods); the same applies for pedology, as rainy seasons can interrupt the work and cause severe degradation of the soil.

Wooded areas: the scheduling of work is not as important, although landowners prefer autumn and winter (ability to make use of the cut wood).

Agricultural production: scheduling is very important, as working during wet seasons can have repercussions on the soil that last for several years (subsidence).

During construction:

- Protect aquatic environments and sensitive wet areas: trap matter in suspension downstream of where the route crosses the brook, use metal plates on weak soil, avoid banking up to create traffic routes, or if not possible use materials suitable for the geology of the area (no chalky materials in acidic wet meadows).
- Respect the soil horizons when refilling the trenches in order to promote the regrowth of vegetation. This is more difficult in wet areas, where prior drying in the sun is needed.
- Reform any slopes that the line crosses over, especially those parallel to contour lines separating thalwegs from higher ground.
- Reform the banks of any rivers crossed and the slope of the riverbed (copying the gradient of the adjacent slopes and the upstream section).
- Limit work footprint through sensitive areas as much as possible (mark areas to be preserved, panels, beacons, adapt the construction equipment to the area being crossed).
- In wooded areas:
  The trench must be a minimum distance from the edge of the tree stumps:
  - 1.5m for deciduous trees,
  - 2.5m for conifers,

  The older the trees are, the more fragile they will be.

Felling aerial sections

The choice of equipment used to fell tree trunks and branches is very important:

- hedge mowers are strictly forbidden,
- trimmers and chainsaws are allowed.

Apart from the choice of tools, the methods used must be tailored to the different sensitivity of wooded structures:

For hedges and copses made of small trees (diameter less than 25cm) and with a large number of stems per unit of area, branches hanging over the line can be cut all together using a trimmer.

For deciduous trees with diameter greater than 25cm, and conifers over 15cm, branches must be cut using a chainsaw:

- without leaving any snags,
- without touching the trunk and without tearing,
- preserving the callus ring in order to ensure the injury closes quickly,

Any remains or products created by the pruning can be left in small heaps in the area, after having been stripped accordingly depending on their size.

Felling underground sections

Pulling up a root is also a major trauma. A clean clear cut allowing healing is difficult, sometimes even impossible.

Deciduous trees have an 'integral' root system which grows relatively equally in all directions. Any trauma caused is 'acceptable' provided the ditch is opened more than 1.5m from the edge of the trunk.

The situation is very different for conifers and poplars which have many thick roots running parallel to the surface of the ground, just a few centimetres deep. Therefore, any trauma caused will only be deemed 'acceptable' if the ditch is located more than 2.5 m from the edge of the trunk. If the ditch is dug any closer, tearing up roots will destabilise the tree and hinder growth.

In general terms:

- the crowns and roots of young trees are not very sensitive,
- average sized trees have very sensitive crowns and roots,
- large trees have very sensitive crowns and roots.

After construction:

Carry out a study of ecologically sensitive areas in order to correct any possible problems.

Recommend localised changes to farming practices in order to preserve certain sensitive soils (grazing in wet areas after

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construction ends can lead to pedological changes).
Watch out for the multiplication of unwanted plants, in agricultural terms, which may benefit from the substrate having been made bare (e.g. thistles).
Stabilise embankments along brooks if the work has weakened them (using planting techniques or more traditional methods using rock fills).

CONCLUSION

The differences between the real impacts observed and the ones mentioned in the Environmental Impact Assessment content have been analysed. Generally speaking, these differences were slight but it is worth noting that the work footprint had been underestimated and the use of geotextile and metal plates did not prevent ruts to be created in limited wet areas.
The second phase of the study focused on the environment ability to recover. Major conclusions can be drawn at this step:

- The healing process is observable in the natural grassland
- A special attention to the wetlands must be taken because of the ruts impacts due to the soil sensitivity to heavy machines. Nevertheless, new habitats favourable to the development of biodiversity were generated.
- Vegetation is renewed and this process helps the emergence of micro habitats diversification.
- The draining effect, even if favourable for cultivated areas, may dry wetlands.

This study showed that measures can be foreseen and planned at an early stage to eliminate or reduce any damage caused by the project to the environment, but at a certain cost. Nevertheless, long term studies have to be launched in order to have a better knowledge on the long term effects such as the drainage and thermal effect.

The results of this study were or are about to be presented both to RTE's Environmental Impact Assessment consultants and RTE's underground cable installation companies.