SWITZERLAND - ITALY INTERCONNECTOR ALL'ACQUA-PALLANZENO-BAGGIO

(Investment 31.642 TYNDP 2016 of ENTSO-E)

Index

1 AIM

This document contains the assessments, made by Terna, referring to the benefits' analysis of the Italy – Switzerland interconnection, called "All'Acqua-Pallanzeno-Baggio"; this document completes and supplements the benefits analysis included in the *Ten Year Development Plan 2016 (TYNDP2016, www.entso-e.eu)* relatively to the 31.642 investment and also represents the additional benefits evaluated on the basis of the Costs Benefits 2.0 methodology, hereinafter referred to as **ACB 2.0**, for the assessment of the infrastructure on the national transmission grid (NTG), defined with Italian Regulatory Authority for Electricity, Gas and Water Resolution 627/2016.

The methodology referred to as ACB 2.0 has the following objectives:

- improve the transparency and completeness of information based on the technical-economic analyses of the development projects on the NTG;
- guarantee the consistency and soundness of the assessments done on the work carried out by the transmission system operator;
- promote the selectivity of investments by the transmission system operator and by the Authority;
- where feasible and relevant, monetise each benefit associated with each development project analysed;
- pay attention to reducing the costs incurred by users of the electricity system and to the utility of projects for the Italian electricity system;
- provide information to develop and introduce selective incentive mechanisms for investments.

In order to guarantee completeness and transparency in the information, even though not specifically required by Resolution 627/2016, this document extends the application of methodology ACB 2.0 to the "Italy – Switzerland" Interconnector project relatively to the 31.642 investment.

The Interconnector Italia - Switzerland project, called San Giacomo project:

- ✓ is included in the list of projects by Law 99/09. The Law 99/09 introduces the type of "interconnectors" funded by end-users (with more than 10 MW) allowed to participate for the financing of new interconnection line identified, realized by Terna;
- ✓ is included in the Terna Development Plan and started on authorization on October 3, 2012; is also included in the Development Plan of the Swiss Network Manager (Swissgrid) where it has already been implemented ("the 380 kV double line on the Swiss side between Airolo in Ticino and the Italian national border has already been realized").

2 DOCUMENT REFERENCES

The main document references are provided below:

- European Parliament and Council Regulation (EC) 714/2009 of 13 July 2009;
- Agency for the Cooperation of Energy Regulators (ACER) position dated 30 January 2013 on the subject of ENTSO-E Guidelines to Cost Benefit Analysis of Grid Development Projects;
- European Parliament and Council Regulation (EU) 347/2013 of 17 April;

- ACER opinion 01/2014 dated 30 January 2014 on the ENTSO-E Guidelines for Cost Benefit Analysis of Grid Development Projects;
- the costs benefits analysis methodology "ENTSO-E Guidelines for Cost Benefit Analysis of Grid Development Projects FINAL- Approved by the European Commission 5 February 2015";
- Document describing ENTSO-E scenarios "TYNDP 2016 Scenario Development Report – Final after public consultation - 3 November 2015";
- ACER opinion 12/2016 dated 4 October 2016 on the document schedule "TYNDP 2016 Scenario Development Report";
- Ten Year Development Plan 2016, www.entso-e.eu
- Resolution of the Authority no. 627/2016/R/EEL of 4 November 2016 and relevant Annex A;
- National Transmission Grid Development Plan 2017 www.terna.it
- *Costs of air pollution from European industrial facilities 2008-2012"* published in Nov 2014 (https://www.eea.europa.eu/publications/costs-of-air-pollution-2008-2012)
- CO2 evaluation Stockholm Environmental Institute, 2016 (http://www.eib.org/attachments/thematic/economic_appraisal_of_investment_projects_en.pdf)

3 THE PROJECT

In implementing Art.32 of Law No.99/2009 of 23 July 2009 "Provisions for the development and internationalization of enterprises and energy" and Law No. 41/2010 of 22 March 2010", converted into law with amendments by Decree-Law No. 3 of 25 January 2010, containing urgent measures to guarantee the security of electricity procurement to the major islands", Terna – together with other neighbouring grid operators – investigated the possibility of setting up new possible electricity corridors of common interest" in the form of Interconnectors pursuant to Regulation (EC) No.1228/2003, including the necessary internal decongestion projects for the National Transmission Grid.

In the scope of bilateral cooperation with neighbouring grid operators, preferential electricity routes were identified and agreed on to implement projects for increasing capacity on the Italy - Switzerland border: San Giacomo project.

The project was incorporated in the National Transmission Grid Development Plan as from 2010, and the authorisation formalities began on 3 October 2012. Similarly, the project was included among the projects envisaged by the Swissgrid, see website www.swissgrid.ch.

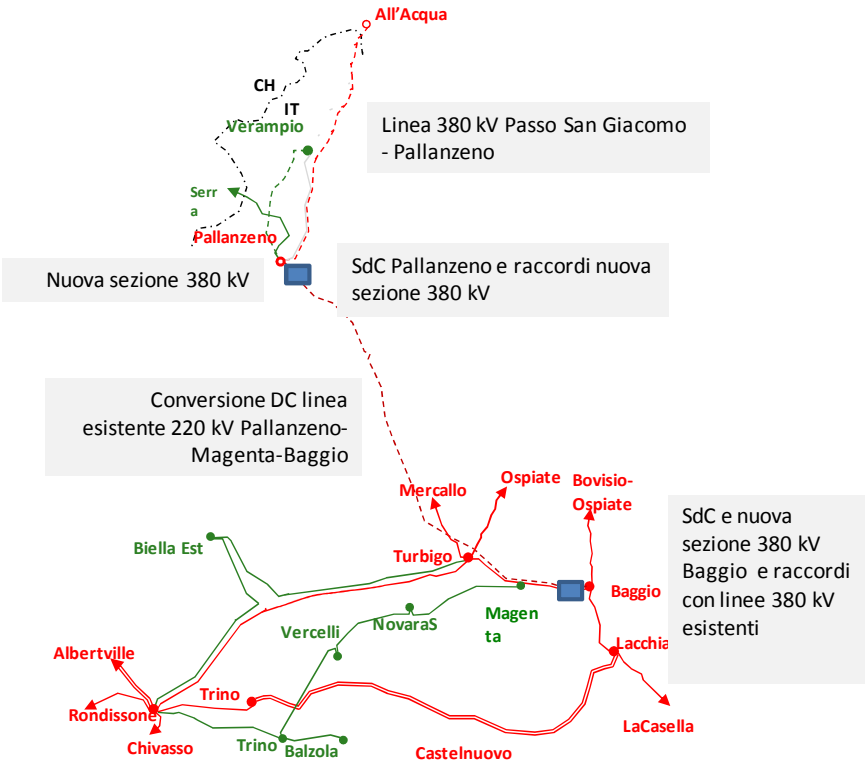
On the Italian side, the project comprises:

- an initial portion consisting of a simple 380 kV circuit power line that would start from the aforementioned point on the border and reach the area of Pallanzeno; here it would be deployed on the new 380 kV section to be realised, thus extending the existing station. In its initial section, the power line will be constructed on the same double circuit palisade of the upgrade project to the existing 220 kV power line All'Acqua-Ponte, which currently has been authorised in the scope of the "Rationalisation of the HV grid of Val Formazza";
- a second part of the Interconnector works is associated with increasing transfer capacity on the existing 220 kV line between the stations of Pallanzeno – Magenta - Baggio, which will be done by

transforming the current asset into a direct current line with a nominal voltage between ±300 kV and ±350 kV, where possible utilising the existing infrastructure.

The electricity lines are shown below.

Interconnector S. Giacomo Project



The analysis provided below refers only to the Italy - Switzerland interconnection link, investment n. 31.642 of the TYNDP 2016 of ENTSO-E, called "S. Giacomo Project".

4 ANALYSIS OF BENEFITS

4.1 Introduction

The project benefits are calculated on the basis of grid simulations with and without the project in question and/or market simulations with and without the impact on the transit limits associated with the project in question.

The analyses to calculate the benefits are generally conducted on single projects, by comparing the system's operation without and with each of the projects in the reference scenario in the year horizon under consideration; this reference scenario (base case) includes all the projects that are planned to become operational over the same time horizon.

The project in question is then removed from this scenario, and the difference between the base case and the case without the development project provides the benefits achieved by the project itself (TOOT approach: Take Out One at the Time).

The project is included in the *Ten Year Development Plan 2016*; for the sake of providing complete information, the relevant assessments appear below.

TyNDP 2016 – Project 31.642 Italy -Switzerland

General CBA Indicators	
Delta GTC contribution (2020) [MW]	IT-CH: 600
	CH-IT: [1000 ; 1100]
Delta GTC contribution (2030) [MW]	IT-CH: 750
	CH-IT: 750

and

Scenario specific CBA indicators	EP2020	Vision 1	Vision 2	Vision 3	Vision 4
B1 SoS (MWh/yr)	N/A	N/A	N/A	N/A	N/A
B2 SEW (MEuros/yr)	40 ±< 10	10 ±10	30 ±20	<10	10 ±10
B3 RES integration (GWh/yr)	<10	<10	<10	<10	30 ±20
B4 Losses (GWh/yr)	50 ±25	-25 ±25	-25 ±25	25 ±25	25 ±25
B4 Losses (Meuros/yr)	2 ±1	-2 ±2	-1 ±1	1 ±2	1 ±2
B5 CO2 Emissions (kT/year)	1000 ±70	300 ±100	400 ±300	±100	-300 ±100

For the purposes of this study, the development scenarios used are those in the Terna 2017 Development Plan, and are consistent with the scenarios under Vision 1 and Vision 3 of the ENTSO-E 2016 TYNDP - and see **2017 Development Plan -** ***Report on Progress of Previous Development Plans*** *(www.terna.it).*
It is also noted that, as reported in TYNDP 2016, the benefit associated with interconnection projects, depends on the sequence with which the respective promoters declared the date of entry into operation, greater benefits to the first projects. In other words, in the analysis, including the only under construction projects, the benefit of the interconnector Italy-Switzerland in terms of Socio-economic-welfare (SEW) would be:

Socio Economic Welfare – sensitivity analyses from TYNDP 2016

	Vision 1	Vision 2	Vision 3	Vision 4
SEW (M€/anno)	37	62	29	31

4.2 SIMULATION TOOLS

In the scope of the costs benefits analyses, the tools generally used for the simulations fall into two main categories:

- grid simulations;
- market simulations.

In the case of the first, the determining grid simulation tool was **SPIRA** ("Sistema di Pianificazione Reti di Alta tensione" - "Planning System for High Voltage Grids"): a tool for the planning of the electricity system, with the objective of:

- ✓ analysing AC/DC load flows;
- ✓ optimal dispatching of active and reactive power flows and generation with grid restrictions - OPF;
- ✓ assessment of flicker disturbances and propagation of voltage/current harmonics;
- ✓ assessment of Short circuit.

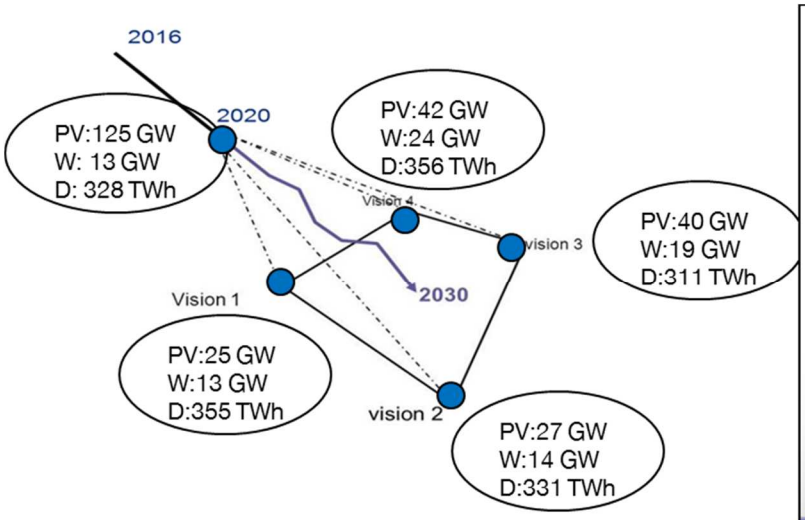
The tool for probabilistic grid simulations used was **GRARE**: an application analysing the reliability of electricity systems, integrated in the SPIRA software that adopts a probabilistic Monte Carlo methodology, by capturing thousands of possible System configurations (determined on a random basis), based on which it applies operational policies: Weekly Unit Commitment (UC), based on the units available and their specific average cost, on the need to retain rotating System and Area reserve margins, taking into account exchange limits between adjacent areas; carrying out an Optimal re-Dispatching and possible Load-Shedding to Resolve Overload problems.
The tool used for the market simulations was **PROMED**: a tool that is able to assess market trends for the assessment of the Social Economic Welfare (SEW) and relative components, identifying grid development requirements and investment priorities, by integrating market requirements with technical and environmental constraints.

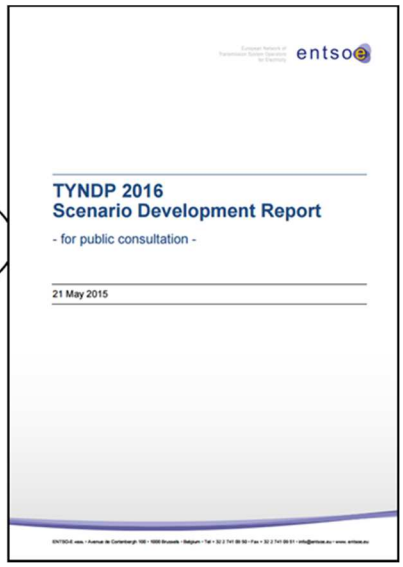
The tools used for the calculations below were the same as those recognised and adopted in the scope of ENTSO-E for the purposes of the assessments in the Mid Term Adequacy Forecast Reports and Ten Year Development Plan.

For the purpose of this study, the development scenarios used are in the Terna Development Plan 2017 and consistent with the ENTSO-E's TYNDP 2016 Vision1 and Vision 3 scenarios, see Italian Development Plan 2017 (www.terna.it), with the following updates on the National Electrical System:

- demand: on the basis of the national evolution trend, lower in the V1 scenario and significantly higher in V3; however, compliant with the "perimeter of ENTSO-E outlines" (V1: 351 TWh; V2: 331 TWh; V3: 311 TWh; V4: 356 TWh);
- conventional power plant: the scenario is aligned with the most recent forecast taking into account the progressive decommissioning from 2012 to 2016 of about 15 GW.

Therefore, the Italian Power System Vision 3 scenario is compliant with the ENTSO-E Vision 4, therefore the results, in terms of system benefits, could be compared.





4.3 Benefits estimate

4.3.1 Change (increase) in social economic welfare (SEW) - (B1)

The indicator measures the increase in social welfare resulting from the greater efficiency/convenience in electricity exchanges on the market related to the implementation of new transmission infrastructure.

Social welfare is assessed using the Total Surplus (TS) approach, where the objective function envisages maximising the system's welfare in markets based on the marginal price system. In these systems, if there are congestions, this equates to maximising the sum of the consumer surplus, the producer surplus and the congestion rents.

The following simplified assumptions are used in the assessment:

- perfectly competitive market (in particular, as a rule, trends resulting from the existence of possible market power are ignored);
- profitable plants, i.e. offering prices on the market that avoid economic losses and obtain revenue that is higher or equal to the variable generation costs.

The Total Surplus makes it possible to:

- identify changes in the welfare of each market area[1] represented in the model;
- identify the change in the benefit of the grid development project for consumers[2] and producers;

The benefit resulting from implementing the development project arises from the social welfare difference (and its producer surplus, consumer surplus and congestion rent components) with and without the project

[1]This aspect is of fundamental importance for interconnection projects with other countries, because the TS method makes it possible to calculate the benefit in terms of the surplus for Italy.
[2] i.e. the parties that are currently supporting the transmission infrastructure cost in Italy.

in question, in relation to the change in the exchange limits between the market area that are determined by the project itself.

The indicator is therefore applicable to the benefits assessment of only those interventions that increase the transit/exchange limits between the market areas, including those right on the borders.

The analysis directly provides for the indicator's economic valorisation (€M/year) and is monetised in the same ways referred to in the TYNDP 2016.

The benefits calculated in the 2025 and 2030 scenarios for Vision 1 and for Vision 3 are provided below.

Social Economic Welfare (B1) Vision 1 and Vision 3

	Social Economic Welfare EUROPE [€M]
Vision V1 2025 (1000 MW)	56.6
Vision V1 2030 (750 MW)	30
Vision V3 2025 (1000 MW)	24.9
Vision V3 2030 (750 MW)	16.8

4.3.2 Change (reduction) in expected energy not supplied - (B3)

With regard to the benefits assessment in terms of reducing the risk on energy not supplied (ENS) in relation to the implementation of new development projects, reference is made to the two approaches used.

Typically for portions of the extended grids, probabilistic type simulations are done analysing a number of probable situations.

In the N-1 analysis with probabilistic simulations, when a >100% overload occurs and no dispatch action is available, the simulator makes a linear reduction of the load to bring the overload component to 100%.

The linear reduction in the load determines the value of the Power not supplied (P_{NS}).

All the N-1s simulated in the N-1 analysis are separate events, and therefore accrue for the purposes of the ENS estimate.

The sum of the P_{NS} of each of the conditions considered, on the basis of the number of conditions checked, is adjusted in relation to an equivalent year.

For the purposes of this analysis, the electricity not supplied is also assessed in terms of the contribution to the adequacy that the interconnection line could provide to the Italian system.

The analysis provides the ENS (MWh/year), valorised according to the method in Annex A to Resolution No. 627/16 (Art 12.9).

Reduction in average expected Electricity not supplied (B3a)

Avoided energy not supplied	MWh	€M/[year]
	909	36,4

4.3.3 Greater integration of production from renewable energy sources (FER) calculated by network simulations (local congestion) - (B5)

Curtailments of renewable production are classified locally at times when renewable generation has to be reduced in order to avoid overloads due to congestion / limitations on the network, particularly sub-transmission.

Curtailments of renewable energy due to local security constraints, in other words the reduction of the risk of Over Generation (OG), can be quantified in the following two ways:

- by probabilistic simulations ($B5_A$);
- by deterministic simulations with static load-flow ($B5_B$).

The analysis provides the value in energy (MWh / year), valorised as foreseen by Resolution 627/16.

Avoided Over Generation (B5a)

OG – B5A	MWh	M€/[anno]
	695.09	41.7

4.3.4 Change (reduction) in negative external factors associated with the increase in CO_2 emissions, in addition to the impacts already monetised in the B1 benefit with the price of CO_2 to take into account the possible different value of emissions for the company - (B18)

This indicator measures the benefit resulting from the reduction in CO_2 emissions, which is associated with the following factors:

- impact of emissions on public health (e.g. respiratory, cardio-circulatory problems, hypertension, etc.);
- impact of emissions on the environment (e.g. calcareous deposits on buildings, dust, etc.);

not assessed in the scope of indicator B1.

The assessment of CO_2 emissions is based on:

- the change in the production mix, in favour of more efficient thermoelectric plants or plants supplied by renewable sources, consequent to the implementation of a development project aimed at reducing or resolving grid congestion either at inter-zone (increase in exchange limits between market zones) and intra-zone level (increase in transfer capacity on critical sections of the EHV or HV grid within a market zone);

- the reduction in grid losses, with corresponding lower electricity production from traditional sources.

To quantify the change in emissions associated with the change in the production mix, simulations are used that can analyse the dispatch of the generation with and without the relevant development project.

The impacts relating to development projects that increase the exchange limit between market zones is measured using market simulations that can calculate the variation in annual volumes (MWh/year) of electricity produced for each type of impact.

For impacts relating to intra-zone development projects, where the impact influences the volumes on the MSD market, the benefit will take into account the new dispatch of production plants and the new production mix.

The volumes of electricity due to the new production mix or to a reduction in losses are converted into the corresponding value of lower CO_2 emissions (tons/year), using emission coefficients that are specific to each generation technology.

The analysis provides the emission value (kton/year) and is monetised at the value [€/kton] valued in the ***Stockholm Environmental Institute, 2006*** equalling

Reduction in external negative aspects associated with CO2 (B18)

	CO2 avoided	
Vision	**[Mt/year]**	**M€**
V1_2025	**1.93**	**57.94**
V3_2025	**1.70**	**62.78**
V1_2030	**1.40**	**46.14**
V3_2030	**0.91**	**16.39**

4.3.5 Change (reduction) in negative impacts associated with the increase in other non CO_2or greenhouse gas emissions, such as sulphur oxide and nitrogen oxide (B19)

This indicator measures the benefit for the Italian system resulting from the reduction in pollutant emissions such as NO_x, SO_2, $PM_{2,5}$ and PM_{10}, which are associated with the following factors:

- impact of emissions on public health (e.g. respiratory, cardio-circulatory problems, hypertension, etc.);
- impact of emissions on the environment (e.g. calcareous deposits on buildings, dust, etc.);

not assessed in the scope of indicator B1.

The assessment of emissions is based on:

- the change in the production mix, in favour of more efficient thermoelectric plants or plants supplied by renewable sources, consequent to the implementation of a development project aimed at reducing or resolving grid congestion either at inter-zone (increase in exchange limits between market zones) and intra-zone level (increase in transfer capacity on critical sections of the VHV or HV grid within a market zone);
- the reduction in grid losses, with corresponding lower electricity production from traditional sources.

To quantify the change in emissions associated with the change in the production mix, simulations are used that can analyse the dispatch of the generation with and without the relevant development project.

The impacts relating to development projects that increase the exchange limit between market zones is measured using market simulations that can calculate the variation in annual volumes (MWh/year) of electricity produced for each type of impact.

For impacts relating to intra-zone development projects, where the impact influences the volumes on the MSD market, the benefit will take into account the new dispatch of production plants and the new production mix.

The volumes of electricity due to the new production mix or to a reduction in losses are converted into the corresponding value of lower emissions in the respective pollutants (tons/year), using emission coefficients that are specific to each generation technology.

The analysis provides the emission value (kton/year) and is monetised in accordance with the values in the ***Costs of air pollution from European industrial facilities 2008–2012, EEA***.

Reduction in negative external factors other than Co2 (B19)– 2025 scenario and 2030 scenario

		NOx		SO2 avoided		CO avoided		PM10		of which PM2.5	
Vision	**€M negative external factors**	**[Mt/year]**	**M€**	**[Mt/year]**	**M€**	**[Mt/year]**	**M€**	**[Mt/year]**	**M€**	**[Mt/year]**	**M€**
V1_2025	17.64	0.89	13.71	0.12	3.53	0.24	0.00	0.004	0.06	0.00	0.33
V3_2025	15.45	0.79	12.24	0.11	3.21	0.19	0.00	0.000	0.00	0.00	0.00
V1_2030	11.18	0.63	9.65	0.05	1.40	0.17	0.00	0.001	0.02	0.00	0.11
V3_2030	6.58	0.41	6.35	0.01	0.23	-	-	-	-	-	-

4.3.6 Increased interconnection or transport capacity between network sections, in terms of MW (I21)

The increasing interconnection capacity (in both directions) is performed by static load flow analysis, until reaching the N-1 safety margin. As a result of network studies carried out with neighbouring TSOs, the increasing of transmission capacity is:

Increasing	Svizzera -> Italia	Italia -> Svizzera
Scenario 2020	**1000**	**1000**
Scenario 2030	**750**	**750**

It is good to state that in the absence of the Interconnector Italia - Switzerland link (ENTSO-E, TYNDP 2016 Investment 31.642) the minimum interconnection capacity target of 10% would be largely unsuccessful in the 2030 horizon in V3 and V4 scenarios.

Below are the interconnection capacity targets [GW] in the ENTSO-E TYNDP 2016 scenarios.

.2030 V1	2030 V2	2030 V3	2030 V4
13	**12**	**15**	**16**