

Towards a Smart Water Distribution Network for Assessing the Effects by Critical Situations in Electric Networks. The Pilot Case of Castel San Giorgio

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Abstract. Water and electricity networks are among the main national critical infrastructures. One of their characteristics is mutual functional interdependence. This work presents the technological advancements will affect the pilot water network of Castel San Giorgio within the RAFAEL Project. Predictive modeling capabilities coupled with networked sensors to be installed along the water distribution system will allow the water supplier GORI to control network hydraulics during critical situations due to electrical system failures in order to minimize the effects on customers service.

Keywords: Critical Infrastructures (IC) · Water distribution network · Water supplier

1 Introduction

Critical infrastructures are elements, systems or parts of them which are essential for the maintenance of the vital functions of society, health, safety and the economic and social well-being of citizens and whose damage or destruction would have a significant impact due to the impossibility of maintaining those functions (Directive 2008/114/CE). Critical Infrastructure Systems (CI) include utility networks such as energy, water, telecommunications and transport systems, or discrete critical structures such as hospitals, ports and airports, among others. The objective to be achieved by GORI, as water supplier, within the funded RAFAEL Project [1, 2] will be the development of a smart water network able to effectively manage critical situations due to electrical network failures. In particular, the water distribution network of Castel San Giorgio will be analysed from the perspective of the water risk, the vulnerability and resilience of water networks in relation to the failure of the electrical networks, quantifying their impacts on the provided water service. The RAFAEL Project aims to integrate CIs, with technologies developed ad hoc, within a Decision Support System (DSS) CIPCast, which will become the reference platform to provide services to companies and the Public Administration.

CIPCast is an advanced DSS for predicting the occurrence and impact of natural or anthropogenic events on Critical Infrastructures and Essential Service Operators as well

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as on the population and the industrial system. Within RAFAEL Project, this system will extend its use to the areas of Southern Italy in order to gradually expand its functionality to the whole national territory. CIPCast System implements tools for assessing the Ics risks due to essentially disastrous natural events tacking into account ICs operative interdependences.

For achieving the project objectives, an optimal sensor placement method will be developed for monitoring physical and chemical parameters along the entire pilot network. Optimal sensor schemes will be defined on the basis of on which a distributed sensor network will be installed by GORI aimed at optimizing the modelling accuracy. In particular, IoT-derived sensory nodes will be integrated for the pervasive sensing of water parameters based on new generation data transmission networks. Predictive modelling capabilities will be developed refereed at the pilot water distribution network of Castel San Giorgio in order to assess the vulnerability and resilience of the water supply network in relation to electricity network failures, quantifying the impacts on the water service.

GORI will be able to quickly analyse alternative operating scenarios and compare them for determining the most appropriate solution to address the critical situations due to eventual electrical service failures.

2 The Water Supplier: GORI SpA

GORI S.p.A. is the water supplier of the Integrated Water Service of the "Sarnese-Vesuviano" District Area in Campania and its main target is to make efficient, effective the management of water resources. To date, GORI manages the Integrated Water Service of 74 municipalities. Total area of the district is about 897 km^2 with a resident population of 1′422′435 as of 31.12.2019 (source ISTAT _ National Institute of Statistics) and a number of users as of 31.12.2019 equal to 526′775 of which 467′554 domestic and 59′221 non-domestic.

2.1 The Water Supply of the "Sarnese Vesuviano" District

The Water System of the "Sarnese Vesuviano" District is divided into three main subsystems (Fig. 1):

- The Vesuvian System
- The Lattari Mountains System
- The Ausino System

The three water systems draw water resources from:

- Managed endogenous sources (wells and springs)
- Campania Region Supply (Vesuvian Aqueduct System and Monti Lattari Aquedottistic System)
- ABC Supply (Vesuvian Aqueduct System)
- Ausino Supply (Ausino Aqueduct System)

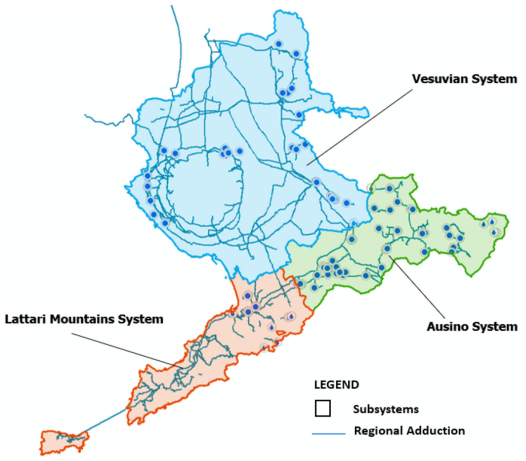


Fig. 1. "Sarnese Vesuviano" District– Regional Adduction.

In the Table 1, geometric data related to the entire water system managed by GORI are listed.

Table. 1 The geometry data of the water distribution network

Infrastructure	Consistency	Measurement unit
Water network distribution	4′226	km
Water network adduction	861	km
Wells	116	n
Springs	13	n
Water lifts	122	n
Tanks	206	n

The table summarizes the data relating to the consistency of the water service infrastructures currently managed by GORI (up to 31/12/2019).

The company guarantees users the supply of drinking water (the quality of which is assured by continuous controls) and a service appropriate to a modern European country, obtained also through investments aiming at the improvement of infrastructures and concerning above all technological innovation. Constant attention is assured to environmental protection. The innovation spirit has addressed the participation of the water supplier GORI in the research project of RAFAEL. As said, the main target of this Project is to optimize and integrate methodologies and technologies developed in the field of Critical Infrastructure Protection and GORI as stakeholder and project partner will give its contribution by the water network pilot.

The network pilot chosen in the Project is the water network of the Castel San Giorgio Municipality.

3 The Water Distribution Network of Castel San Giorgio

3.1 The Territory

The Municipality of Castel San Giorgio is located in the South of Italy, in Campania Region. The city is located at an altitude of 90 m above sea level and covers an area of 13,363 km^2. Castel San Giorgio is an agricultural, commercial and industrial centre and home to canning industries, which represent one of the main production activities, together with that of building materials. The population based on ISTAT data updated on 31st December 2019 is 13′695 inhabitants (Fig. 2).

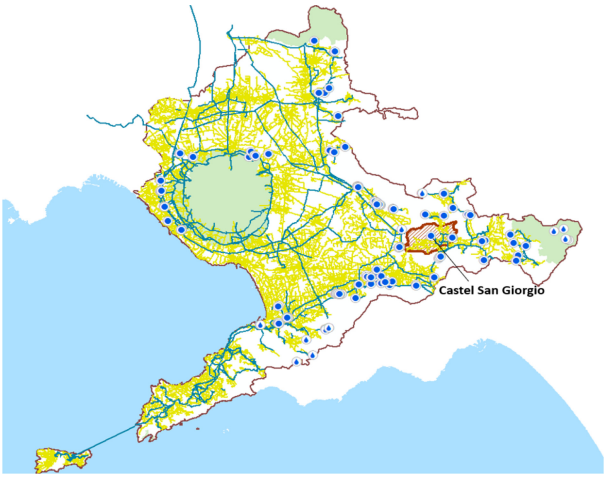


Fig. 2. The pilot municipality of the RAFAEL Project: Castel San Giorgio.

3.2 Consistency Status of the Water Network and Service Data of the Municipality of Castel San Giorgio

GORI, with a complex water supply and distribution network, supplies the entire territory of Castel San Giorgio serving about 5′715 consumers including domestic, commercial, artisan, agricultural and industrial users.

The Municipality of Castel San Giorgio, although it falls within the boundaries of the Ausino Aqueduct System, which is the system of adduction for the municipalities of the "Sarnese–Vesuvian" District Area covering the easternmost outcrops of the territory served, is fed exclusively through the use of the water outlet from three wells located within the municipal territory: Pozzo Traiano 1, Pozzo Traiano 2 and Pozzo Santa Croce. In particular, the water released from the two wells of the Campo Pozzi Traiano, located in the eastern part of the territory at an altitude of about 100 m.a.s.l., is accumulated in the tank having the same name, which has a capacity of about 130 m^3, and then is raised by two separate lifting systems towards the tanks of Santa Croce (125 m.a.s.l.) and Torello Cortedomini (160 m.a.s.l.) with a storage capacity of 930 and 1188 m^3 respectively.

At the Torello Cortedomini Tank, fed only and exclusively by the water of the Campo Pozzi Traiano, belong two distinct districts: a larger one powered by fall (Distr. Idr. CGG Serb. Torello Cortedomini) and a smaller one placed higher than the tank which is fed by means of a small lifting system (Distr. Idr. CGG Serb. Torello Cortedomini ZA) (Fig. 3). The third district of Castel San Giorgio (Distr. Idr. CGG Serb. Santa Croce) is instead subtended to the Santa Croce Tank, which is fed by the water of the Santa Croce and Traiano wells. There is also a fourth district within the administrative boundaries of the Municipality of Castel San Giorgio which is instead hydraulically fed by the Municipality of Siano and specifically by the Boscoborbone Tank.

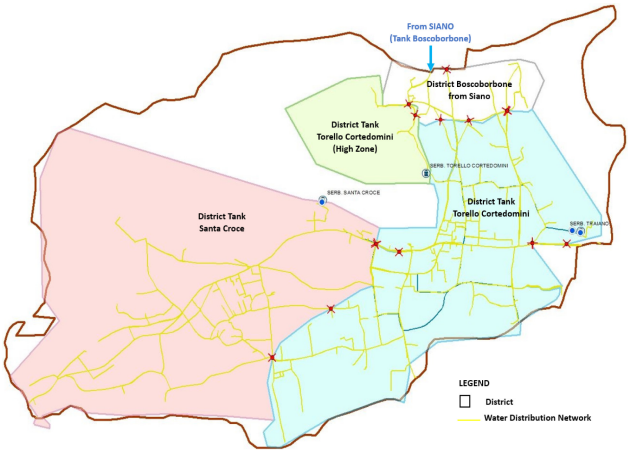


Fig. 3. The water network of the Castel San Giorgio Municipality.

A simplified diagram of the power supply of the Municipality and the individual plants will be shown in the following sections. In the meantime, some summary tables (Table 2, 3, 4 and Table 5) containing important information on both the hydraulic and management level are given in the following.

Table. 2 Hydraulic service data of the municipality of Castel San Giorgio

Hydraulic service data		
Inhabitants		13′695
Territorial area		13,363 km^2
Active users		5′715
Typology users	Domestic	85,34%
	Public	1,14%
	Commercial and craft industries	13,4%

(*continued*)

Table. 2 (*continued*)

Hydraulic service data		
	Industrial	0,12%
Km of adductors		8,38
Km of water distribution network		63,08
Wells		3
Springs		0
Tanks		3
Water lifts		3

Table. 3 Hydraulic data of wells

Well	Height [m.a.s.l.]	Average flow rate emitted [l/s]
Traiano 1	103	32,9
Traiano 2	105	14,1
Santa Croce	125	11,3

Table. 4 Hydraulic data of tanks

Tank	Height [m.a.s.l.]	Compensation capacity [m^3]
Traiano	100	130
Santa Croce	125	930
Torello Cortedomini	160	1188

Table. 5 Hydraulic data of water lifts

Water lift	Height [m.a.s.l.]	Medium lifted range [l/s]
Traiano 1	100	33,4
Traiano 2	100	12,2
Torello Cortedomini	160	N.D

4 Remote Control Schemes

Using a remote control platform developed in a SCADA environment, the company remotely manages the operating rules of the individual systems and the active alarms, while all the hydraulic/topographic part is recorded in a GIS system and is updated daily.

The water supply diagram of the Municipality of Castel San Giorgio can be schematically represented in a simplified way as shown on the remote control platform (Fig. 4).

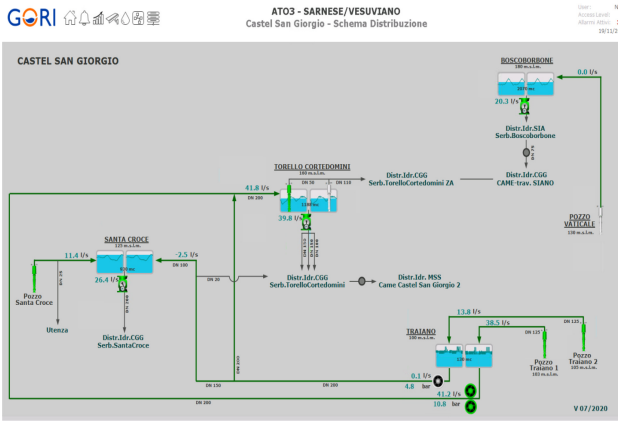


Fig. 4. TLC simplified water scheme of the Municipality of Castel San Giorgio Municipality.

Details of each individual plant related to the power supply scheme of the Municipality can then be displayed on its dedicated page of TLC (Remote Control System).

The remote control of each plant allows a constant monitoring of following values: flow rate (input and output) [l/s], pressure [bar], wells level [m] and tank levels [m] with alarms (set at the minimum and overflow threshold). Operating rules of the individual plants, pumps and automations applied to inverters, metering pumps and automated flow control valves are indicated.

5 Conclusions

The water supplier Gori as partner within the RAFAEL Project aims to analyse several hydraulic behaviour scenarios that can occur in ordinary or critical management situations and evaluate the impact on network and customers.

The participation in the RAFAEL Project will represent for GORI a further positive note in terms of innovation because it will return to the operator a water distribution network equipped with sensors that will allow a continuous monitoring of physical/chemical parameters distributed along the entire network. At the same time this participation will allow GORI to assess the effects due to critical situations in the electrical service on the eater distribution network and the impact on the customers service. All this at the scope to prepare efficient emergency management plans and promptly and properly respond in order to minimize the impacts on the served people. The participation of GORI in the RAFAEL Project shows, once again, how careful the Company is in guaranteeing the supply of drinking water to the users, and in providing an adequate service in compliance with the Italian regulation framework by ARERA, also through the realization of

investments aimed at improving infrastructures and concerning above all technological innovation, with constant attention to the safeguarding of the environment.

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