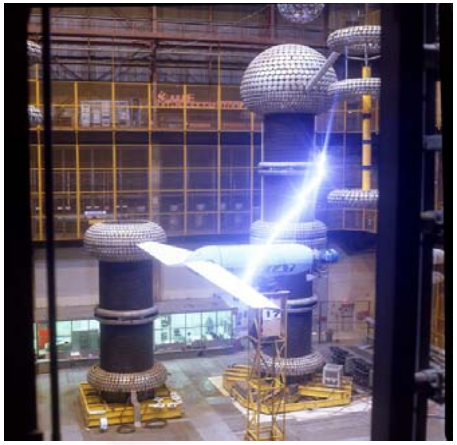
E-Mobility Integration Symposium – October, 23rd 2017 - Berlin

Flash Recharging Tram Catenary Free: Impact Analysis on Italian Distribution Networks

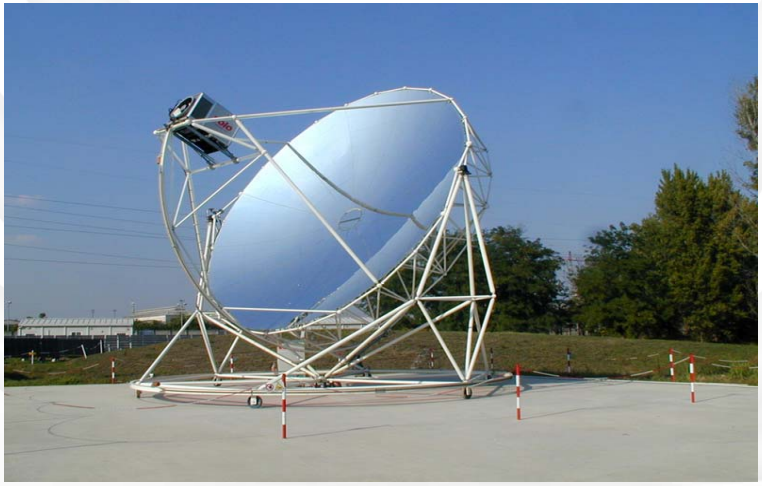
Claudio Carlini, Diana Moneta

RSE
Ricerca sul Sistema Energetico

RSE S.p.A. (formerly CESI RICERCA SpA, ERSE SpA) has been established at the end of 2005, with the mission to take over funded research activities of national and international interest focused on electricity and energy sector and it started operating on January 1st 2006.



RSE S.p.A. is currently owned by GSE, a publicly-owned company promoting and supporting renewable energy sources in Italy.



- ~320 researchers and technicians in 4 departments (60% with degree)
- Research on all aspects of energy sectors: security, power supply, regulation…

Skills

Developing Capacities for Electric Vehicle Interoperability Assessment

- COTEVOS – Concepts, capacities and Methods for Testing EV Systems and their Interoperability within the Smart Grids
- Duration: September 2013 – February 2016
- 11 partners from 9 countries
- Support: European Commission, FP7
- EC Grant Agreement No.: 608934

e-MOTICON - e-MObility Transnational strategy for an Interoperable COmmunity and Networking in the Alpine Space

- Programme priority 2 - Low Carbon Alpine Space - Increase options for low carbon mobility and transport
- Project duration 30 months
- Coordinator

Collaboration with Lombardy Region: e-mobility recharging infrastructure guidelines

Monography on electric mobility

Agenda

Conclusions

Study cases & Results

Methodology

Operational context

2050 decarbonisation scenario

Scenario

EU 2050 Energy Roadmap (2011)

Share of fuels in primary energy consumption %

		Reference scenario		Current Policy Initiatives		Decarbonisation scenarios	
	2005	2030	2050	2030	2050	2030	2050
Solids	17.5	12.4	11.4	12.0	9.4	7.2-9.1	2.1-10.2
Oil	37.1	32.8	31.8	34.1	32.0	33.4-34.4	14.1-15.5
Gas	24.4	22.2	20.4	22.7	21.9	23.4-25.2	18.6-25.9
Nuclear	14.1	14.3	16.7	12.1	13.5	8.4-13.2	2.6-17.5
Renewables	6.8	18.4	19.9	19.3	23.3	21.9-25.6	40.8-59.6

Final energy consumption by fuel in various scenario

		Reference/CPI		Decarbonisation scenarios	
	2005	2030	2050	2030	2050
Electricity	20,2%	24,5% - 25,1%	29,1% - 29,4%	25,2% - 26,0%	36,1% - 38,7%
RES (direct)	4,9%	9,1% - 9,2%	9,0% - 9,4%	8,5% - 10,5%	23,8% - 30,0%
Oil	42,2%	36,1% - 36,8%	35,0% - 35,5%	33,2% - 34,6%	14,9% - 15,6%
Gas	24,2%	18,7% - 19,1%	16,1% - 16,6%	19,4% - 20,0%	11,9% - 12,7%
Heat	3,8%	7,3% - 7,5%	8,2% - 8,6%	7,1% - 8,0%	6,7% - 10,0%
Solid fuels	4,6%	3,2% - 3,3%	2,9% - 3,1%	2,5% - 3,0%	0,3% - 0,4%

+ Efficiency - Environmental impact

Paolo Nespoli from ISS (October 2017)

Operational context

Public transport vehicles evolution

Operational context

Tram vehicle evolution

- ***Approximately 30-40%*** *of the new world-class tram lines are catenary free*
- *The catenary free tram was born to avoid the wires visual impact within city centers.* ***Is this still true?***

1980s: Low floor (Paris)

1980s: Articulated bodies and modular vehicle (Paris)

1990s: Rubber tyred solutions (Nancy, Caen, Clermont-Ferrand)

2000s: First off-wire solution (Bordeaux)

2010s: On-board energy storage (Zaragoza, Sevila)

2010s: Non-continuous permeable slab (Bordeaux)

2010s: Energy saving solutions (Qatar, Kaohsiung)

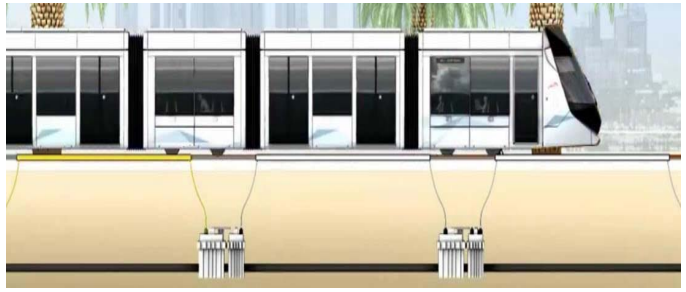
2010s: Compact vehicle (Besançon)

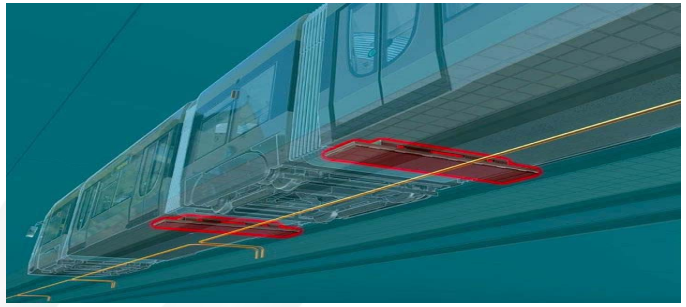
2015: First 100% off-wire tramway line (Dubaï)

Operational context

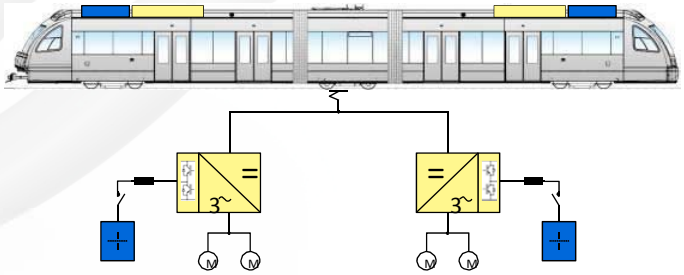
Catenary free: current solutions

- ***Ground level power supply:***
  - ***Alstom APS***
    Dubai, Angers, Bordeaux, Brasilia, Rio, Orleans
  - ***Ansaldo Tramway***
    Naples, Zhuai
  - ***Bombardier Primove***
    Augsburg, Nanjing



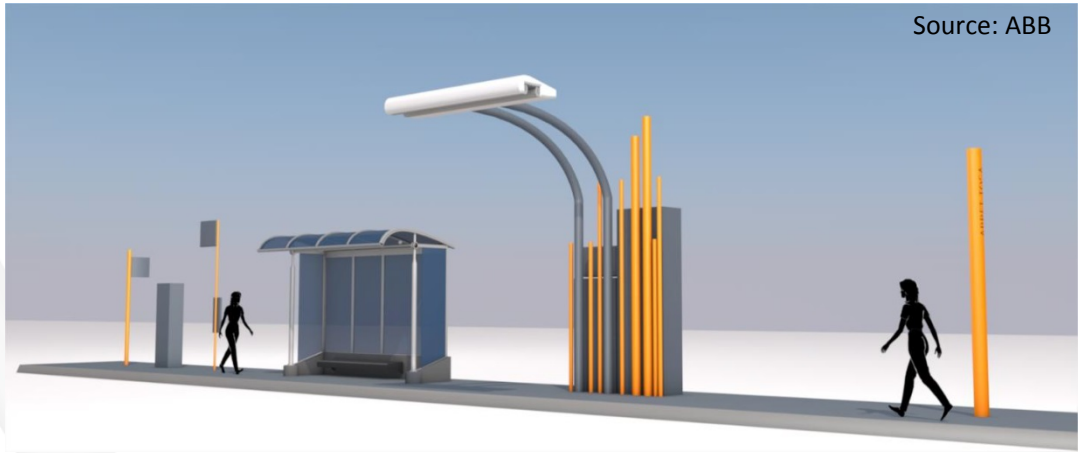


- ***On board energy storages***



Operational context

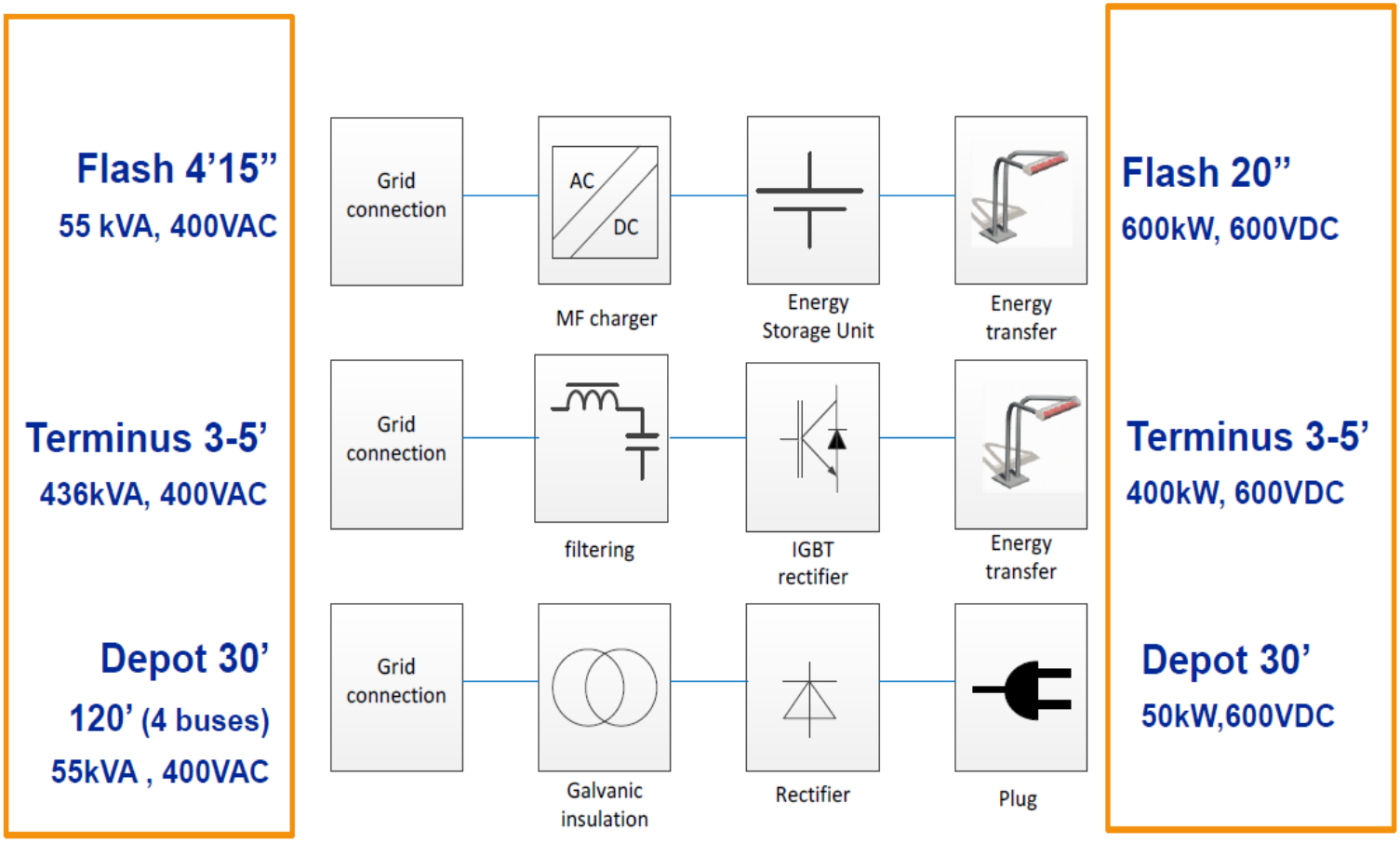
Catenary free recharging solution



- *TOSA pilot (bus) – Ginevra, CH (since 2013)*
- *Longest catenary free tram line (20 km, 23 stop): Huai'an, China (2015)*
- *Flash recharging: 1 ÷ 4 stop + at terminals*
- *Electricity network high impact expected*

Operational context

Catenary free recharging solution



Source: ABB

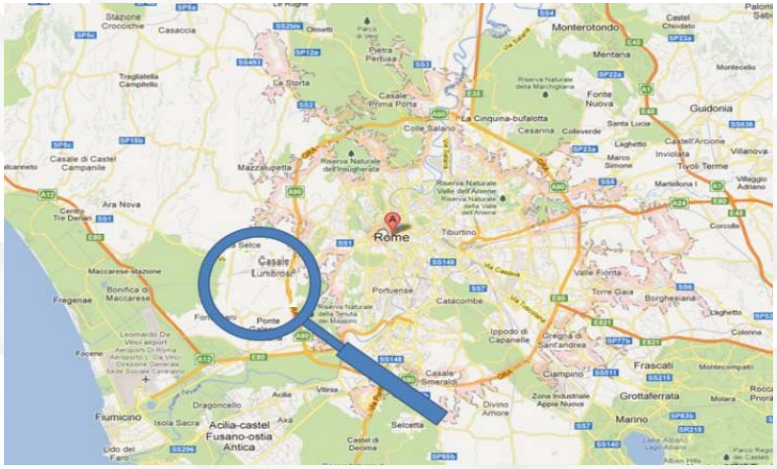
Methodology

- Flash recharging technology applied to 36 m long tram vehicles
- TOSA charging device (600 V_{DC})
- Shifting phases as linear loads (PQ model)
- Vehicles type CRRC Huai'an / Alstom Citadis 305
- Each vehicle is fully charged at each station
- Overlapping between stop, flash charging point, and MV/LV substations
- Electricity grid:
  - Rated voltage: 15 ÷ 20 kV (according to area)
  - Estimated power load profile: 35% residential, 25% industrial, 20% tertiary, 15% agrarian, 5% lighting
  - Load power factor: 0.95
  - No distributed generation in site

-> applied to 2 case studies (metropolis and low density area)

Case study «Rome» (urban)

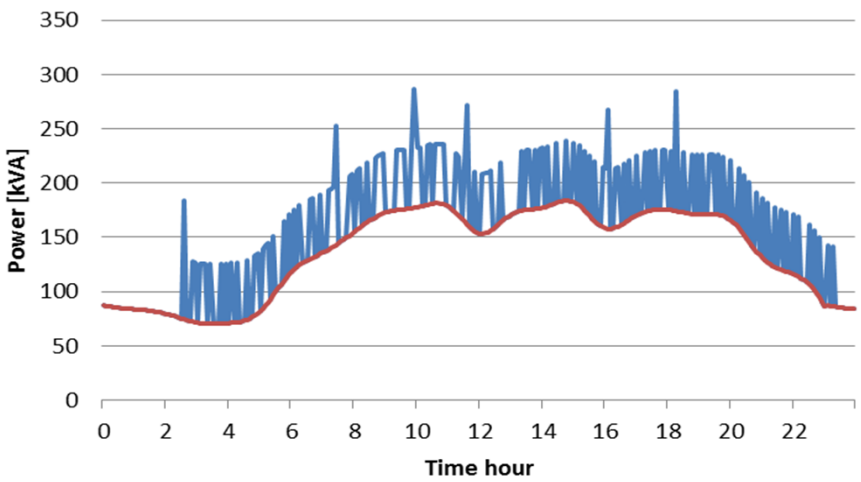
- Place: Rome «smart grid» (Malagrotta – Ponte Galeria)
- Track: 10 km (Malagrotta – Eiffel)
- 3 bus lines (23, 89, 808) «converted» to CF tram
- 16 stop / MV/LV substations
- 2 HV/MV substations (Raffinerie, P.te Galeria)

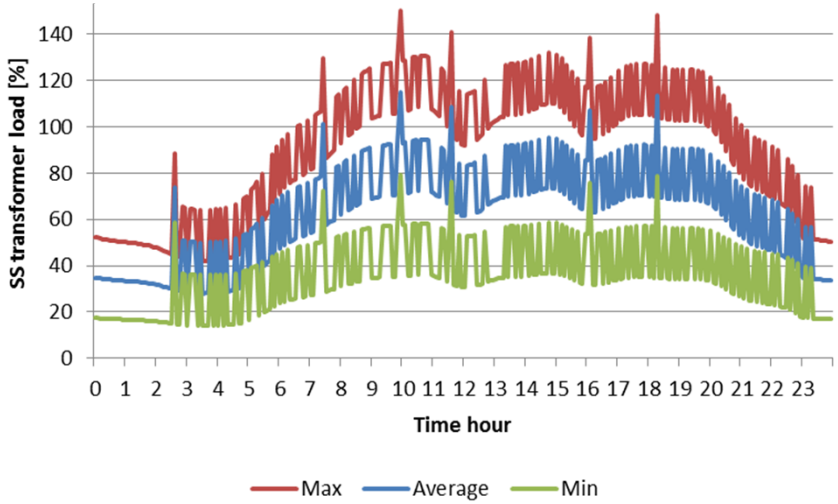


Stop	Line	Distance (km)	HV/MV substation
Malagrotta	23[a]	0	Raffinerie
Casale Bruciato	23	0.6	Raffinerie
Podere S. Pietro	23	1.3	Raffinerie
Podere C. Murata	23	1.7	Raffinerie
Podere Lungarina	23	2	Raffinerie
Podere P. Rotondo	23	2.3	Raffinerie
Idrocarburi	23	2.9	Raffinerie
Civico 248	23	3.5	Raffinerie
Pisana	23, 89, 808	5.5	Ponte Galeria
Civico 181	23, 89, 808	6.4	Ponte Galeria
Moratelle	23, 89, 808	6.7	Ponte Galeria
Pitentino	23, 808	7	Ponte Galeria
Domus de Maria	89, 808	7.9	Ponte Galeria
Portuense	23, 89, 808	8.3	Ponte Galeria
Ex Dazio	89[a]	8.7	Ponte Galeria
Eiffel	89,808[a]	10.2	Ponte Galeria

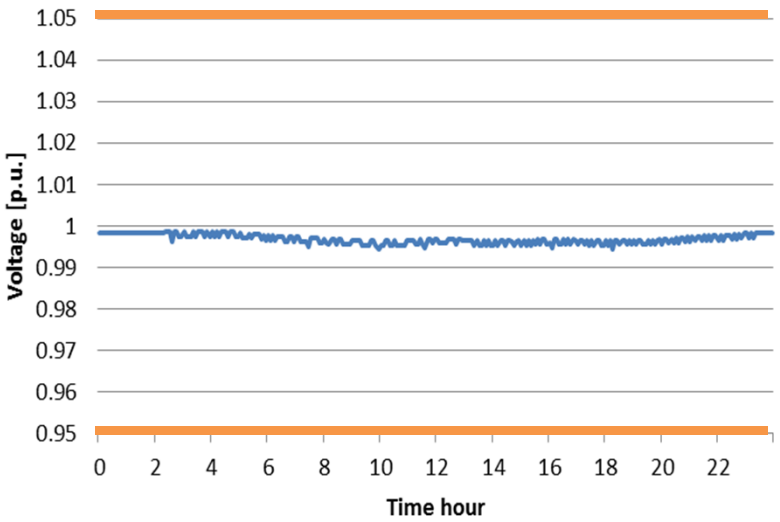
Case study «Rome» (2)

Pisana (to Eiffel)				
	89		*808*	*23*
5 H	5.40		5.35	
6 H	6.10	6.40	every 15’	6.00
7 H	7.15	7.50	every 15’	7.05
8 H	8.25		every 15’	8.05
9 H	9.00	9.35	every 15’	9.05
10 H	10.10	10.45	every 15’	10.05
11 H	11.20	11.50	every 15’	11.05
12 H	12.30		every 15’	12.05
13 H	13.00	13.40		13.05
14 H	14.10	14.40		14.05
15 H	15.20	15.50	every 15’	15.00
16 H	16.30		every 15’	16.00
17 H	17.10	17.50	every 15’	17.05
18 H	18.30		every 15’	18.05
19 H	19.10	19.50	every 15’	19.05
20 H	20.30		every 15’	20.05
21 H	21.05	21.40	every 15’	21.05
22 H			every 15’	22.05
23 H			23.40	23.00

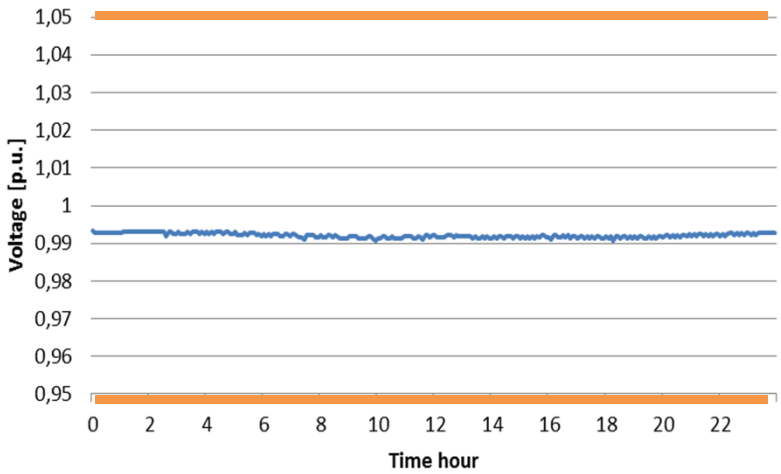




Case study «Rome» (3)



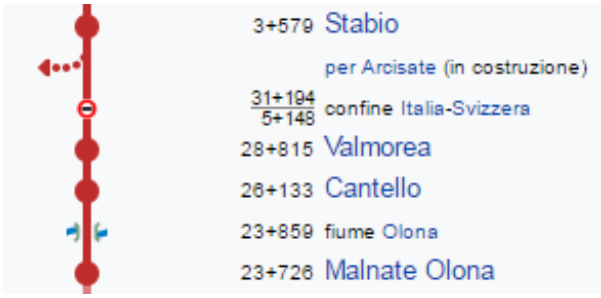
- Daily voltage profile - «Pisana» stop

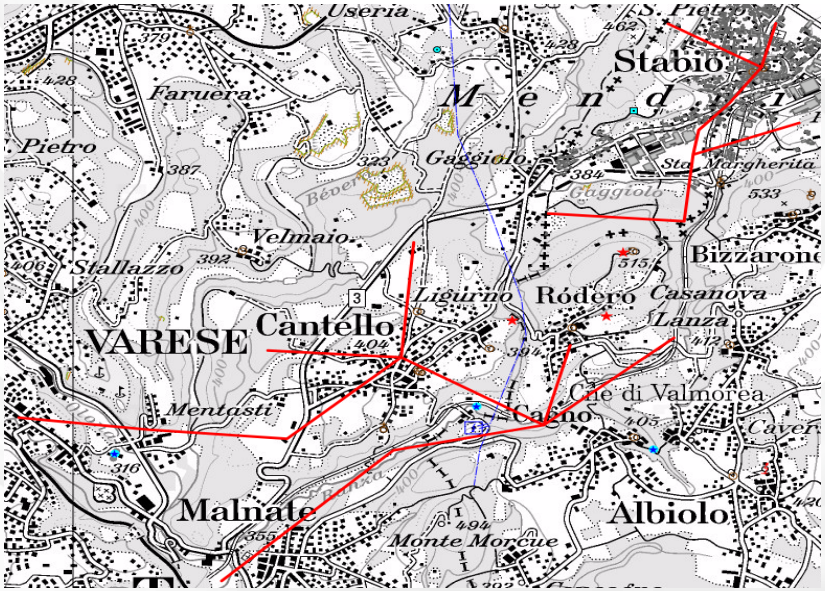


- Daily voltage profile - «Malagrotta» terminal

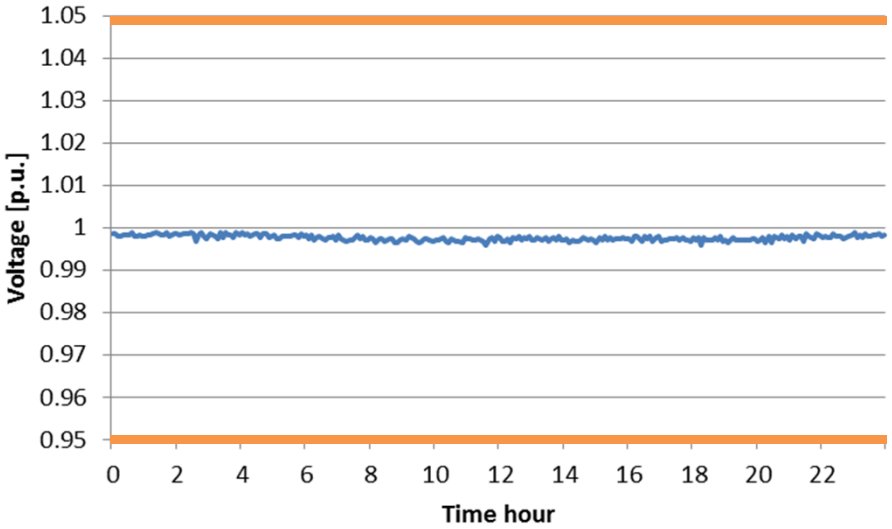
Case study «Valmorea» (rural)

- Place: former international railway IT-CH «Valmorea»
- Low density area
- Track: 7 km
- 3 stops / MV/LV substations
- 1 HV/MV substation (Cagno)

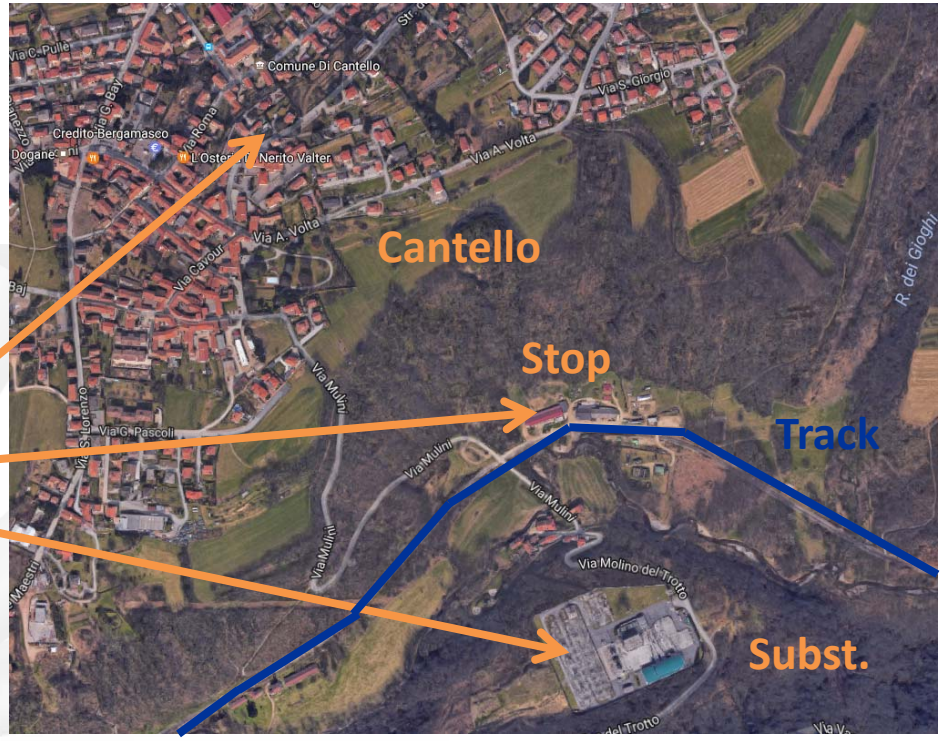




Case study «Valmorea» (2)



- Daily voltage profile - «Cantello» stop



- Voltage profile stabilised by HV/MV «Cagno» substation

Conclusions

- The impact on distribution networks for refurbishment of non-catenary flash recharging trams has been assessed considering different aspects (geographic area, traffic flows, etc.) for the potential application of this technology in Italian metropolitan and rural areas.
- Two real case studies (urban, rural) have shown the (expected) limited impact of flash recharging stations on the operation of the distribution grid. A more in-depth analysis, with detailed data, is required for specific evaluations.
- In any case, distribution networks *do not appear to be the barrier* to the widespread adoption of this solutions
- Following phases will address further considerations about technology across urban and suburban areas of distribution networks also by using more sophisticated transportation models.

Contacts:

Claudio Carlini, Diana Moneta

Research group «Active networks and demand side management»

Ricerca sul Sistema Energetico RSE SpA

www.rse-web.it

{claudio.carlini;diana.moneta}@rse-web.it