The ElecLink Project

A new direct current electricity interconnection between the United Kingdom and France.

Strategic energy infrastructure supporting the transition to a low carbon economy.

November 2019

EXECUTIVE SUMMARY

The concept of a direct current electricity interconnector in the Channel Tunnel was envisaged from 1986 in the fixed link Concession agreement. Eurotunnel Group started to develop this Eleclink concept from 2011.

In 2013, the project was granted PCI status by the European Commission confirming its entry into a select list of energy projects which are considered essential for completing the European internal energy market and for achieving the European Union's policy objectives of affordable, secure and sustainable energy.

In 2014, the project was further endorsed by the national energy regulators, Ofgem in Great Britain (GB) and CRE in France, through their joint Exemption Decision which was also approved by the European Commission. The decision sets out a bespoke economic and regulatory model for the project, under which ElecLink is expected to make material contributions to social welfare in both France and the UK as it is obliged to return 50% of its profits, above and beyond a predetermined threshold, to the national transmission system operators, National Grid in the UK and RTE in France.

The ElecLink project is a first-of-a-kind in many respects. The first electricity interconnector between the two countries since 1986 with the capacity to transport electricity to power more than 1.5 million households. The first privately funded investment in cross-border transmission infrastructure not underwritten by consumers. The first non-subsea link between continental Europe and GB with zero impact on the marine environment.

Once operational, the ElecLink interconnector will offer 1000MW of state-of-the-art bi-directional transmission capacity at a time when security of supply in both countries is expected to be at risk due to ageing plants reaching the end of their lifetimes and environmental legislation dictating the phase-out of polluting coal-fired power stations.

Construction works commenced in late 2016. ElecLink has partnered with globally renowned EPC contractors with unparalleled expertise of delivering projects in similar sectors, namely Siemens, Balfour Beatty and Prysmian. The civil and electromechanical works outside the tunnel are fast approaching completion while the required enabling works inside the tunnel have already been carried out successfully. This paves the way for the final stage of the project: the installation of the DC cables in the north running tunnel.

Throughout the development of the project, from the initial feasibility studies to date, Eurotunnel has remained committed to satisfying the legal requirements and to ensuring that the installation of the interconnector does not impact on the current level of safety within the tunnel environment.

The project has applied a rigorous and systematic approach to risk assessment in line with the European Railway Safety Directive and European Common Safety Method for Risk Evaluation and Assessment (CSM) Regulations as well as adopting best industry practice to inform decisions regarding the choice of technology, the detailed engineering design, the location and technical specifications of the apparatus inside the tunnel, as well as the installation methodology.

The project has been - and continues to be - subject to independent review by subject specialists. Eurotunnel have also sought many second opinions to provide additional independent verification that all possible hazards have been identified, properly assessed and sufficiently controlled prior to the commencement of the cable hauling activities.

In compliance with the CSM regulations, Eurotunnel have also appointed an AsBo to provide confidence that the introduction of the interconnector within the tunnel environment will not adversely affect the current safety level of existing railway infrastructure. Following extensive review of the project's technical documentation over the course of the past 18 months, as well as numerous risk assessment workshops, which have included HAZID, HAZOP and PFMEA workshops, the AsBo has concluded that "*the project entity will be able to commence installation without detriment to the current level of safety of the fixed link transport system".*

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TERM	DEFINITION
AC	Alternating current
AsBo	Assessment Body
Cap & Floor	Regulatory framework applicable to GB electricity interconnectors whereby consumers underwrite a revenue “floor” to protect investors from downside and revenues are capped at an upper limit, the “cap”
CRE	Commission de Régulation de l'Energie
CSM	Common safety methodology
Concession	The concession operated by the Eurotunnel Concessionaire under the Channel Tunnel Act 1987 (the “**CTA 1987**”), under the agreement dated 14 March 1986, as amended from time to time, entered into between (1) the Secretary of State for Transport; (2) le Ministre de l'Urbanisme du Logement et des Transports; (3) the Channel Tunnel Group Limited; and (4) France-Manche S.A.
DC	Direct current
EPC	Engineering, procurement and construction
EU	European Union
Eurotunnel Concessionaire	The Channel Tunnel Group Limited and France-Manche S.A. as the concessionaires named in the Concession
Exemption Decision	The final joint decision of Ofgem and CRE on the request of ElecLink for an exemption under Article 17 of Regulation (EC) No. 714/2009 for a Great Britain - France electricity interconnector
FMEA	Failure Modes and Effects Analysis
GB	Great Britain
HAZID	Hazard identification
HAZOP	Hazard and operability
HV	High voltage
HVDC	High voltage direct current
IAA or Interconnector Access Agreement	The agreement of such name between ElecLink and the Eurotunnel Concessionaire
IFA	Interconnexion France-Angleterre
IT	Information Technology
km	Kilometre
kV	Kilovolt
LCC	Line Commutated Converter
MW	Megawatt
NGET	National Grid Electricity Transmission plc
Ofgem	Office of Gas and Electricity Markets
PCI	Project of common interest
PFMEA	Process Failure Mode and Effects Analysis
RAB	Regulated Asset Base
RCC	(Eurotunnel) Rail Control Centre

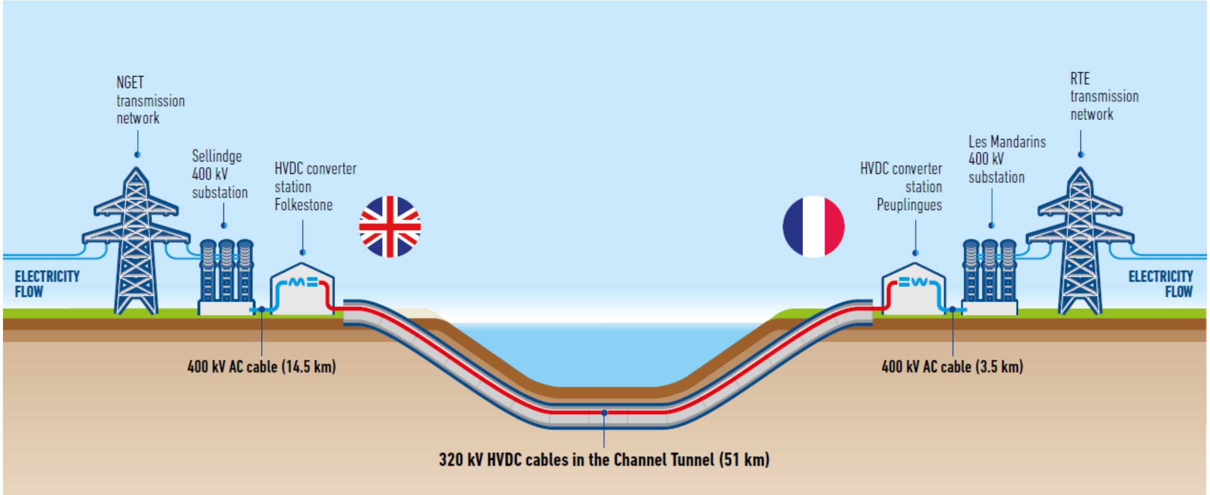
TERM	DEFINITION
RTE	Réseau de Transport d'Électricité
SAR	Safety Assessment Report
STATCOM	Static Synchronous Compensator
Third Energy Package	Means collectively the following: (1) Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC; (2) Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003; (3) Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC; (4) Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005; and (5) Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009 establishing an Agency for the Cooperation of Energy Regulators.
TSO	Transmission System Operator
TWh	Terawatt hour

2. PREAMBLE

2.1 INTRODUCTION TO ELECLINK

ElecLink, a wholly owned subsidiary of Getlink, is constructing a 1000 MW HVDC electricity interconnector between France and Great Britain. The ElecLink interconnector, the first of its kind between the two countries since 1986, will connect to the French and British HV transmission systems at the 400 kV substations in Les Mandarins and Sellindge respectively.

Figure 1: Diagrammatic layout of the ElecLink interconnector



The interconnector is intended to pass through the north running tunnel and consists of the following primary components:

(a) **Two HVDC converter stations** in Folkestone, UK and Peuplingues, France;

(b) **51 km of HVDC cables** inside the north running tunnel;

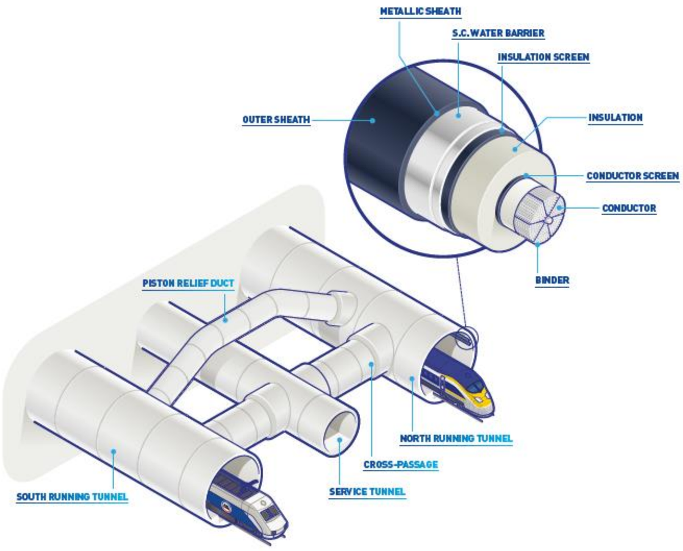
(c) **14.5 km of underground AC cable on British soil** to link the Folkestone converter station with the substation of NGET in Sellindge;

(d) **3.5 km of underground AC cable on French soil** to link the converter station in Peuplingues with the substation of RTE in Les Mandarins;

(e) Switchgear and associated electrical connection **equipment at the NGET substation** in Sellindge; and

(f) Switchgear and associated electrical connection **equipment at the RTE substation** in Les Mandarins.

Figure 2: Location of the HVDC cables in the north tunnel



2.2 EPC PARTNERS

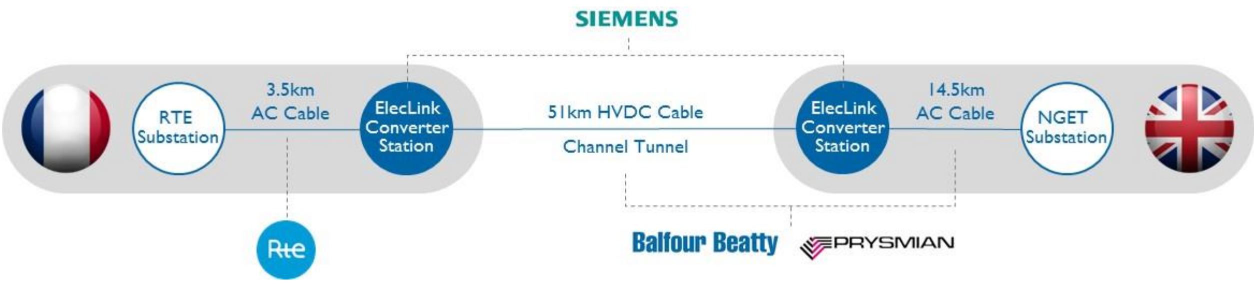
The design, construction, installation, commissioning and testing of the electromechanical equipment have been awarded to partners with worldwide reputation and long and successful track records delivering complex turnkey projects of a similar nature:

a) **Siemens** for the construction of the two converter stations in France and the UK; and

b) **Balfour Beatty and Prysmian** for the manufacturing and installation of the DC cables in the tunnel as well as the underground AC cable system in the UK.

RTE have overseen the installation of the underground AC cables in France and the associated connection works at the substation in Les Mandarins, while NGET have been responsible for the respective connection works at the Sellindge substation in the UK.

Figure 3: Construction partners



2.3 REGULATORY FRAMEWORK

ElecLink has been certified[1] as a TSO under the Third Energy Package. It is regulated by the CRE in France and by Ofgem in the UK. Unlike Cap & Floor interconnectors, which are underwritten by consumers, or RAB interconnectors, which are financed entirely through transmission tariffs levied on grid users, ElecLink is 100% financed through private funds and bears 100% of the investment risk without any recourse whatsoever to consumer underwriting or a guaranteed regulated rate of return.

The regulatory and economic model for ElecLink is underpinned by the Exemption Decision[2] issued jointly by Ofgem and CRE and endorsed by the European Commission[3] in 2014. Under the Exemption Decision, ElecLink is expected to make material contributions to social welfare in both France and the UK as it is obliged to return 50% of its profits, above and beyond a predetermined threshold, to the national TSOs, NGET and RTE, despite not benefiting itself from any subsidy or other means of support.

2.4 RELATIONSHIP WITH EUROTUNNEL

As the entity responsible for the operation of the Fixed Link under the Concession, Eurotunnel is identified as 'proposer' under the CSM regulations. Eurotunnel has entered into a formal contractual relationship with ElecLink, the Interconnector Access Agreement (IAA). The IAA sets out ElecLink's rights and obligations for access to and use of the Channel Tunnel infrastructure, including an ongoing requirement for ElecLink to comply with Eurotunnel's safety and security policies, for the purpose of constructing, installing, commissioning, testing, operating and maintaining the interconnector.

2.5 APPROACH TO SAFETY

Safety is the top priority for both Eurotunnel and ElecLink. Both companies are committed to constructing, operating and maintaining the interconnector in strict compliance with all applicable rail and energy sector safety regulations in both France and the UK. The project makes use of best industry practice, globally renowned construction partners and involves the use of tested and proven technologies.

A very robust project organisation was established from the outset, and engagement with all key project stakeholders has taken place to ensure that, at all stages of the project's development, risks are considered over the whole life of the interconnector - from the preliminary feasibility studies up until the interconnector becomes operational - then for the full extent of the asset's planned operational lifetime.

All identified risks are documented in the project's hazard record which has evolved since 2013, are fully assessed and have identified mitigations with appropriate actions which have been validated by independent experts.

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[1] Ofgem certification decision: http://www.eleclink.co.uk/information/Ofgem_Certification%20Decision.pdf

CRE certification decision: http://www.eleclink.co.uk/information/CRE_Certification%20Decision.pdf

[2] https://www.ofgem.gov.uk/publications-and-updates/final-decision-eleclink-limited%E2%80%99s-request-exemption-under-article-17-regulation-ec-7142009-great-britain-france-electricity-interconnector

[3] https://ec.europa.eu/energy/sites/ener/files/documents/2014_eleclink_decision_en.pdf

3. APPROACH TO SAFETY

Given the nature of the HVDC Interconnector Project integrated within the Eurotunnel infrastructure, also a wholly owned subsidiary of Getlink, its safety assessment is being undertaken as part of Eurotunnel's Safety Management System.

As such, Eurotunnel, concessionaire of the Channel Fixed Link, is the Proposer for this project – assessed as being 'significant' under the Common Safety Method.

3.1 LIFECYLE RISK APPROACH

Since the initial studies into the feasibility of the project through to the present day, the project has applied best practice to the assessment of risk, termed in this document as a *'holistic approach to risk assessment'*.

The key steps in the risk analysis process applied by the project are (as per definitions from Common Safety Method – Risk Evaluation and Assessment - CSM-RA Regulations):

i. **Risk analysis (identification):** means systematic use of all available information to identify hazards and to estimate the risk;

ii. **Risk evaluation:** means a procedure based on the risk analysis to determine whether the acceptable risk has been achieved.

Risk assessment: means the overall process comprising a risk analysis and a risk evaluation. The project deems that a *'holistic approach to risk assessment'* can be declared when all of the following criterion have been met:

a) **Life-cycle model:** A best-practice project life-cycle model is used to provide a documented structure to the systematic process of risk assessment;

b) **Robust risk assessment:** All risk analysis and evaluation undertaken is shown to be demonstrably robust (fit-for-purpose input information, required attendees with defined competences etc.); and

c) **Continuing risk assessment through-out project development:** Risk analysis and evaluation continues throughout the evolution of the project.

The project has been - and continues to be - subject to independent review by subject specialists appointed through 3rd party bodies who provide independent verification that the 'holistic approach to risk assessment' is being rigorously applied. The independent review of the project is explained further in section 3.3.

3.2. STUDIES AND SAFETY CASE JUSTIFICATION

In order to guarantee a thorough approach, the project design can be considered in four phases, each with their own associated risk assessments:

1. Prior to 2013 (feasibility, section 3.2.1 below);

2. 2013 (development of concept /outline design, section 3.2.2 below);
3. 2016 to present day (following appointment of the detailed design and build main contractors, section 3.2.3 below); and
4. Future planned assessment (section 3.2.4 below).

To date, the project have held over 15 detailed workshops including further subject specific HAZID (Hazard Identification), HAZOP (Hazard Operability) and PFMEA (Process Failure Mode and Effects Analysis) workshops.

The application of this comprehensive approach provides comfort to all stakeholders that a systematic approach has been adopted, and that all areas related to safety risk have been analysed.

3.2.1 FEASIBILITY (PRE-2013)

As part of the pre-2013 review of feasibility, the concept of an interconnector system through the service or rail tunnels of the Channel Tunnel was explored which included high level considerations of the possible effects on the safety of the railway system (with consideration of both terminal and tunnel infrastructure).

This involved a global review of available interconnector technologies to confirm which of the following options would be applicable:

i. define whether proven interconnector technology was available that would be able to operate harmoniously within the Eurotunnel boundaries;
ii. review whether an interconnector was feasible, but with extensive research and development in certain areas (which would introduce unproven technology to the project), in order to maintain the current level of railway safety; or
iii. determine if the cost of any railway or interconnector modifications would either be technologically infeasible or cost prohibitive to implement.

Although the co-existence of a railway and grid interconnector is considered novel, the existing Eurotunnel railway system is considered a mature system, and there are many interconnector systems worldwide using the latest Voltage Source Converter (VSC) technology already with many years in-service experience. The review concluded that use of this existing VSC technology should be taken forward to the preliminary design phase for a more in-depth analysis with the railway environment.

The project's aspiration, therefore, has always been to reduce any additional risk of novelty by primarily utilising tried and tested interconnector technology. Many other technologies were reviewed and ruled out as not providing adequate compatibility with the railway environment during this early stage of the project (oil filled cables, AC interconnector (grid-grid direct connection), AC interconnector (with AC/DC/AC converters in each country), Converter Stations using older 'LCC' technology).

Examples of leading industry technology with proven in-service experience assumed during the feasibility and developed further during the 2013 outline design included:

i. Specification of fast acting protection systems;
ii. The highest levels of fully duplicated and redundant controls;

iii. Significant electrical impedance between AC and DC sections, limiting fault infeed from the transmission grids; and

iv. Use of the latest VSC (Voltage Source Converter) technology not exceeding existing industry proven levels of 1000MW and 300-320kV.

On completion of this high-level risk assessment, these design parameters were therefore considered as the base project requirements to be adopted unless specific later risk assessments proved the need for a variation or enhancement to industry proven systems (as was subsequently demonstrated by the example of the required modification to the outer XLPE cable compound to comply with Tunnel fire requirements such as the low emission of toxic gases and smoke, combined with exhibiting low flammability and fire propagation).

From the outset, the latest proven industry technology which was considered to demonstrate the greatest compatibility with the railway tunnel environment were assumed as core requirements in the design. These were then considered to be the base assumptions used as inputs for the project's formal 2013 documented hazard assessments.

3.2.2 2013 RISK ASSESSMENT

The 2013 hazard analysis involved a number of workshops to review the pre-2013 feasibility design of the project with various Eurotunnel stakeholders, and to develop a demonstrably safe outline design that could be used in the invitations to tender for the main design and build EPC contracts.

During the feasibility review of the project, concerns were raised about the possibility of locating the interconnector in the service tunnel due to its defined purpose as a designated safe area. Having carried out risk analysis of additional hazards that would only be present with the location in the running tunnel (such as contact with trains, EMC interaction, projectiles/loose objects from trains etc.) and considering the pre-existing risks due to the presence of the AC catenary system in the running tunnel, it was clear that the preliminary design should consider the running tunnel as the most appropriate location for the interconnector.

Following a risk analysis of the most optimum location within the running tunnel, the "10'clock position" was specified as one of the further locations away from the walkway side of the tunnel (which is required during emergency evacuation), whilst also being at a height clear of both the cooling pipes and catenary assembly which reduces risk in operation as well as during maintenance.

A 'second opinion' review by independent consultant WSP was sought which confirmed this to be the optimum location.

The 2013 risk assessments consisted of a preliminary hazard analysis in June 2013, a HAZOP workshop held in August 2013, and the follow-up hazard analysis reports in October 2013. The concerned Eurotunnel departments were present at these project meetings and helped influence or validate the outline design proposals.

These reports sought to:

i. Validate the choice of location of the cable in the 10 o'clock position of a running tunnel;

ii. Re-confirm that ET maintenance implications had been fully considered;

iii. Provide recognition that the preliminary design had fully acknowledged all risks of electromagnetic interference and to confirm the need for future validation studies which may dictate or influence any future design decisions;

iv. Reinforce the choice of VSC technology with its associated low harmonics;

v. Reinforce the need for fast shutdown in response to faults;

vi. Confirm acknowledgment of the additional fire risk associated with the cables and to define the need for further studies to validate or influence any cable design choice; and

vii. Review construction considerations (defining safety requirements to ensure that future construction activities will not damage or adversely affect the rail infrastructure).

There are numerous examples during the hazard process which considered the final energised state of the cable during its full operation life and influential design choices such as:

a) Requirements to demonstrate resistance to corrosion in wet zones which could otherwise affect the structural integrity of cable support system;

b) recognition of need to avoid multiple failures of support brackets and to contain individual failures;

c) recognition of movement and forces on cables as a result of short circuit fault. Specified need for this force to be contained;

d) recognition that electromagnetic effects from the DC cable current induce current in the traction power bonding system. Highlighted as a concern to be addressed in the contractor's design (risks and benefits of having a separate bonding system);

e) hot surface of cable - risk to maintainers, a review confirmed that the expected HVDC cable surface temperature does not create a risk (safety requirement that the maximum cable temperature is safe to hand-touch when energised);

f) cable support system to continue to maintain the cable outside of railway gauge in the event of a short circuit fault. Specified requirement for contractor's detailed design;

g) Evacuation of people adjacent to energised cable, safety requirement for the proposed cable position to be on the opposite side from the normal evacuation route.

Preliminary electromagnetic compatibility (EMC) studies indicated there was unlikely to be any adverse effects on the railway system during operation or faults, and therefore no additional safety requirements were specified (recognising that VSC technology has low harmonic emissions and typical metallic sheaths in cables significantly contain electric fields).

Given the understanding of the proposed XLPE cable and VSC interconnector technology, it was concluded that there were no identified safety requirements at this stage for any specific mitigating measures to either the proposed interconnector or the existing railway system other than to undertake a full EMC study to validate this assumption.

The tender specifications therefore contained a safety requirement for a full Electromagnetic Compatibility (EMC) study using the actual VSC converter station and XLPE cable parameters to validate this initial analysis in order to demonstrate comprehensively that there would be no risk to adjacent railway equipment and systems.

In summary, the 2013 hazard studies included a number of workshops with key stakeholders, particularly from Eurotunnel operations and maintenance which have had influence on the evolving preliminary design, as well as defined safety requirements that were included in the tender documentations which would become the responsibility of the successful EPC contractors.

The Preliminary Safety Case was reviewed by an independent body, EGIS Rail, who undertook an independent review of the Engineering Safety documentation including the electromagnetic studies by a nominated subject expert.

Their report "*EGIS RAIL 3rd party safety case review of the ElecLink project to establish a HVDC link in the Channel tunnel*" published in November 2013 concluded "*The referential* {the dossier of evidence reviewed} *considered for this safety case is valid and exhaustive*".

3.2.3 2016 TO PRESENT DAY (FOLLOWING APPOINTMENT MAIN CONTRACTORS)

The roles of the main EPC contractors are to:

i. carry out further risk assessments associated with any progressive development of the design concepts into detailed design; and,
ii. undertake a full validation of the known hazards presented in the 2013 Preliminary Safety Case to ensure that all hazards had been captured and evaluated.

The starting point of this exercise was the initial 2013 preliminary design along with the known hazards that had been mitigated through the prior design stages or had been defined as requiring mitigation through the detailed design.

Over 15 detailed hazard workshops that have been held since appointment of these contractors to achieve the aims stated above which have influenced the detailed design.

This quantity of detailed workshops held, which are further supported by numerous studies, demonstrate that the project has undertaken suitable and sufficient risk assessment (analysis and evaluation), with the inclusion of all relevant project stakeholders, prior to making any detailed design decisions.

All workshops have considered the final energised state of the system along with any temporary installation states. Most workshops have been witnessed by independent bodies who have endorsed the robustness of the sessions.

Beside the risks directly related to works for cable installation, more than 100 potential risks have been comprehensively identified for the cable in operation. All are now fully controlled following the robust hazard evaluation exercise leading to identification of suitable mitigation measures. The most critical ones concern:

- cable selection;
- electromagnetic compatibility;
- energy release;
- emergency and maintenance procedures.

3.2.3.1 CABLE SELECTION

As part of the development of this stage of the project, the design of the cable was examined in detail. The initial analysis to pick the optimum cable was undertaken by Mott Macdonald (see 2013 risk assessment above) with the original decision to adopt XLPE insulation technology being subject to a Hazard & Operability (HAZOP) study.

Accordingly, the contract requirement issued in November 2016 was to have an XLPE cable to deliver the planned power through the interconnector. However, as part of the cable design, various HAZID exercises identified that the fire performance of the cable was one of the critical requirements and the fire hazard needed to be further mitigated.

Even though a specific existing cable product with in-service experience was selected as per contract requirements, the hazard mitigation exercises brought out clearly that the cable fire performance needed to satisfy the EU regulation 1303/2014 (Safety in Railway Tunnels Technical Specification for Interoperability) Clause 4.2.2.4. This necessitated re-design of the material of the outer layers of the cables in January 2018. The enhanced cable now meets the EU Regulation requirements fully whilst retaining the majority of its proven in-service design.

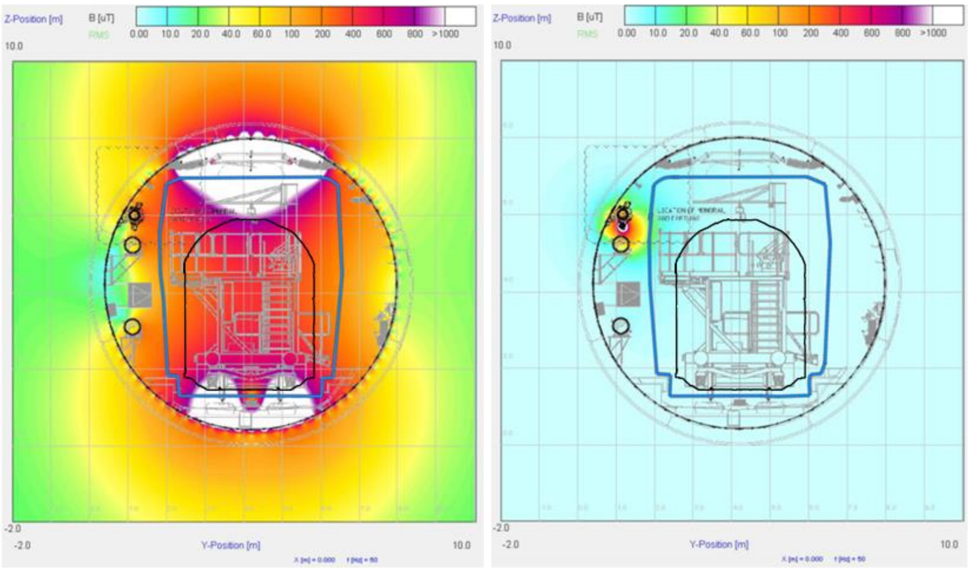
The development of the Electromagnetic Compatibility (EMC) studies also confirmed that there was no safety requirement to modify the cable design itself to provide any additional electromagnetic screening on the cable as the cable emissions were already small and expected to conclude compatibility with the railway.

3.2.3.2 ELECTROMAGNETIC COMPATIBILITY

The risk of electromagnetic radiation from the HVDC interconnector on persons present in the Tunnel must be taken into consideration. The same applies to the risk of electromagnetic interference between the cable and the various electrical components of the railway system (signalling, catenary, rolling stock, etc.) and the other systems present in the Tunnel (detectors, control of cross passage and crossovers doors, electrical networks, etc.).

The safety of the cable is mainly demonstrated on the basis of:

- concerning persons, references set by health standards;
- concerning equipment, detailed studies using a comprehensive inventory of all systems concerned including review of any safety-critical functions;
- the determination of worst cases represented by a HVDC cable fault based on extensive simulation of the various scenarios that could occur (different modes of coupling, stationary and transitory regimes, etc.);
- comparison with existing scenarios that can occur in railway operations such as a catenary trip as demonstrated below.



Catenary fault HVDC cable fault

Results of EMF-Study

Showing magnetic field generated by catenary fault compared to HVDC cable fault - same scaling

Eurotunnel Shuttle gauge Eurostar high speed train gauge

Electromagnetic field computational simulations, supported by measurement of the existing baseline levels present in the tunnel and readings from an reference HVDC system, have provided a positive conclusion on the safety of the cable both for persons and for equipment. The analysis performed on each equipment has also led to the definition, for some of them, of a series of tests/measurements to be conducted prior to commissioning the cable in order to validate and complete the results of the simulations.

The same positive conclusion on the safety of the converter stations on Eurotunnel Terminals and on the adjacent railway infrastructures has also been demonstrated.

3.2.3.3 *ENERGY RELEASE*

This corresponds to the energy released in the event of an insulation fault between the current-carrying core of the cable and the metallic sheath sitting on the outside of the cable insulation layer. Various scenarii were assessed which demonstrated that the worst case energy release involved a fault in the middle of the Tunnel. A series of 9 physical tests were conducted which showed that:

- the energy released by direct current (the case of Eleclink) remains at most in the order of 163 kJ (the amount of energy required to evaporate 80g of water);

- the non-metallic protective shield surrounding the entire HVDC cable system in the tunnel remains unharmed in all situations.

The effectiveness of the emergency shut down in the event of a fault being detected has been studied in depth. In all foreseeable cases, including consideration of foreseeable failures of elements of the electrical protection system, the amount of energy released would remain at a level very similar to the value above. This statement is supported by the results of the computer simulations and physical laboratory tests of this type of fault which have been performed.

3.2.3.4 CONDITIONS FOR EMERGENCY SERVICES INTERVENTION

Maintaining the current level of effectiveness of the emergency procedures in the Tunnel, whether they relate to the evacuation of Shuttles and trains, the interventions by the FLOR or by the SLOR, is based on the ability of the Eurotunnel RCC to activate, when required, the electrical shut down of the electrical power of the interconnector and to ensure it is earthed.

This feature is designed to provide an earthing time of 5 to 8 minutes, the equivalent earthing of catenary and obviously below the maximum time taken to for the emergency services to arrive at the scene of an incident in the Tunnel. The analyses produced confirm the reliability and integrity level of this equipment is comparable to equivalent railway safety equipment.

In parallel, workshops are taking place, with the active participation of Emergency Services representatives. These workshops ensure that the current conditions for Emergency Personnel and their interventions will not be affected by the presence of the interconnector.

3.2.3.5 MAINTENANCE PROCEDURES

The analysis work on the impact of the presence of the cable on Eurotunnel maintenance procedures has classified the Tunnel maintenance operations according to their nature and their proximity to the cable. Some of them may require one or more of the following measures:

- tool modification which could go as far as a review of the works modules design;
- installation of a mechanical protection on the interconnector prior to carrying out work;
- shutting down the power and earthing of the interconnector.

This safety assessment also includes maintenance works on the interconnector itself.

3.2.4 FUTURE PLANNED RISK ASSESSMENTS

Following completion of all detailed design deliverables, an all-day hazard validation was held in Coquelles on 23rd July 2019. This meeting included senior representatives from every technical department of Eurotunnel including maintenance, operations, security, IT systems, projects, safety and rolling stock, as well as independent review by MMRA-IA, AEGIS Engineering and the Assessment Body (AsBo). Attendees from all areas of ElecLink (EPC contractors, designers, O&M staff etc) were also in attendance.

The workshop covered the entire project design and invited challenge to the project hazard record prior, during and following the meeting. The numerous questions raised confirmed the robustness of the hazard record and confirmed that all reasonably foreseeable hazards. The workshop agenda was structured around the project's 'overall system definition' which defines the final configuration of the project.

The project is now developing detailed test procedures for the energisation of the converter stations and the cable within the tunnel and will ensure that these are subject to HAZIDs to ensure that:

a) the proposed system tests can be demonstrated to have no negative effects on surrounding infrastructure; and

b) that any tests imposed as a safety requirement in the hazard register which are required to ensure the safe operation of the new equipment with the railway environment have been sufficiently included in the test specifications.

Siemens have already held a HAZID for the future maintenance and operation of their elements of the interconnector system, with further HAZIDs and verification exercises planned for the commissioning phase.

Necessary assurance of the above will be provided through the issue of Safety Assessment Reports by the AsBo, and Eurotunnel will continue their close involvement and influence on all aspects both prior to the project becoming operational and during the operations and maintenance (O&M) phase.

3.3. INDEPENDENT ASSESSMENT

The project has been subject to extensive independent review during its development. As noted in 3.2.2 above, the preliminary safety case produced in 2013 was subject to full independent review

During the detailed design phase of the project, there have been many second opinion documents produced which themselves provide support for the arguments being made by the project.

Examples of recent 'second opinion' reports include:

	Description	Date	Originator	Report Ref.
1	3rd party Safety Case review of the ElecLink project to establish a HVDC link in the Channel tunnel	04/11/2013	EGIS Rail	3880 EK RS131313 B
2	Third party review of DC Cable Fault Simulations	29/11/2017	Growler Energy	R-EL-PP-01-05
3	2nd Opinion on SIEMENS Document: 'EMC Infrastructure Interaction Study'	04/12/2017	SYSTRA	ER-001
4	3rd party opinion on DC Cable Position	Dec. 2017	WSP	70041261
5	Review of Eurotunnel cable arcing investigations and testing.	Oct. 2018	Dr. Morris Lockwood (RINA Consulting)	FEW01693-001 v3

Along with these individual technical second opinion reports, the project is also subject to continual review (progressive assurance) from a number of independent bodies employed by both ElecLink and Eurotunnel. These include:

	Originator	Scope/Deliverables
1	Mott MacDonald	Technical Advisors and reviewers of all technical documentation for compliance with contract requirements.
2	AEGIS	Employed as both an Independent Competent Person (ICP) and Independent Safety Assessor (ISA) to review all technical documentation associated with the Project's new rail vehicles and cable hauling systems. Certificates have been successfully issued for all vehicles and cable hauling systems to date.
3	IFFSTAR	Employed to provide review project documentation and provide assurance of compatibility of electromagnetic effects from the interconnector to all rail systems.
4	MMRA-IA	Employed to review the full scope of the project using 3rd party reviews and second opinions as required supplemented by detailed technical reviews in all other areas.
5	MMRA AsBo	Eurotunnel are the 'Proposer' under the CSM Regulations. The 'significance' of the project requires appointment of an Assessment Body (AsBo). The AsBo have been reviewing the application of the safety processes of the project in detail since mid-2017.

The AsBo is the main body which is appointed under the CSM Regulations to provide confidence to the 'Proposer' (Eurotunnel) on the safe interaction of the change (the introduction of the ElecLink Interconnector) to the existing railway environment.

The AsBo has undertaken numerous assessments on specific documentation and uses the technical reviews noted in the table above to provide a judgement at pre-determined stages of the project.

Prior to allowing the unenergised cable system to be introduced inside the Channel Tunnel, Eurotunnel requested the issue of a design phase 'Safety Assessment Report' (SAR) from the AsBo in order that the AsBo could document their opinion on the application of the holistic risk assessment process undertaken up to that point in time and to provide an opinion on whether commencement of cable hauling should begin.

The AsBo had been reviewing relevant documentation for around 18 months by the time the request was made. The AsBo provided a non-objection to the commencement of cable hauling based on the extensive reviews undertaken by 3rd parties, along with their own detailed examinations. The AsBo's report states:

> *"As a consequence of the assessment carried out (and by reference to the work of other independent bodies engaged with the ElecLink project), the ASBO has obtained a high level of confidence in the documentary evidence, made available to show that the project entity will be able to commence installation without detriment to the current level of safety of the fixed link transport system"*

The AsBo will continue their assessment in line with the CSM Regulations up to at least 3 months after commencement of operation of the interconnector with a view to providing continued assurance to Eurotunnel.

4. CURRENT STATUS OF THE CONSTRUCTION ACTIVITIES

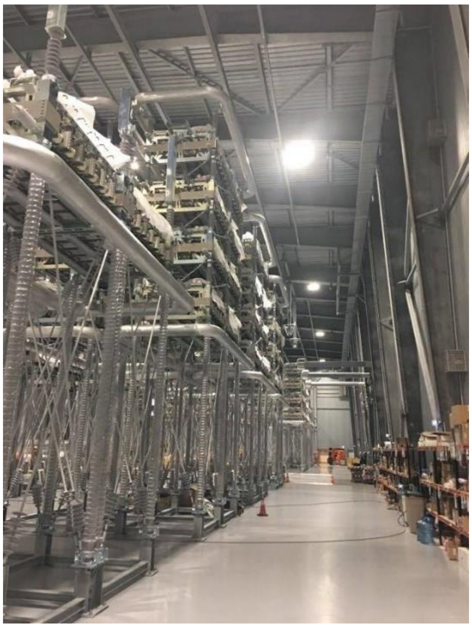
The section below summarizes the status of the construction activities as at the end of October 2019.

4.1 CONVERTER STATIONS

As can be evidenced in the pictures below, the EPC works for the two converter stations have been completed. Commissioning of the installations in STATCOM mode[4] can begin imminently.

Figure 4: Exterior of the converter station (FR)

Figure 5: Interior of the converter station (FR)



[4] Energisation of the converter stations and auxiliary equipment without transfer of active power between the two ends of the interconnector.

Figure 6: Low voltage distribution panels

Aside from the electromechanical equipment controlling the flow of electricity over the interconnector, ElecLink has invested heavily in state-of-the-art IT infrastructure which will enable both physical and commercial operations to be conducted in a safe, fully controlled and automated manner.

Figure 7: IT hardware and systems

4.2 HVDC CABLE SYSTEM

4.2.1 CABLE

The HVDC cable has been manufactured and delivered to site in 2.5 km drums as shown below.

Figure 8: HVDC cable drums

4.2.2 SPECIALIST WORKS TRAINS

One-of-a-kind works trains have been designed and manufactured specifically for the ElecLink project to enable the installation of the support structure and cable management system within the tunnel environment. This bespoke equipment comprises drilling modules, monorail modules, jointing platforms and hauling equipment as shown below.

Figure 9: Drilling module

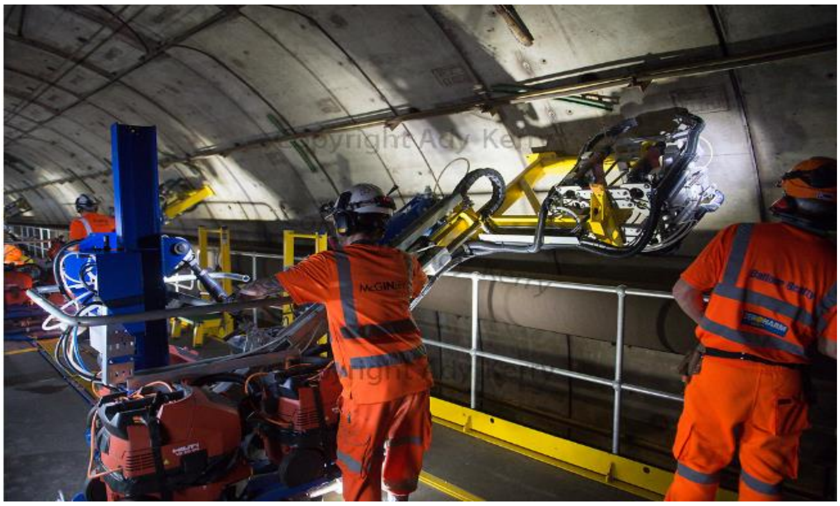


Figure 10: Monorail module

Figure 11: Jointing module

Figure 12: Hauling module

Figure 13: Hauling module control unit

4.2.3 ENABLING WORKS INSIDE THE TUNNEL

All of the required enabling works inside the tunnel have been completed. These include the installation of the supporting steel structure (brackets affixed to the tunnel lining which support a monorail system) as shown in the pictures below.

Figure 14: Installation of steel brackets in the north running tunnel

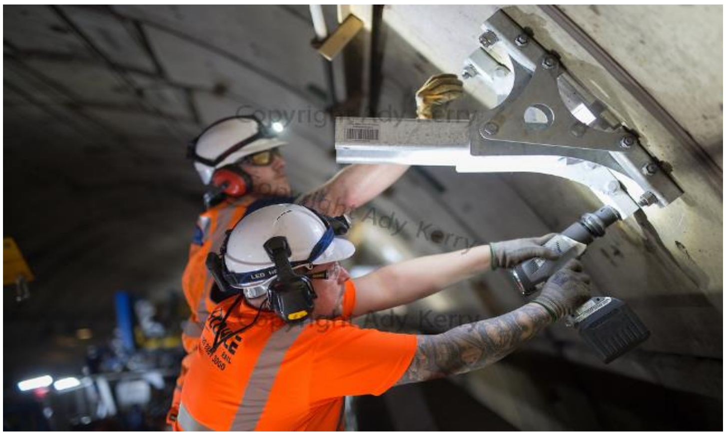


Figure 15: Installation of monorail system in the north running tunnel

4.2.4 ENABLING WORKS OUTSIDE THE TUNNEL

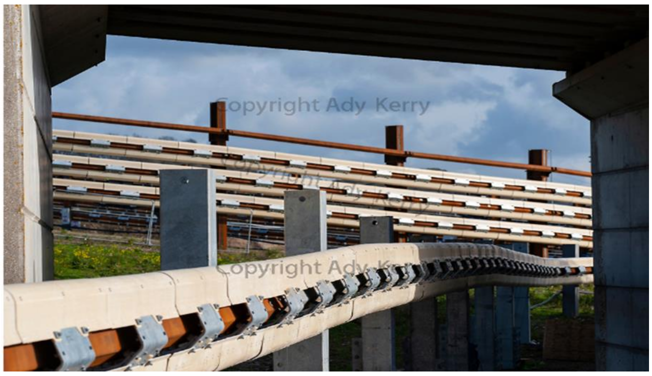
Similarly, to the enabling works inside the tunnel, all of the required enabling works outside the tunnel have also been completed. These have included the construction of tailor-made assembly and jointing facilities, where the HVDC cables are assembled into position in readiness to be driven onto an external monorail system which includes a specially designed helix, all of which have also been constructed specifically for the purposes of the ElecLink project.

Figure 16: External assembly facility

Figure 17: External jointing facility

Figure 18: External monorail

Figure 19: External loaded helix



4.3 AC CABLE CONNECTION IN THE UK

The cable installation works along the 14.5km route from the ElecLink converter station in Folkestone to the NGET substation in Sellindge have been completed. In terms of the new switchgear and connection apparatus at the Sellindge substation itself, all works have been completed too.

Figure 20: Underground AC cables in the UK

4.4 AC CABLE CONNECTION IN FRANCE

The 3.5km long underground AC cable linking the ElecLink converter station in Peplingues with the substation of RTE in Les Mandarins has also been fully constructed. The works were carried out by RTE.

5. STRATEGIC AND SOCIOECONOMIC BENEFITS

5.1 VALUE OF INTERCONNECTION

The positive contribution and increasing importance of interconnectors is widely recognised by national governments, energy regulators and the European Commission. Interconnectors are ideally placed to solve the "energy trilemma" faced by modern societies: how to guarantee energy security in an environmentally friendly way and at the lowest cost to consumers. This is precisely why cross-border electricity interconnectors have become such a vital component of the Third Energy Package and the completion of the internal energy market.

Figure 21: Value of interconnection

The value of interconnection

1 Energy security

✓ Interconnectors **enhance security of supply** for the connecting countries by enabling bi-directional flows and ensuring that electricity always flows from the country with a surplus to the country with a shortfall.

2 Sustainability

✓ Interconnectors **reduce CO_2 emissions** by enabling the most efficient and environmentally-friendly generation plant to meet demand across a wider region.

3 Affordability

✓ Interconnectors **reduce prices for consumers** by diversifying supply sources, enhancing competition in the marketplace and increasing choices for consumers.

5.2 SUPPORT FROM NATIONAL GOVERNMENTS

The European Commission has adopted EU-wide policy targets aiming to increase each member state's interconnection capacity to at least 15% of installed capacity by 2030. This is a very ambitious, yet essential, target that ElecLink will contribute greatly to considering that the current level of interconnection capacity in the UK approximately 5% and in France circa 10%.In recognition of its importance towards achieving this vital objective, the ElecLink project has, therefore, been endorsed by both the French and the UK governments since its very inception.

Figure 22: The ElecLink foundation stone laid by the UK Minister for Industry & Energy[5]

The ElecLink interconnector has been designated as a PCI; a status reserved for selected energy infrastructure projects which are considered essential for completing the European internal energy market and for reaching the European Union's energy policy objectives of affordable, secure and sustainable energy.

[5] https://www.gov.uk/government/news/new-electricity-connection-to-france-gets-go-ahead

The project was also identified in the UK Government's national infrastructure plan (part of the Chancellor's Autumn Statement in 2012) and further referenced in a 2012 joint communication of the French and UK governments:

"We acknowledge the importance of developing new electricity lines between our two countries in order to strengthen further the linking of our grids, improve the security of our energy supplies and facilitate the integration of intermittent energy sources. We encourage further studies to be undertaken on the interconnector projects currently under consideration, namely the IFA2 led by the Réseau de Transport d'Electricité and the National Grid … and ***ElecLink led by STAR Capital and Eurotunnel****".*

5.3 SOCIOECONOMIC BENEFITS OF ELECLINK

The ElecLink interconnector is one of the most advanced new interconnection projects across Europe and the first of its kind between Britain and France since 1986, when the existing IFA interconnector was commissioned.

Once operational, ElecLink will provide 1000 MW of reliable state-of-the-art bi-directional transmission capacity. This represents an increase of 50% on the current level and enough capacity to power more than 1.5 million households. The project is not only expected to bring considerable benefits to consumers by way of reducing electricity prices (net social welfare benefits are estimated in the region of €0.6 billion over the economic lifetime), but to do so in the most sustainable and environmentally friendly way. It will utilize existing infrastructure, have no impact on the environment (contrary to existing subsea lines which interfere with marine life) and generate carbon emission reductions of approximately 6.1 million tonnes CO_2 up to 2030.

As mentioned previously, ElecLink is expected to make further material contributions to social welfare in France and GB by virtue of its bespoke economic and regulatory model set out in the Exemption Decision. The latter provides that the company must return 50% of its profits, above and beyond a predetermined threshold, to the national TSOs, NGET and RTE, despite not benefiting itself from consumer underwriting or a guaranteed regulated rate of return on the investment.

5.4 STRATEGIC VALUE OF ELECLINK

Historically, GB has been importing nearly four times more electricity than it has exported. With ageing generation plants fast approaching the end of their technical lifetimes and stricter environmental standards necessitating the closure of all coal-fired facilities (currently accounting for circa 10% of total generation capacity) by 2025, the need for imports is only likely to increase in the short to medium term.

At the same time, France is becoming increasingly reliant on electricity imports to meet peak demand during winter. This is due to the widespread use of electric heating which causes consumption to spike during cold spells. This trend is only likely to persist and further intensify if the national energy policy objectives to phase out coal-fired facilities and reduce the share of nuclear power were to materialize.

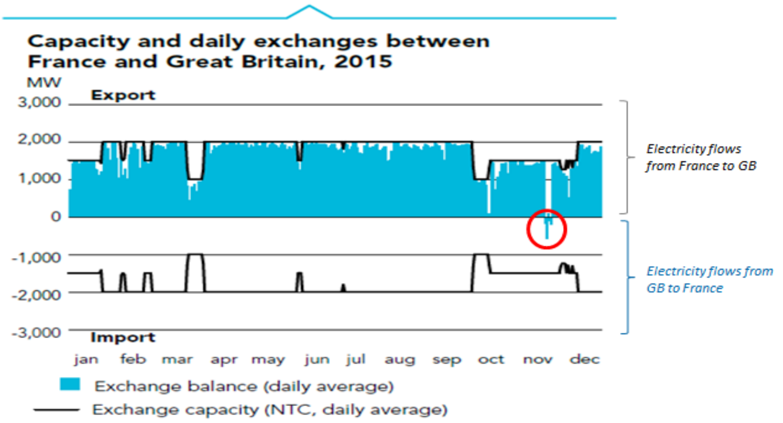
The importance of interconnectors for security of electricity supply in France is indeed acknowledged by the national TSO, RTE:

"In January [2017], France showed a net import balance of 0.951 TWh, a new record. ***The country relied on imports because of the cold spell that occurred that month, illustrating the important role of interconnections between European countries in guaranteeing security of electricity supply.*** *In January, France was a net importer from the CWE region, Spain and Great Britain. It also showed a net import balance of 0.826 TWh in*

November, when the availability of nuclear capacity was low and temperatures were unseasonably cold (-0.8°C on average).'[6]

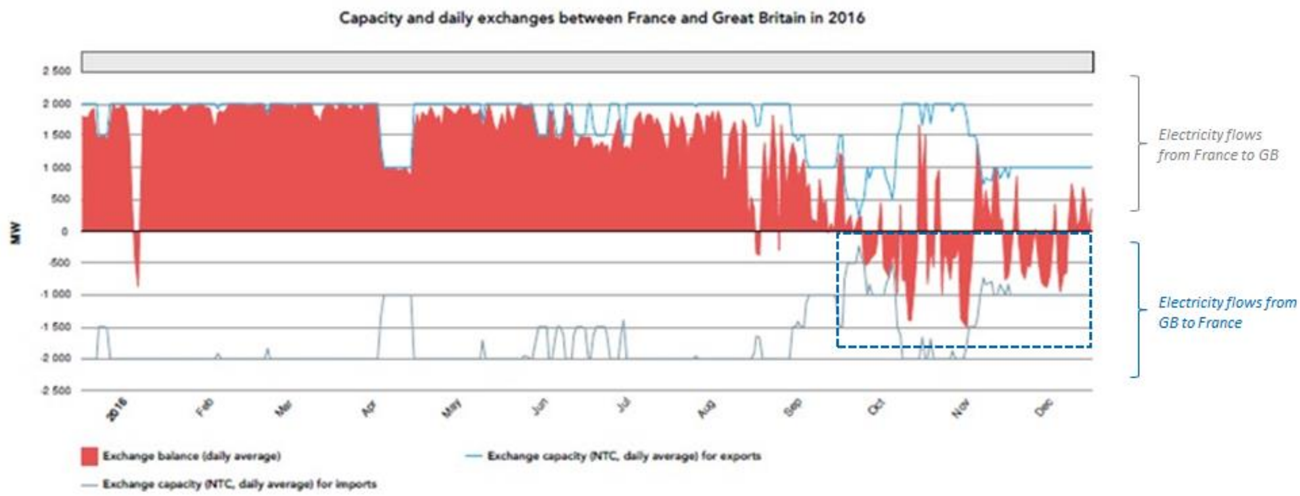
The strategic value of ElecLink for GB (in terms of reliable baseload imports of lower-priced electricity) and for France (in terms of its increasing dependence on electricity imports during winter) can also be demonstrated in the following charts which depict how the electricity exchange balance between the two countries has evolved in the period 2015 – 2017.

Figure 23: FR - GB electricity exchanges in 2015[7]



Except for a very limited period in November 2015, during which GB exported sporadically to France, the direction of flow in 2015 was almost always from France into GB.

Figure 24: FR - GB electricity exchanges in 2016[8]



The situation started to change in 2016 when, as shown on the chart above, GB exported heavily to France in the last quarter of the year. This trend intensified further during 2017 when, as it can been on chart below, France was dependent on imports from GB in order to meet demand in January as well as during a significant part of October and November due to cold weather conditions and low availability of nuclear plant respectively.

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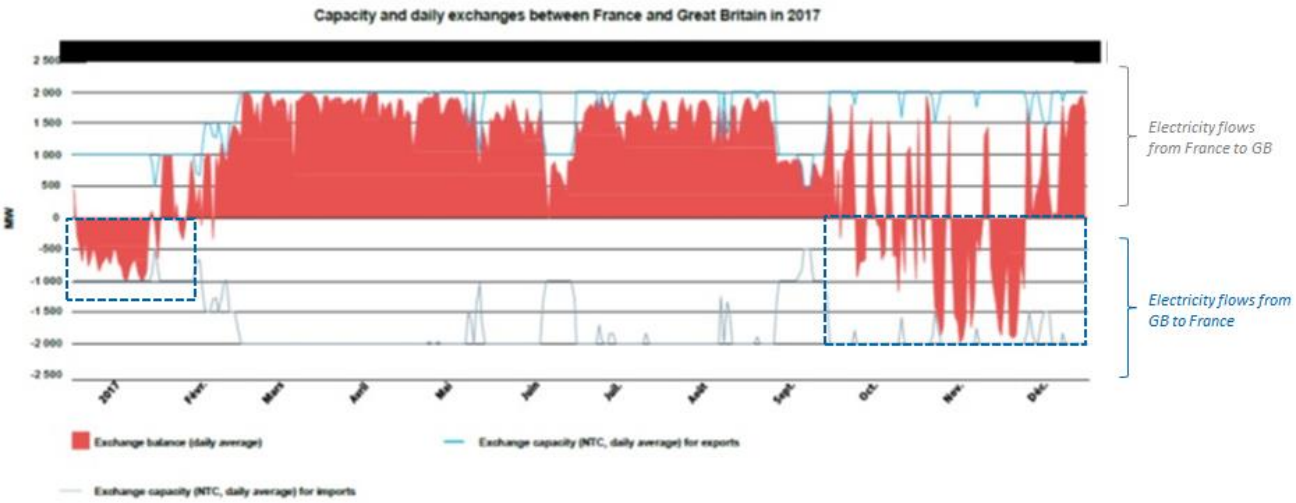
[6] RTE Electricity Report 2017, page 78, https://www.rte-france.com/sites/default/files/rte_elec_report_2017.pdf

[7] RTE 2015 Annual Electricity Report, https://www.rte-france.com/sites/default/files/2015_annual_electricity_report.pdf

[8] RTE 2016 Annual Electricity Report, www.rte-france.com/sites/default/files/bilan_electrique_2016_en_180517_compressed.pdf

Figure 25: FR - GB electricity exchanges in 2017[9]



The same conclusions can be drawn from the table below which summarizes the annual commercial electricity exchanges between the two countries in the period 2015 – 2017. Whilst the flow has remained predominately in the direction from France to GB, the counterflow into France has more than doubled (from 1.8 TWh in 2015 to 3.9 TWh in 2017).

Figure 26: FR - GB commercial electricity exchanges in 2015 - 17[10]

Direction	**2015**	**2016**	**2017**
FR -> GB	15.9 TWh	12.7 TWh	11.8 TWh
GB -> FR	1.8 TWh	2.7 TWh	3.9 TWh

A further notable statistic evidencing France's increasing reliance on interconnector flows, particularly during periods of low nuclear availability, is that while in 2015 there was no single day the country was a net importer of electricity, in 2016 and 2017 there were 46 and 52 days respectively.

[9] RTE Electricity Report 2017, https://www.rte-france.com/sites/default/files/rte_elec_report_2017.pdf

[10] RTE Electricity Reports 2015, 2016 and 2017

6. CONCLUSIONS

As evidenced in the previous sections, at each stage of the project, Eurotunnel and ElecLink have applied a comprehensive, systematic and holistic approach to managing safety risk in line with the CSM regulations and best industry practice. The decisions regarding the choice of technology, the location and design of the apparatus and the installation methodology have been informed by rigorous risk assessments, detailed engineering studies and third-party opinions. These have been further validated by independent technical experts and have been subject to scrutiny by the AsBo.

The civil and electromechanical works outside the tunnel, as well as the enabling works inside the tunnel have all been fully completed. ElecLink is now ready to enter the final stage of the project, which consists of the hauling of the DC cables inside the North running tunnel. The project has obtained a positive Safety Assessment Report from the AsBo which confirms that such cable hauling activities can commence without detriment to the current level of safety in the tunnel environment based on their own detailed reviews and with the support of a number of conclusions from other independent assessors and supporting second opinion reports.