Undersea cable between Italy and Montenegro

Project and forthcoming market and power flow consequences

Lucerne – 4th July 2019

Agenda

- Project overview
- Technical characteristics of the link
- Operation principles
- Evolution drivers
- Regulatory framework
- Project benefits (the European perspective)

Project overview

- **High Voltage Direct Current (HVDC) link** between Italy (Villanova) and Montenegro (Lastva)
- **Converter stations** (Cepagatti in Italy and Kotor in Montenegro) realized with LCC technology
- Cable link between the two converter stations: part marine and part terrestrial - 500 kV insulated. Total length **~ 445 km (~ 423 km in submarine cable)** – maximum depth 1200 m
- Transmission capacity: **600 MW in 2019** (1st pole + marine electrode return)
- Project designed for additional 600 MW bipolar configuration

- The direct current transmission system, which will enter into operation in 2019 and operate in monopolar configuration with marine electrode return, can transmit a power of 600 MW in both directions (both from Montenegro to Italy and vice versa)
- The realization of the 2nd phase **1200 MW bipolar configuration** requires the realization of a second HVDC pole cable, which (according to the planning foreseen in the National Development Plan) is subject to the completion of the complementary infrastructures (trans-Balkan corridor) and development of the regional electricity market in the Balkans
- The whole HVDC link is built, owned and operated by Terna, while CGES (the Montenegrin TSO) realizes the AC station of Lastva 400kV and related connection to the 400 kV grid
- The **total investment cost is about 1.2 Bln€** (for the whole 12000 MW bipolar configuration)
- Project included in the **TYNDP of ENTSOE and in the PCI list** (Project of Common Interests - EU Reg. 347/2013)

Project overview

Network Developments (source: TYNDP of ENTSOE)

Main Benefits:

- increasing the security of supply
- increasing the amount of RES integrated
- reducing electricity price spreads between the connected market areas

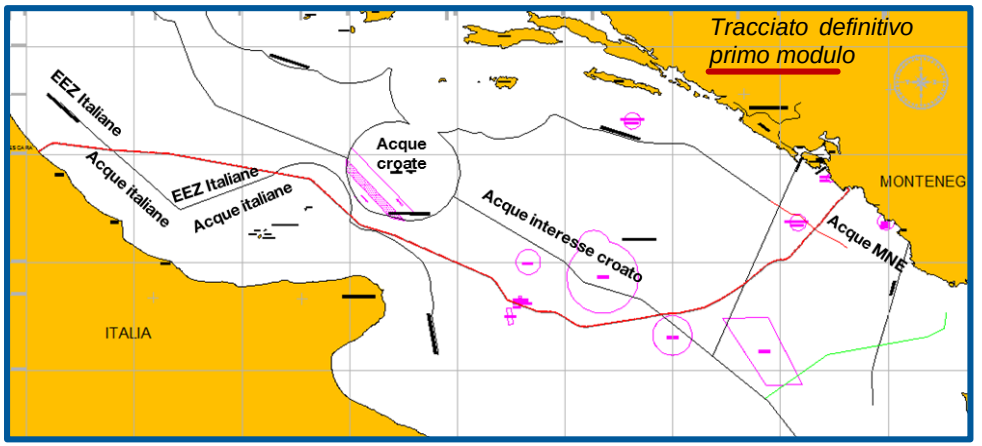
(1) Commissioning date according to CGES updated plan is 2021

(2) Subject to realization of the Trans-Balkan corridor and implementation of the Market Coupling of Montenegrin system with the Balkans.
More in detail, the condition established in the Project Coordination Agreement signed by Terna, CGES and the Montenegrin Government is that:
the commissioning of the HVDC interconnection 2nd pole will occur not later than 5 years after the (i) execution of a binding agreement for the realization of the new interconnection between Montenegro and Serbia and (ii) market coupling of Montenegrin and at least one neighboring electricity market

Project overview

Project Implementation Framework – key elements

2010	▪ February → Intergovernmental Agreement between Italy and Montenegro for the implementation of the project by Terna and CGES ▪ November → Terna became a shareholder of CGES (~ 22%)
2011	▪ January → Terna and CGES entered into a Project Implementation Agreement (PCA) for the joint development of the link ▪ July → authorizations achieved both in Italy and Montenegro ▪ Terna established Terna Crna Gora to realize the project in the Montenegrin territory
2012 - 2019	▪ Procurement and construction
2019	▪ Within December → entry into operation



National competence	Marine (km)	Terrestrial (km)
ITA	77	16
EEZ ITA	236	
Water of Croatian interest	42	
EEZ MNE	43	
MNE	25	6
Totale (km)	**423**	**22**

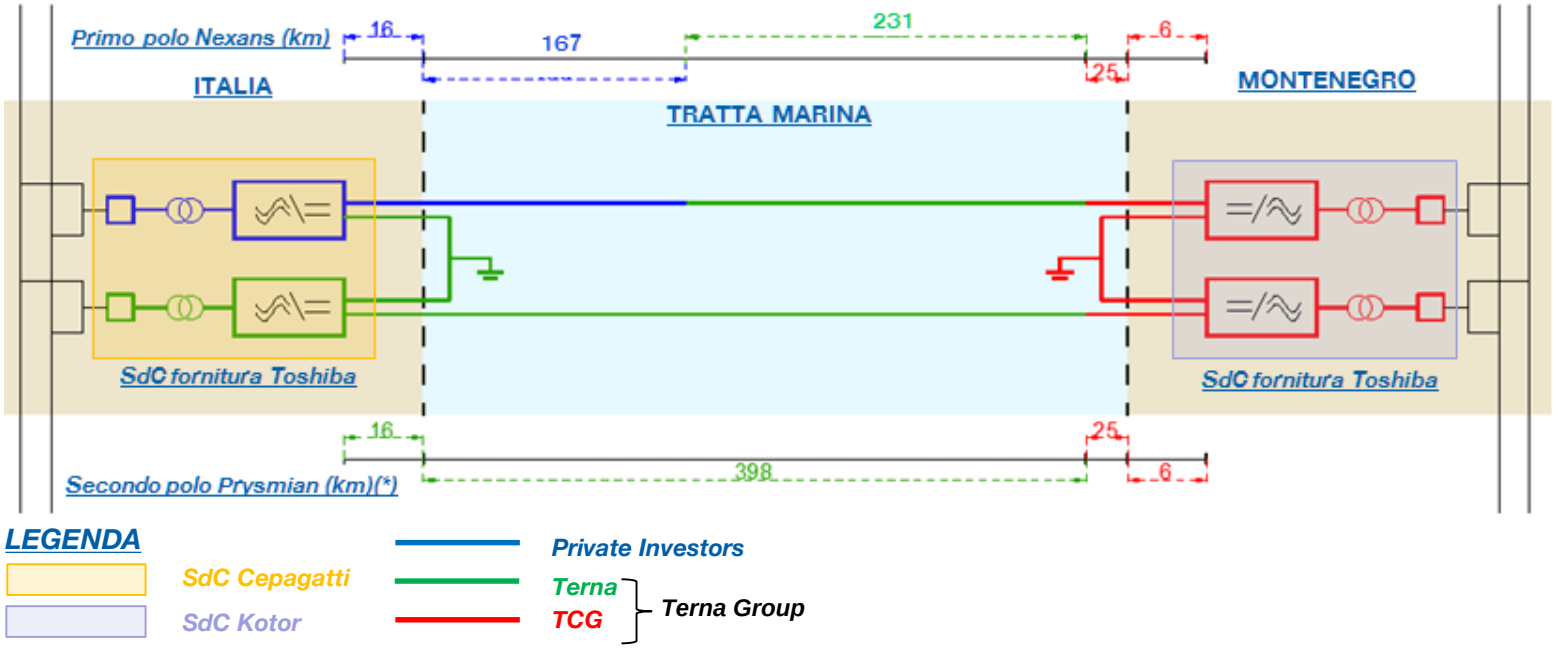
Project overview

Project Implementation Framework – Sharing of assets and capacity

Regarding the implementation of the 600 MW configuration in 2019:

- 200 MW will be available to the Montenegrin side (CGES), while 400 MW to the Italian one
- Moreover, the project is receiving a Third Party Access (TPA) exemption for 200 MW under the Italian law (L.99/09). Due to the TPA exemption, part of the project will be financed by private investors

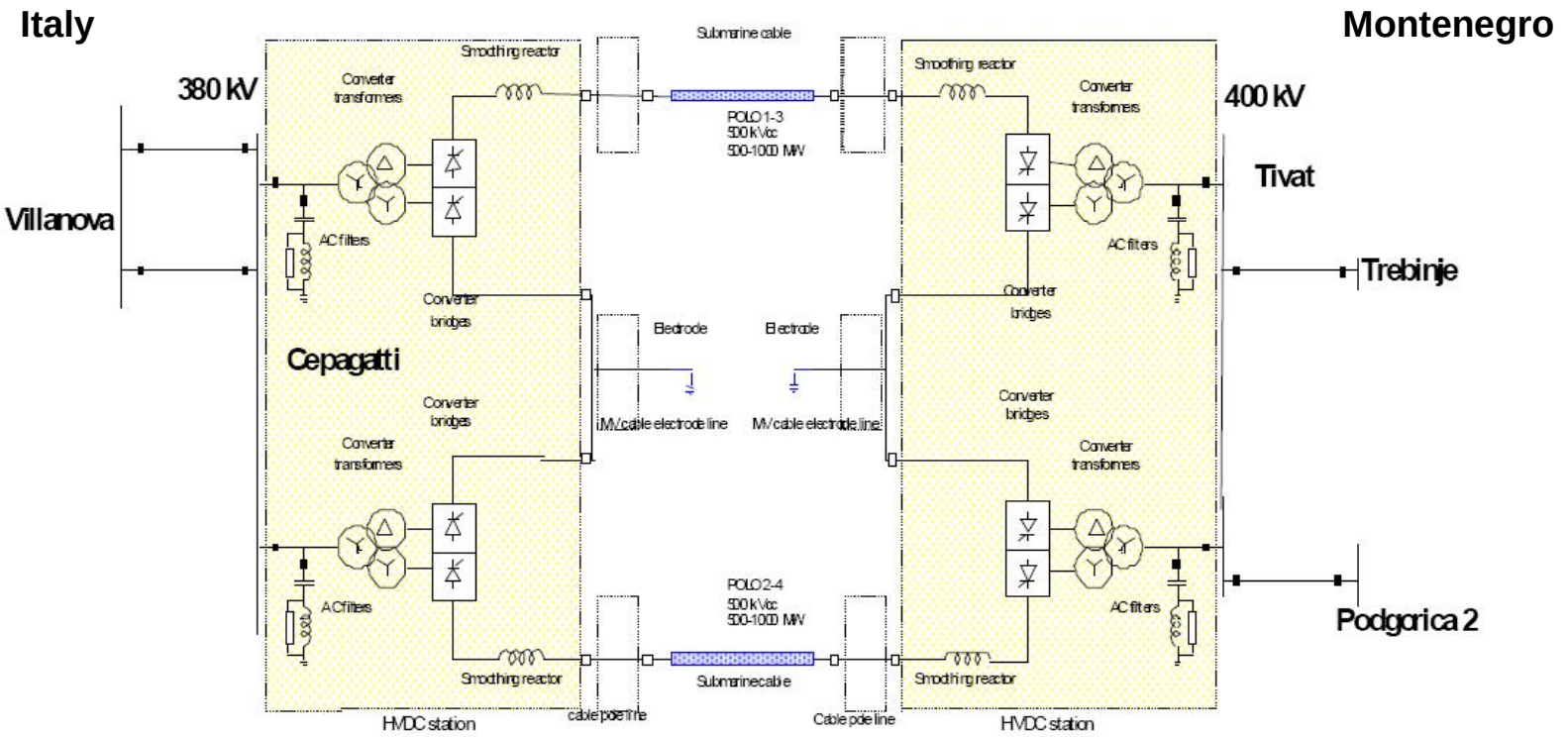
TERNA	PRIVATE INV.	CGES	TOTAL
200 MW	200 MW	200 MW	600 MW



Technical Characteristics of the Link

Main technical information

- **Technology**: HVDC ±500 kV line commutated converter (LCC)
- **Configuration**: Monopolar, ready for future bipolar configuration
- **Maximum power**: 600 MW * (energy flow bidirectional)
- **Overall length**: 445 km (out of which 423 km under the sea)



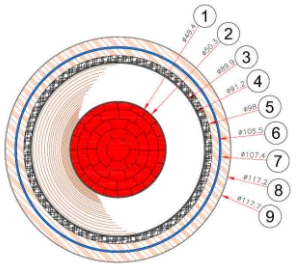
* The realization of the 1200 MW HVDC link will follow the planning foreseen in the National Development Plan

Technical Characteristics of the Link

Focus on the HVDC cable

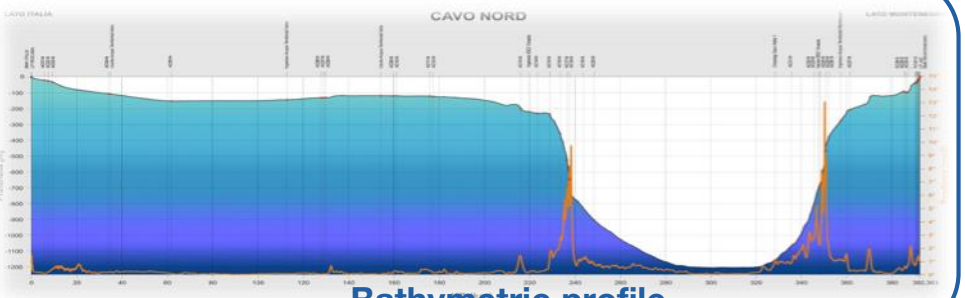
TOTAL LENGHT	approx. 445 km
ONSHORE (IT)	16 km
ONSHORE (ME)	6 km
OFFSHORE	423 km
NOMINAL POWER P_{DC}	600 MW
DC VOLTAGE	± 500 kV
AC VOLTAGE	400 kV (both sides)
STANDARD RAMP RATE	220 MW/min
CONFIGURATION	1 pole with marine electrodes
CONVERSION TECHNOLOGY	LCC
POWER FLOW	Bidirectional
CABLE TYPE	MI (Mass Impregnated)

LAND CABLE (Cu 1x1900 mm²) Ø ~12 cm



No.	Constituents
1	Conductor , round centre wire and concentric layers of "key-stone"
2	Conductor screen, carbon black paper
3	Insulation, water washed wood pulp HVDC cable paper impregnated compund
4	Insulation screen, carbon black paper and metallized paper
5	Lead sheath, alloy
6	Inner sheath, polyethylene
7	Transversal reinforcement
8	Longitudinal reinforcement
9	Outer sheath, polyethylene

HVDC SUBMARIN CABLE (Al 1900 mm²) Ø ~14 cm

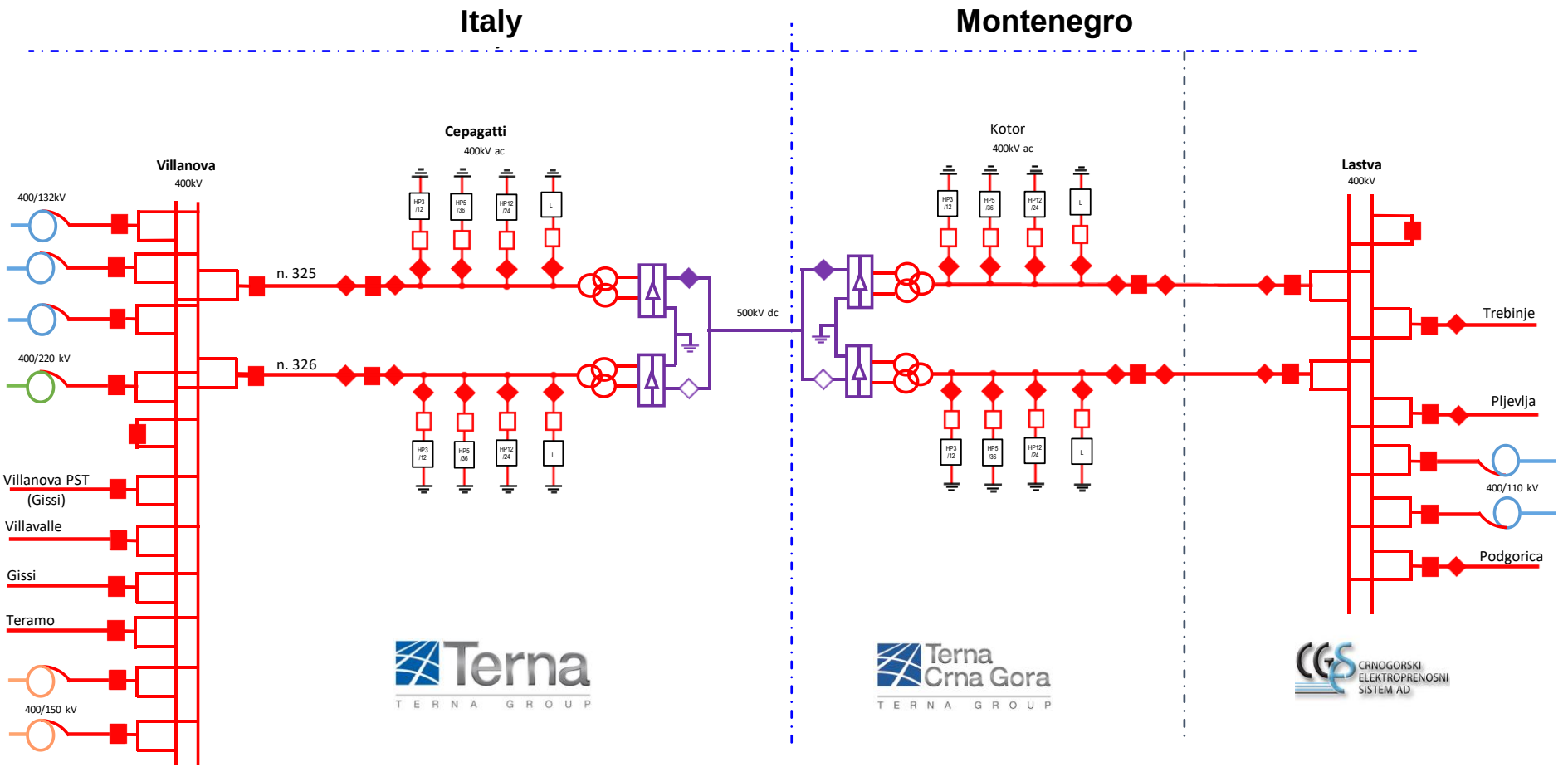


Bathymetric profile

Technical Characteristics of the Link

Single-line scheme

- Terna is the owner of the whole HVDC link
  - The Montenegrin part is owned by Terna Crna Gora (100% Terna)
- CGES owns the 400kV AC station in Lastva and related grid In Montenegro



Operation principles

Operation

The operation of the HVDC MONITA will be performed by **Terna** in cooperation with CGES (Operation Agreement was signed in May 2019)

Inter-TSO coordination

Standard procedures for operators and close coordination between Terna and CGES:

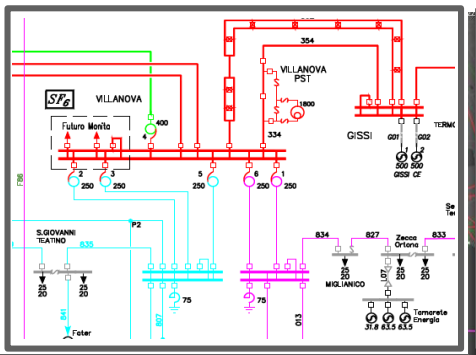
- Standardization of maneuvers to start up/ shut down the link and change the active power settings from the dispatching center
- Procedures to take **remedial actions** in case of real time events both from AC network side and HVDC system side
- **Emergency assistance** service to support both TSOs in case of critical situations (in line with Emergency Restoration Network Code)

Active power

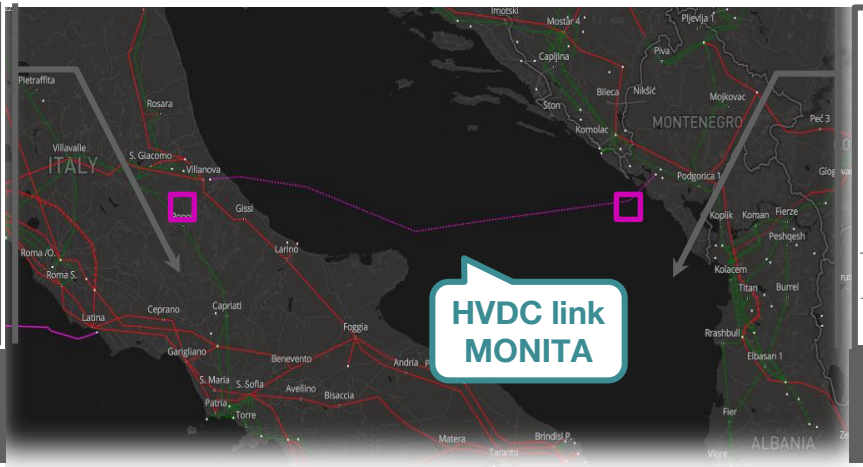
The link will enable **up to 600 MW power flow**. Active power and the set points of the HVDC converters will be automatically regulated in order to respect forecasted power exchanges and compensate any frequency variations

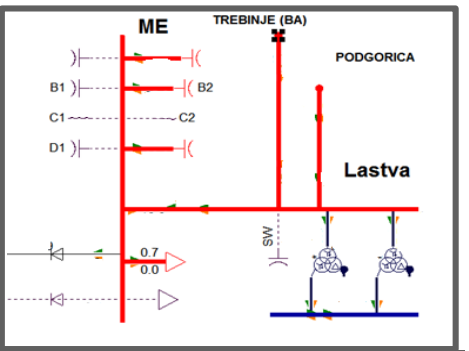
Reactive power

Reactive power will be limited in a completely **automatic** way to a maximum rated output of 50 MVAr (HVDC filters will be used also to this purpose)



Italy connection:
400 kV substation Villanova (existing)

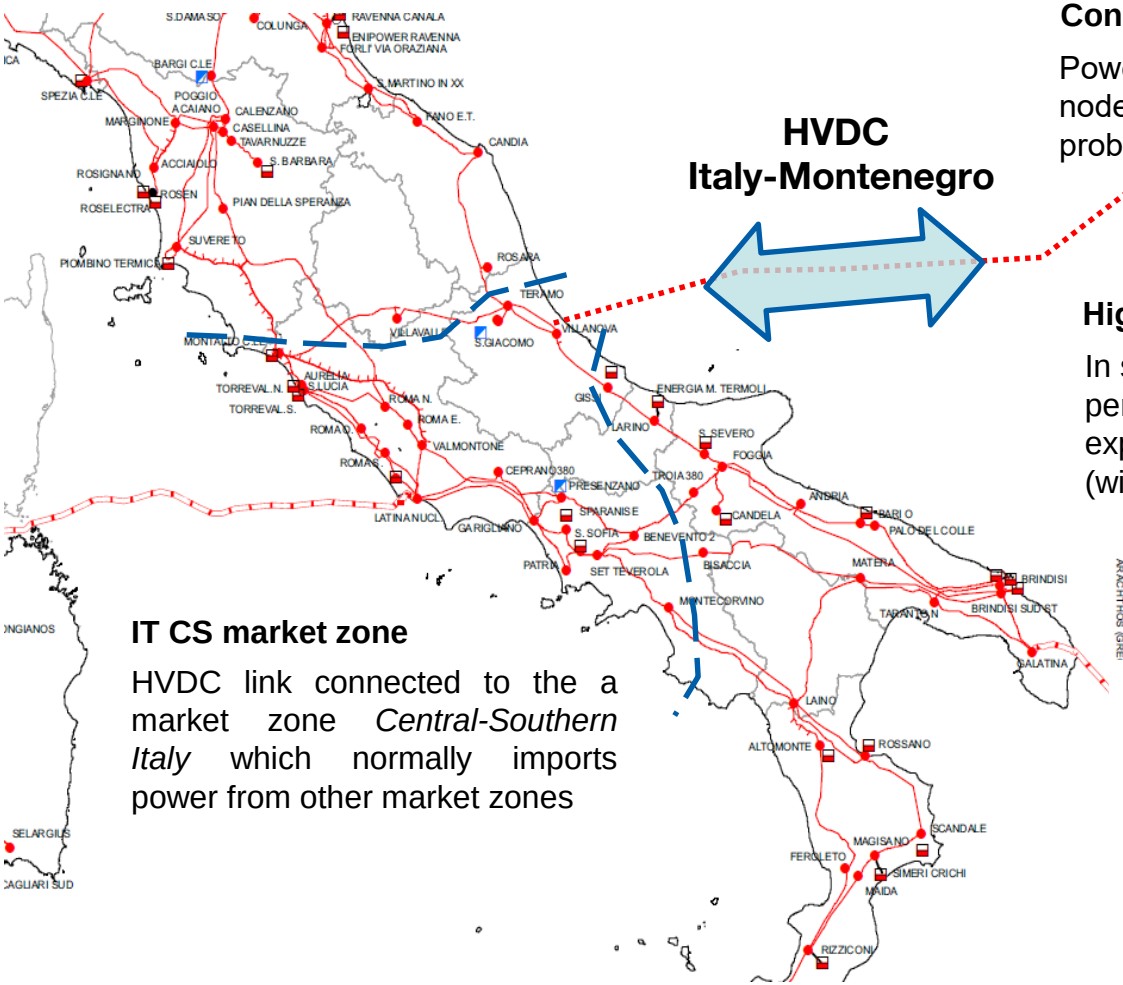




Montenegro connection: 400 kV substation Lastva (new)

Operation principles

Power flows - Italian power system/market perspective



Connection node 380 kV Villanova

Power exchanged at 380 kV Villanova node does not entail any congestion problem on the transmission system

Higher flexibility for RES

In specific conditions (low consumption periods) the Italian power system needs to export overgeneration produced by RES (wind - especially in South Italy - and solar)

IT CS market zone

HVDC link connected to the a market zone *Central-Southern Italy* which normally imports power from other market zones

Increased operational security

- The link will make available additional frequency regulation services and will be integrated in the system defence strategy
- The node of Villanova is particularly strategic for black start service through the HVDC link

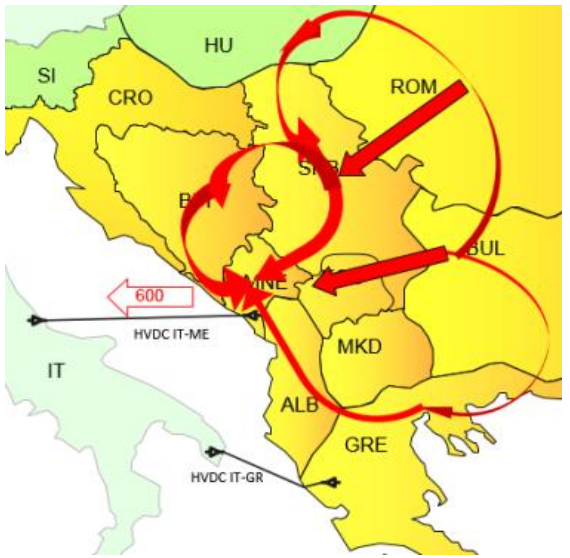
Operation principles

Power flows – SEE power system perspective (short and mid-term horizon)

- No significant changes of the flows in the SEE region induced by 600 MW HVDC flow
- Changes of the flows expected on the tie-lines between Montenegro and neighboring systems do not lead to security problems (overloaded lines or critical variations on the 400 and 220 kV lines) in N and N-1 conditions

POWER FLOW DISTRIBUTION IN THE REGION (600 MW ON HVDC)

BG/RO-IT FLOW PATH

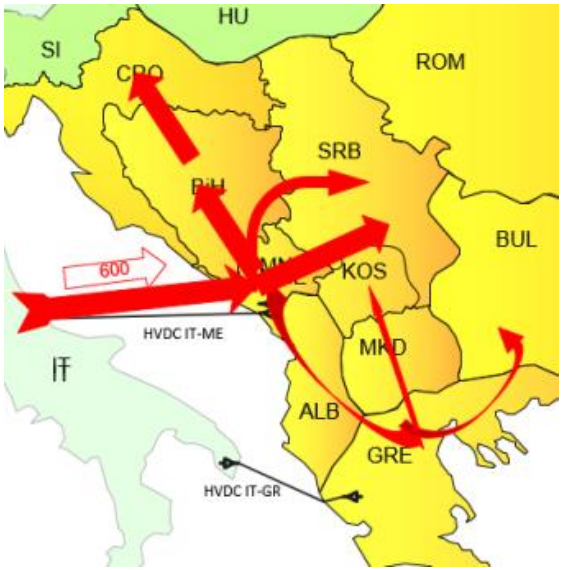


Most of the energy coming from RO and BG is transferred through BA & RS, a small part comes from the other systems

BA/RS-IT FLOW PATH

Energy is directly transferred from BA & RS (regardless the regime). A small part comes from the other systems

IT-SEE FLOW PATH

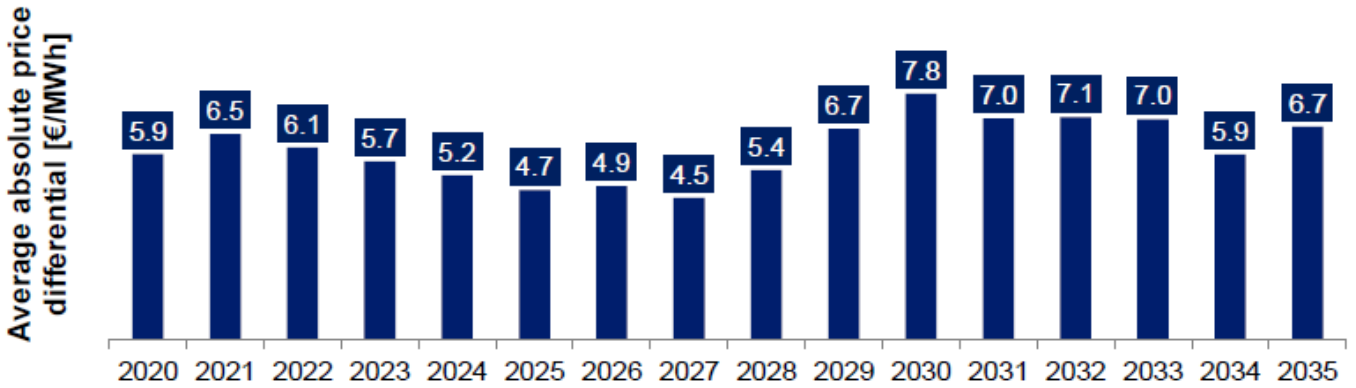


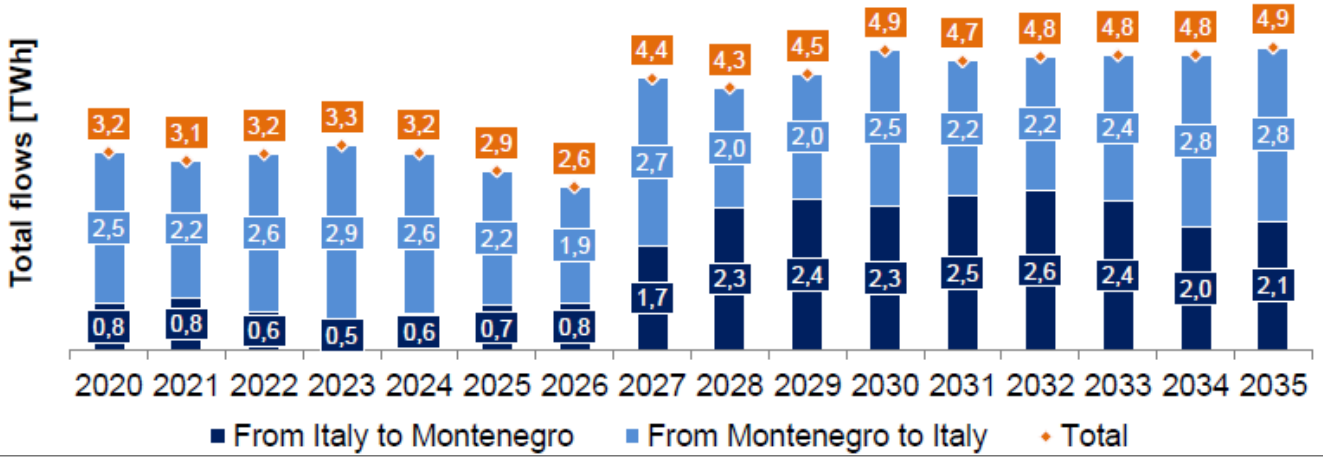
The energy from IT is uniformly spread all over the SEE network

Evolution Drivers

Market's evolution (Italy – Montenegro price differentials) *

- Montenegrin and Italian yearly average prices are projected to converge and to remain aligned in the short/mid-term
- Afterwards, due to a progressive **change of generation mix in the Balkans** (increase of thermal generation from gas and renewables against decommissioning of lignite and coal generation), together with **increasing CO2 obligations for Balkan countries**, Montenegrin price is expected to grow faster, creating a positive average price differential.
- However, structural differences between the markets will ensure the **average hourly absolute price differentials will remain significant all over the next 10 years**



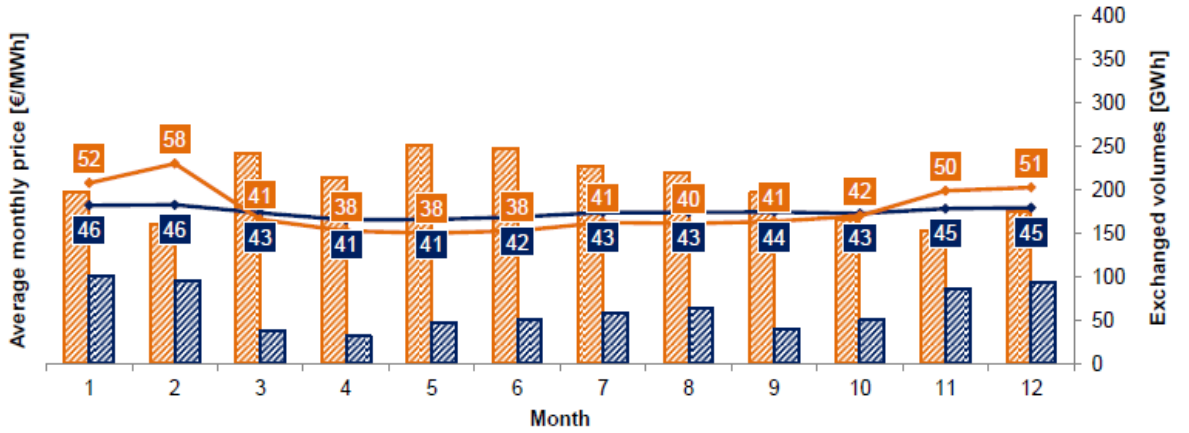


** Source: POYRY Q1 2018 price projections*

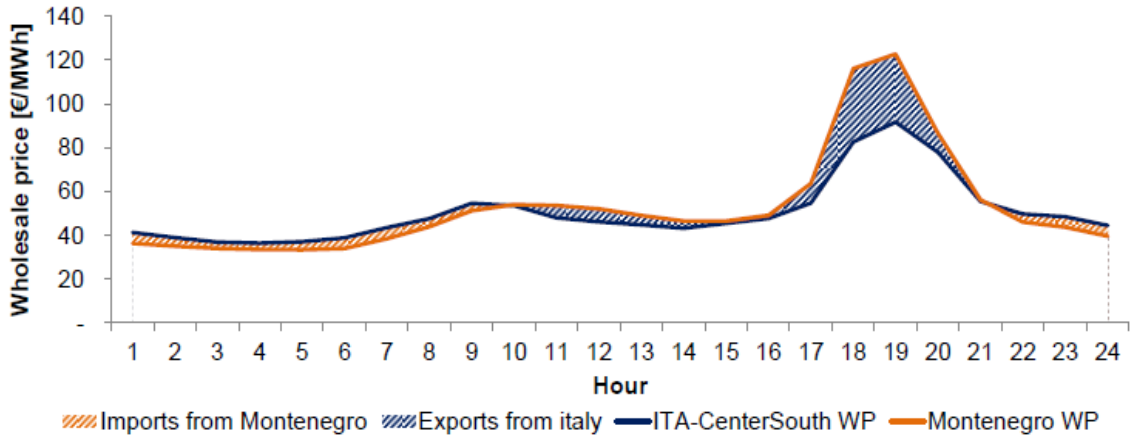
Evolution Drivers

Seasonality and intra-day effects (Italy – Montenegro price differentials) *

Flows seasonality and Wholesale Price – 2022



Intra day price profile – January 2022



- Seasonality and intra-day effects are responsible of the positive hourly absolute price differentials
- Montenegro prices are higher in winter months, due to the monthly demand profile
- In addition, even hourly peak is much more pronounced in Montenegro compared to Italy market zone
- As a consequence, although Italy is a net importer in 2020-2027, the price differential when it exports in winter/evening hours is very high

** Source: POYRY Q1 2018 price projections*

Regulatory framework

April 27th, 2016

- Ministries, NRAs, TSOs and PEXs of the WB 6 countries (Albania, Bosnia and Herzegovina, Kosovo, the former Yugoslav Republic of Macedonia, Montenegro and Serbia) sign the **Western Balkan 6 Memorandum of Understanding** (WB6 MoU)
- The **WB6 MoU** pursues the **integration of the WB6 markets** with the markets of the EU Member States that join the EU Day-Ahead Coupling project

Sept. 5th, 2016

- **Italian NRA also adheres to WB6 MoU** as a first step towards the launch of a market coupling project with the WB6 countries, made technically possible by the forthcoming operation of the submarine cable between Italy and Montenegro
- The WB6 MoU implies the **go-live of the Italy-Montenegro Interconnection** as a precondition for connecting the Western Balkans to the European Internal Energy Market

April 6th, 2017

- **Terna signs the Addendum to the WB6 MoU,** thus expressing its willingness to participate in the **Regional Electricity Market Development** and agreeing on the need for close cooperation of the Energy Community and EU Stakeholders in the implementation of day-ahead market coupling.

WB6 MoU sets strategic objectives to analyse, design and implement day-ahead market integration between WB6 countries and EU member states, through the selection of the appropriate national day-ahead markets design

Regulatory framework

May 5th, 2017

- The **Italian NRA** sets up a ***sub-regional working group*** **composed of TSOs and PXs of Albania, Italy, Montenegro and Serbia** (the so-called **AIMS WG**) and **assigns the group the following tasks** :
  - To elaborate a proposal for a multilateral cooperation agreement;
  - To elaborate a high level design of the market coupling project;
  - To elaborate a proposal for agreements on the management of market coupling processes

Jan 2018

- Italian NRA sets up the **Knowledge Exchange Programme**, aimed at transferring know-how on market coupling initiatives between EU Member States to the NRAs of Albania, Montenegro and Serbia.
- **Terna actively participates** in providing information drawn from the most recent EU experiences on day-ahead market coupling

MAIN ADVANTAGES

- After the commissioning, the **capacity of the link will be used through *explicit auctions***
- However, the **subsequent coupling with the day ahead markets of the rest of Europe** through the interconnection with Italy, fosters the following advantages:
  - A **more efficient allocation of capacity through *implicit auctions*,** as per target model of the EU regulations
  - **Integration and synchronisation with the wider and more liquid EU Internal Energy Market**.
- Therefore, **Montenegro will be able to implement day-ahead market coupling** with the rest of Europe through the interconnection with Italy, **upon achievement of all the prerequisites**, i.e.:
  - Completion of its **market development**, including the entry into operation of the power exchange
  - Implementation of all the **operational procedures** foreseen by the EU coupling
  - Signature of the relevant **contractual framework** foreseen by the EU coupling

The European perspective

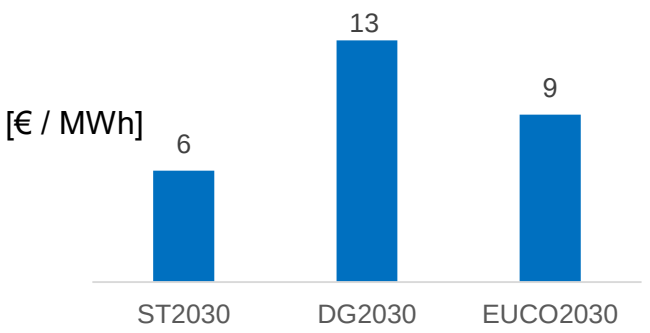
EU Infrastructure needs fulfilled by the project (2030 scenarios)

TYNDP2018

- enabling market integration and reduction of price differentials
- addressing SoS (flexibility and system adequacy) deficiencies
- improving system stability
- cross border impact on existing and future interconnections all along the Trans-Balkan corridor, between Italy and Continental East
- mitigating RES curtailment and improving accommodation of flows

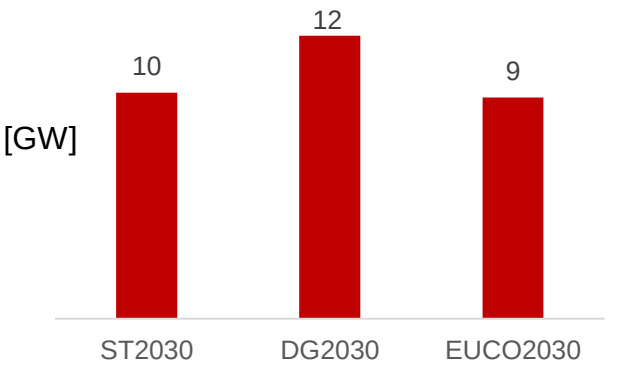
Market Integration

Average price spread without any project ranges from **6** to **13** [€/MWh]



Security of Supply – Flexibility

Max hourly ramp of residual load (load after subtracting the variable RES production)

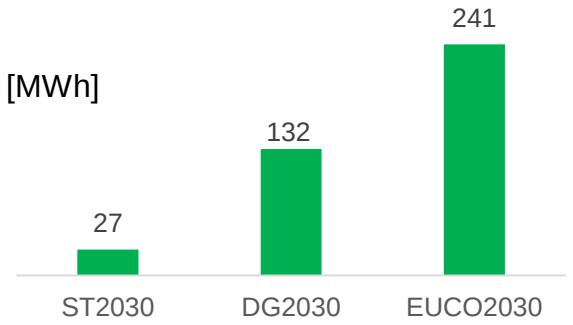


Project's benefits

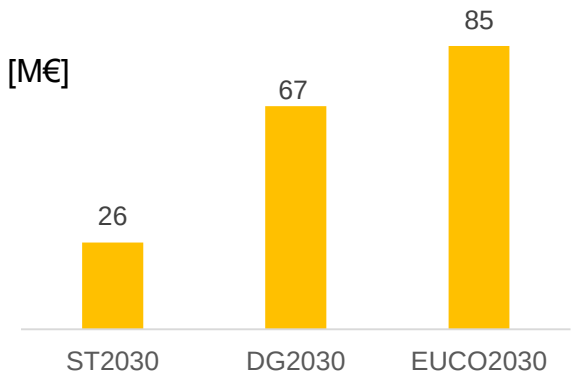
Main technical and economic benefits (2030 scenarios)

TYNDP2018

RES integration



Socio-economic welfare



- **Promoting the exchange of renewable energy**

  The HVDC link MONITA has been designed to support the most efficient use of generation capacity located in SEE countries, to facilitate opportunities for new generation investments in the Balkan region and the exploitation of RES potential both in SEE region and in Italy

- **Creating a stronger interconnected European electricity grid**

  A power link between Italy and Montenegro will help to achieve the EU's goal of creating a stronger and more interconnected European electricity grid, minimizing price differentials between Countries, ensuring that electricity demand, including through imports, can be met in all conditions, and enabling export potential of excess renewable production

- **Enhancing the operation security in Italy and in the Balkan area**

  In particular, the investment is needed to remove infrastructure bottlenecks, improve security of supply, competition and to integrate the growing share of renewables

- **Providing ancillary services to the grid**

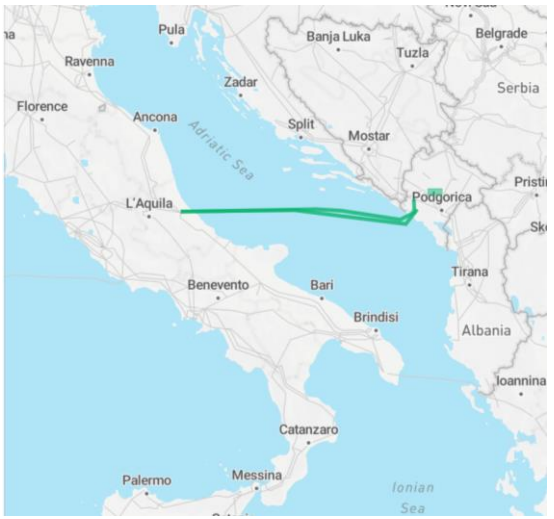
  Including cross-border holding of reserve (primary, secondary and tertiary reserve), contribution to net balancing, black start service

Project's benefits

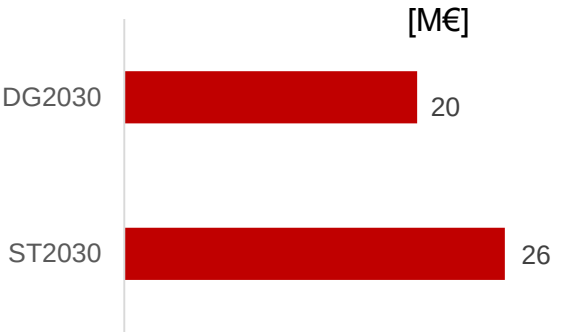
Ancillary Services (2030 scenarios)

TYNDP2018

- The HVDC link, not only increases the transmission capacity between the Italian peninsula and South Eastern Europe, but also allows for sharing of cross-border ancillary services between market zones
- This will reduce the cost of ancillary services which are necessary both to reduce the congestions and to guarantee enough adequacy margins and operational security
- The "reduction of ancillary services cost", is mainly due to capacity reservation costs (i.e. cost for reservation / contracting of the reserves, which means these volumes are blocked for usage in other markets)



Reductions of costs for ancillary services

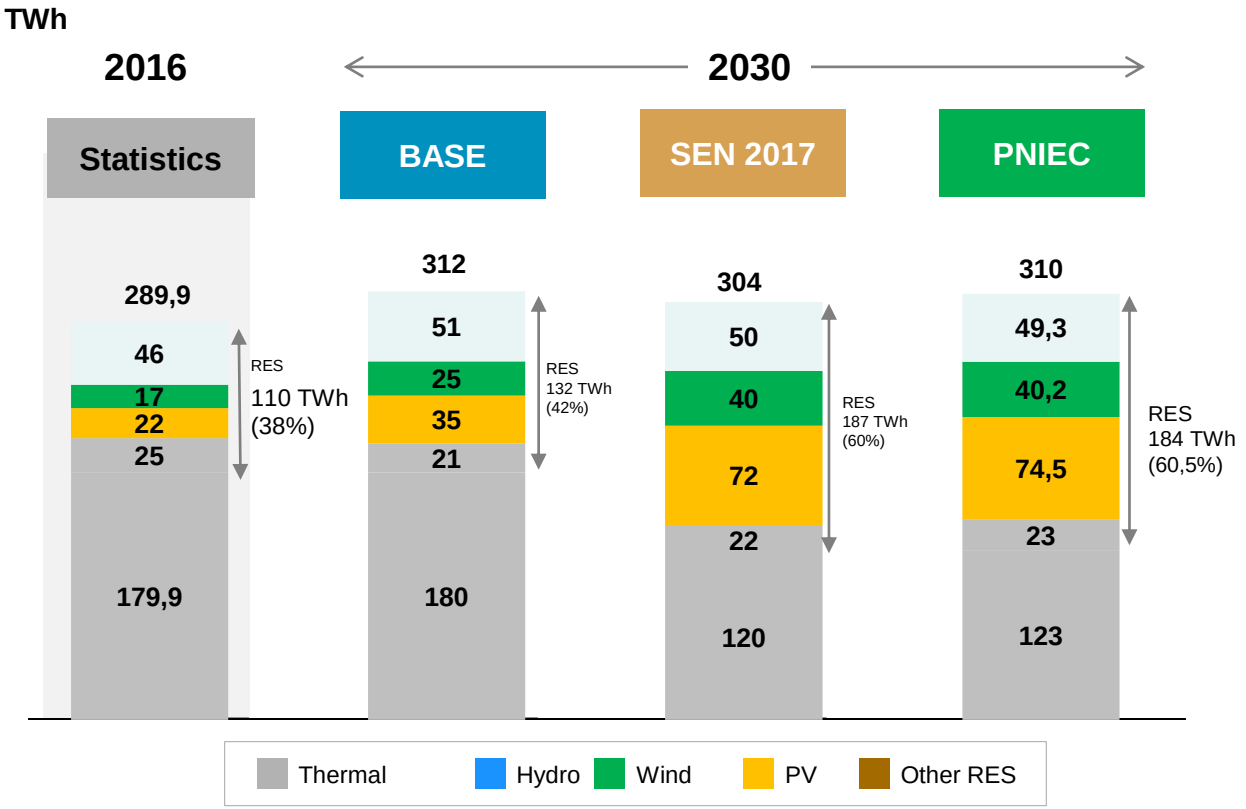


The **CBA** reported in the TYNDP2018 of ENTSO-E highlights that the project **returns positive results in all dimensions**

BACK UP

Evolution Drivers

Forecasted evolution of electricity generation in Italy (NDP - 2030 scenarios*)

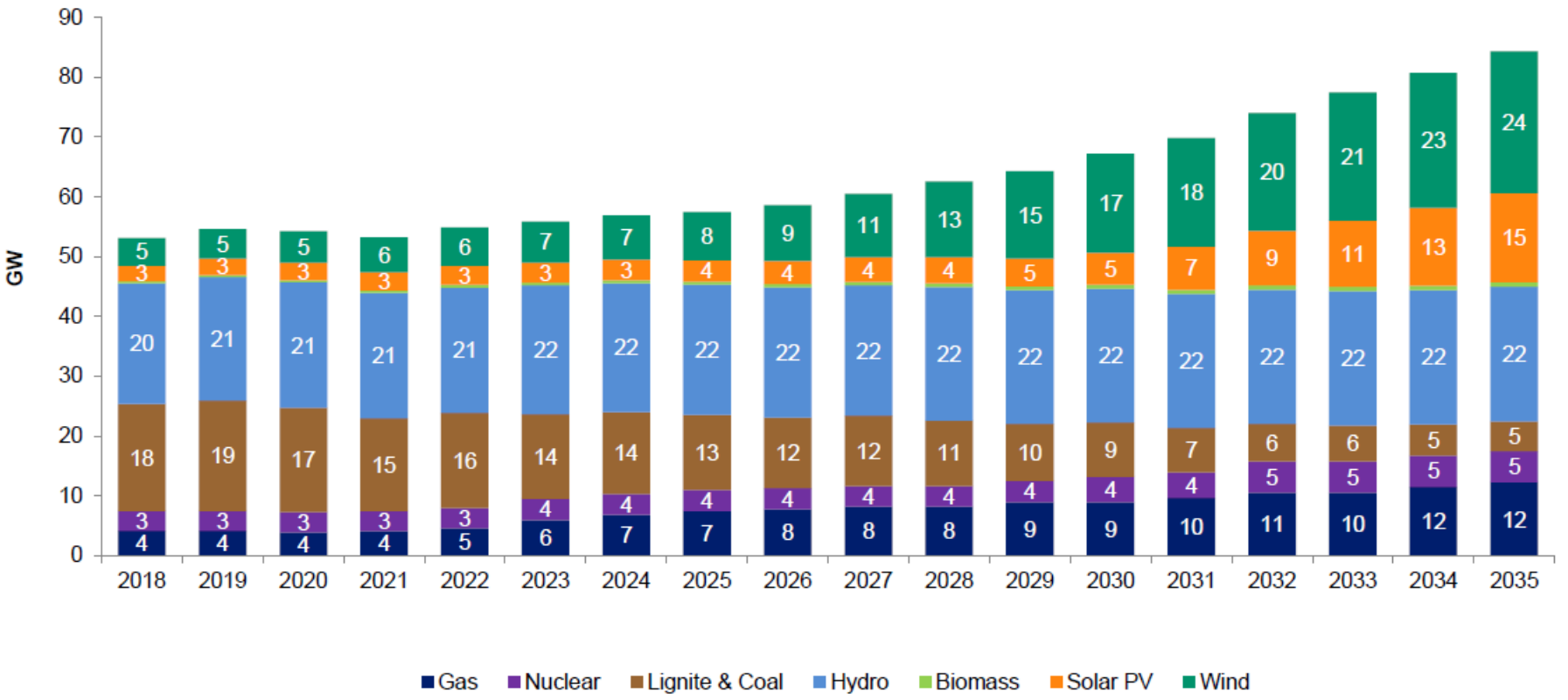


- **RES generation will be central** (over 180 TWh in Policy-Driven Scenarios) with an increase over 67% compared to 2016
- Main contribution to RES increase comes from **wind and solar generation**
- In all scenarios a continuous **reduction of thermal generation** is foreseen (~ -30% in Policy-Driven Scenarios compared to 2016)

** Source: NDP 2019 (Terna statistics; Terna elaboration based on data provided by EU, ENTSOE, ENTSOE-G, SEN2017 and PNIEC)*

Evolution Drivers

Forecasted evolution of the installed capacity – SEE Countries *

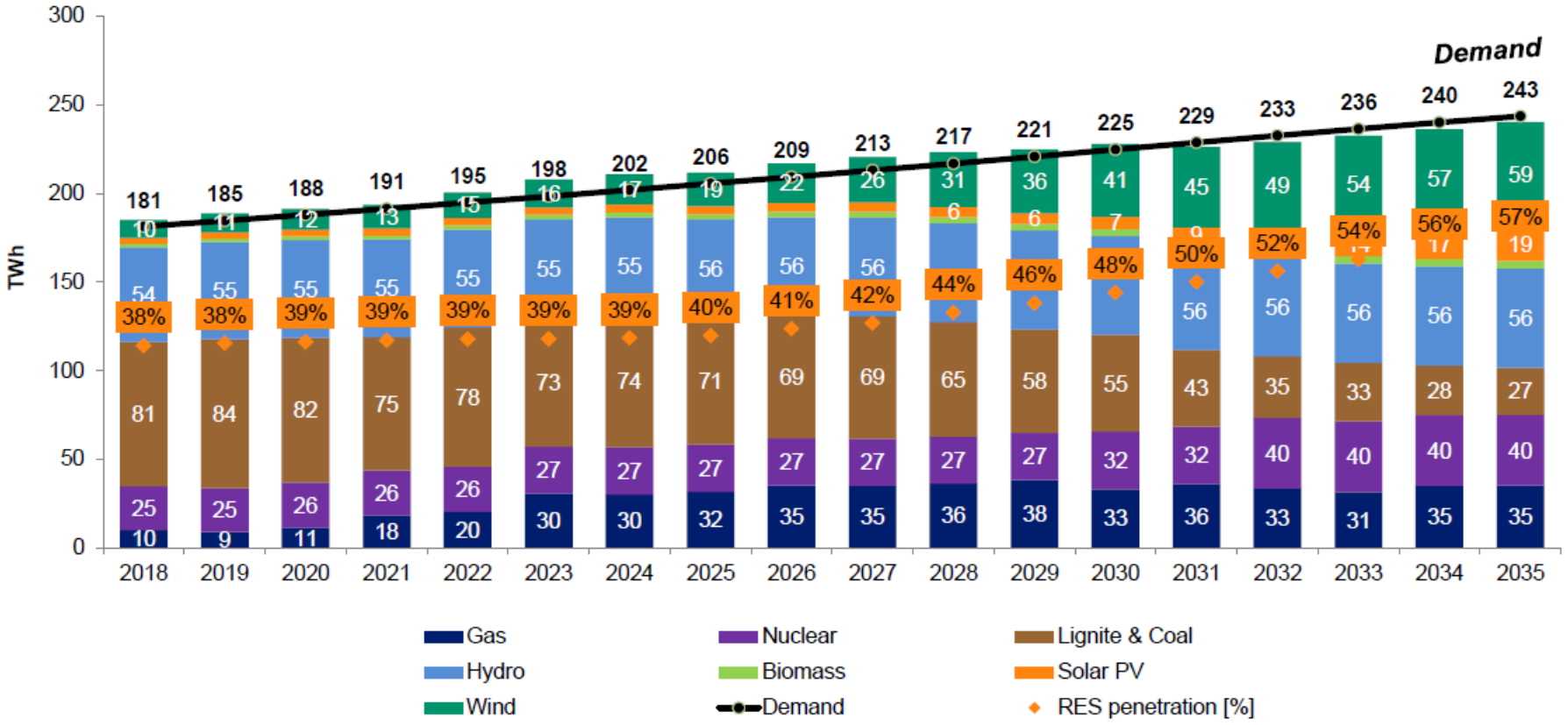


* SEE countries included are:

* Source: POYRY Q1 2018 price projections

Evolution Drivers

Demand & Generation (TWh) – SEE Countries *



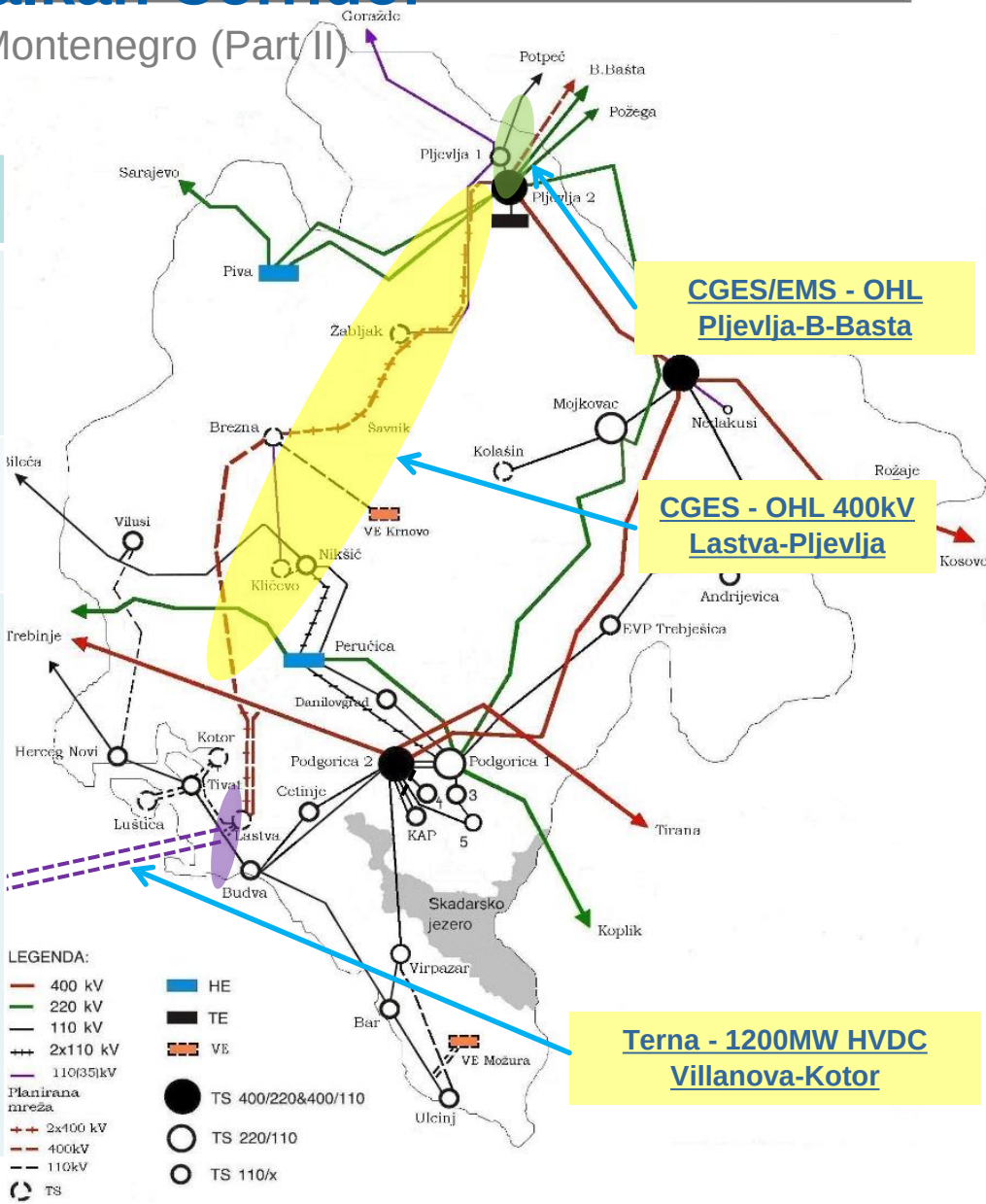
* *SEE countries included are:* *Albania* *Bosnia* *Bulgaria* *Croatia* *Macedonia* *Montenegro* *Romania* *Serbia*

* *Source: POYRY Q1 2018 price projections*

Overview on Trans-Balkan Corridor

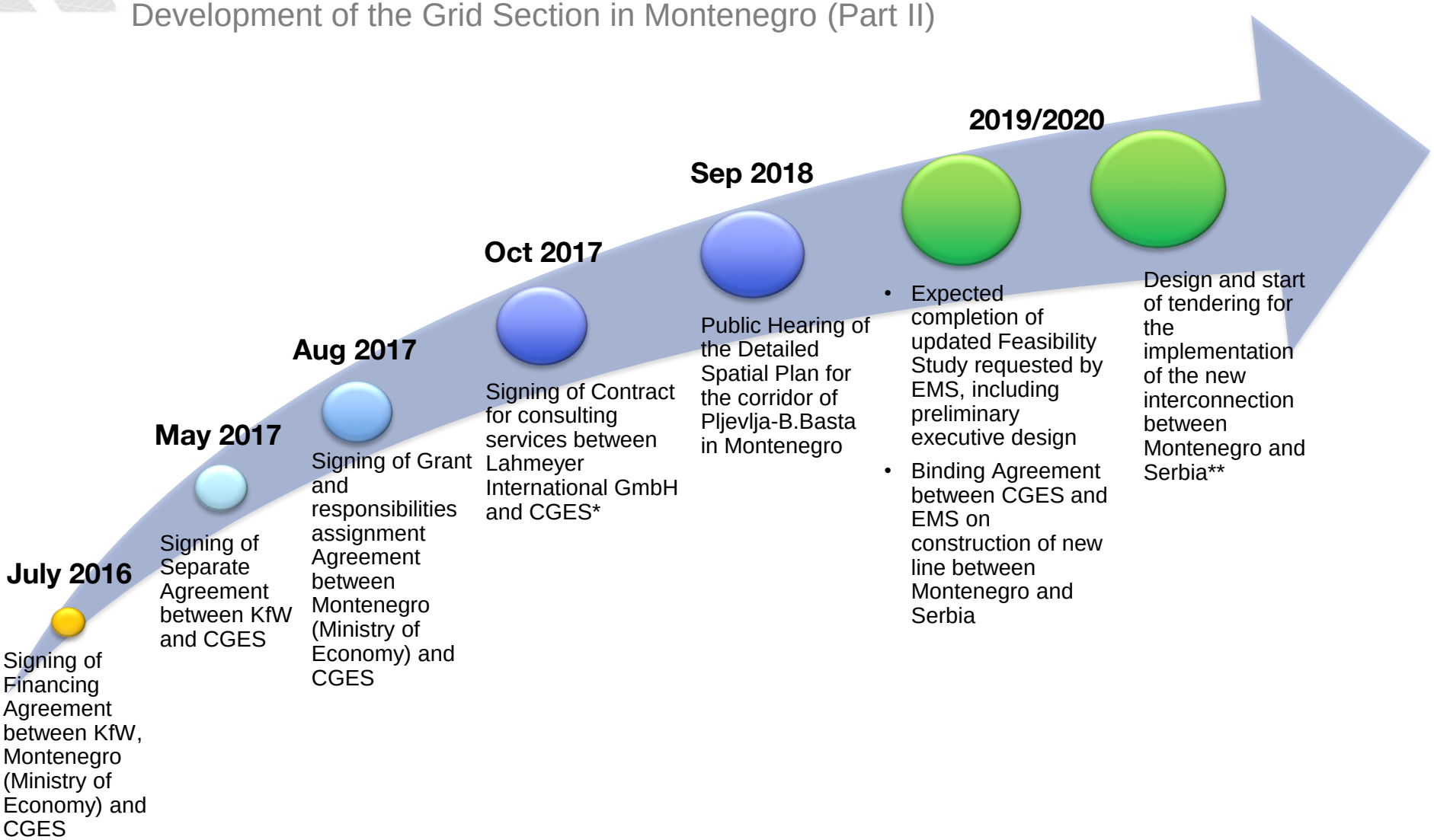
Development of the Grid Section in Montenegro (Part II)

TSO	Asset	Progress Status	Comments
Terna	Submarine and underground cable for further 600MW (2nd pole)	/	Realization of the 2nd pole cable subject to the implementation of Transbalkan corridor and market coupling
CGES	OHL 400kV Lastva-Pljevlja	82%	Construction of OHL 2x400 kV and 400 kV Lastva-Čevo is in final stage
CGES	OHL Pljevlja-B-Basta	/	• Feasibility Study finalized and approved in 2015 • Detailed Spatial Plan in Montenegro to be approved by Montenegrin parliament in first half of 2019. • The implementation of the project is subject to the results of the update of the Feasibility Study requested by EMS



Overview on Trans-Balkan Corridor

Development of the Grid Section in Montenegro (Part II)



(*) the other activities (different by Pljevlja-B.Basta) financed by EU grant are ongoing as planned
(**) subject to signature of the Binding Agreement on asset implementation