5th International Conference on Smart Energy Systems
Copenhagen, 10-11 September 2019
#SESAAU2019

Power-To-Gas potential for energy flexibility of grid-connected and off-grid geographical islands

Benedetto Nastasi & Davide Astiaso Garcia

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Outline

- **Background**
- **H2020 GIFT**
- **Power To Gas (P2G)**
- **Research Questions**
- **Methodology**
- **Results**
- **Conclusions**
- **References**

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Background – 2011/2015

- **25% is the maximum integrable RES share today**
- **RES intermittency, e.g. PV peak, overcomes 25%**

✓ ***Storage & sector coupling to firm RES capacity***

- **Long term contracts signed for fossil fuel supply**
- **Capillary Gas Grid infrastructure**

✓ ***RES-based solutions for decarbonizing supply***

→Power-to-Gas for Electro-Fuels production

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Background – 2011/2015

MOST CITED ENERGY PAPER 2016 presented ad 1st SES Conference

Energy 110 (2016) 5–22

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Hydrogen to link heat and electricity in the transition towards future Smart Energy Systems

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Background - 2019

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H2020 GIFT – Project

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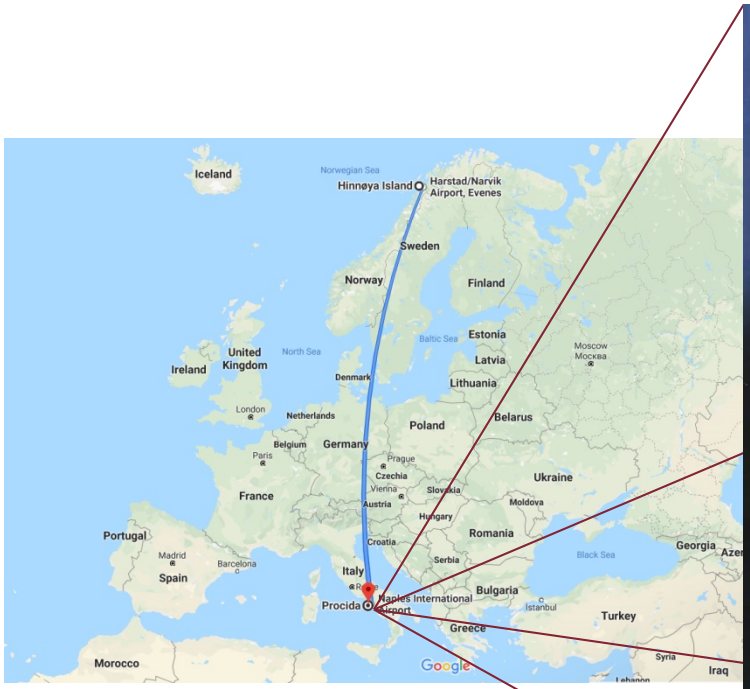
H2020 GIFT – Procida Case Study



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H2020 GIFT – Procida Case Study

- **Local energy production is negligible**
- **Congestion on power cable to the mainland**

✓ ***Fostering distributed and sustainable energy***

- **Reliable Gas Grid present**
- **New business models for inter-sectorial flexibility**

✓ ***Prosum(ag)ers interacting with market***

→Power-to-Gas to offer Power Flexibility

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H2020 GIFT – Data availability

Building 1

YEAR	ACTIVE ENERGY [kWh]	REACTIVE ENERGY [kVArh]	MAXIMUM POWER
2019	31,212	19,466	34.8
2018	16,949	25,560	27.5
2017	51,027	9,376	29.0

Building 2

YEAR	ACTIVE ENERGY [kWh]	REACTIVE ENERGY [kVArh]	MAXIMUM POWER
2019	24,618	22,375	46.4
2018	41,129	59,180	42.0

Building 3

YEAR	ACTIVE ENERGY [kWh]	REACTIVE ENERGY [kVArh]	MAXIMUM POWER
2019	3,213	2,876	6.6
2018	5,315	4,186	6.0
2017	3,723	1,134	5.0

Building …

YEAR	ACTIVE ENERGY [kWh]	REACTIVE ENERGY [kVArh]	MAXIMUM POWER
2019	2,155	971	7.1
2018	19,386	6,227	23.0
2017	24,622	3,975	24.0

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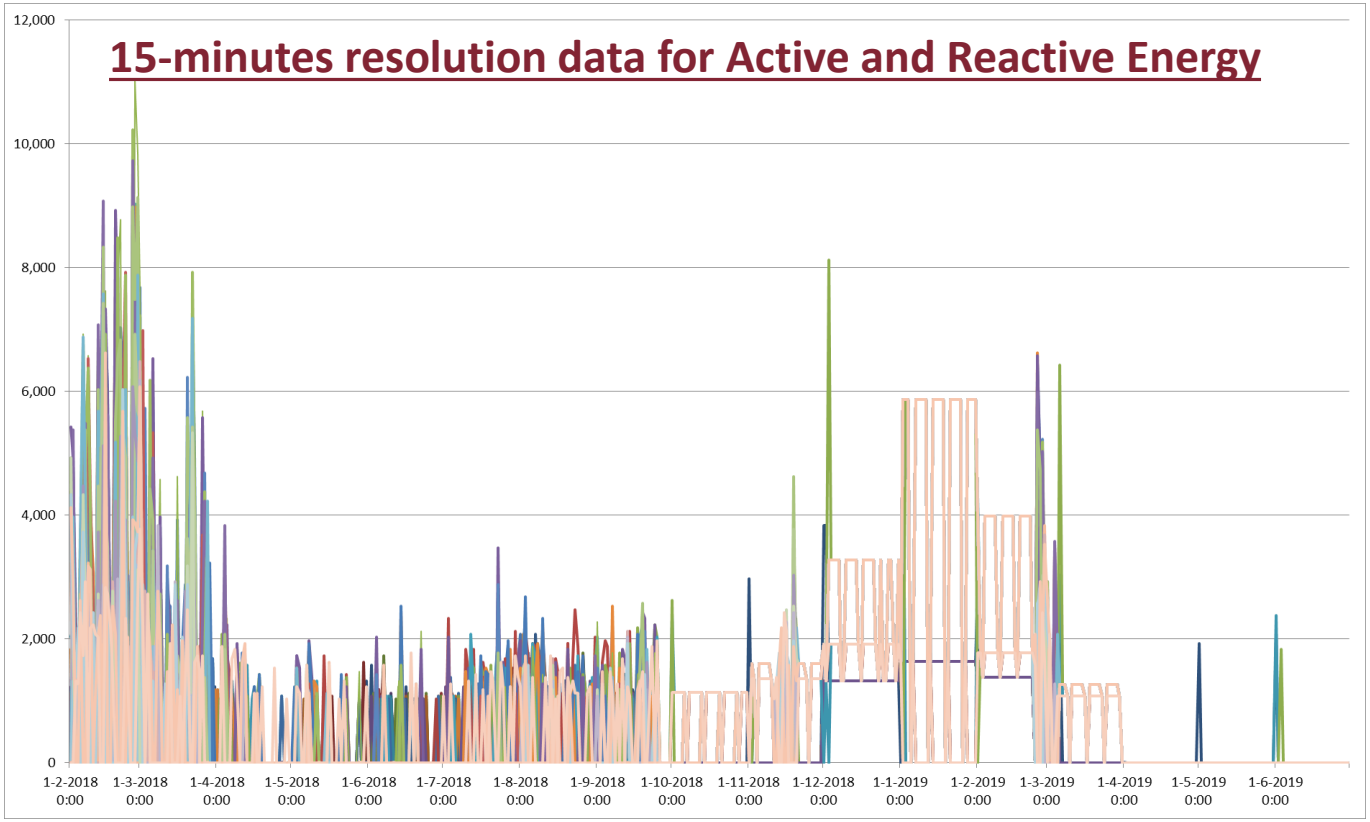
H2020 GIFT – Data availability



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Research Questions

What Reliability could be provided by RES-excess based synthesis considering the different sectors and their demand (fuel, heat, power)?

Electrolysers as sector coupling tool

What changes in Congestion and CO_2 emission could be achieved by handling RES-based fuel?

Potential for NG blending or reversible SOC use

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Methodology

- **Hour quarterly resolution data from DSOs**
- **Reversible Fuel Cell for H_2 production or use**

✓ ***Interacting with Gas Grid or supplying electricity***

- **Electricity market trends and RES share included**
- **Behaviour of different sizes of H_2 components**

✓ ***Using the available RES to secure the system***

→Power-to-Gas viable to offer Energy Flexibility

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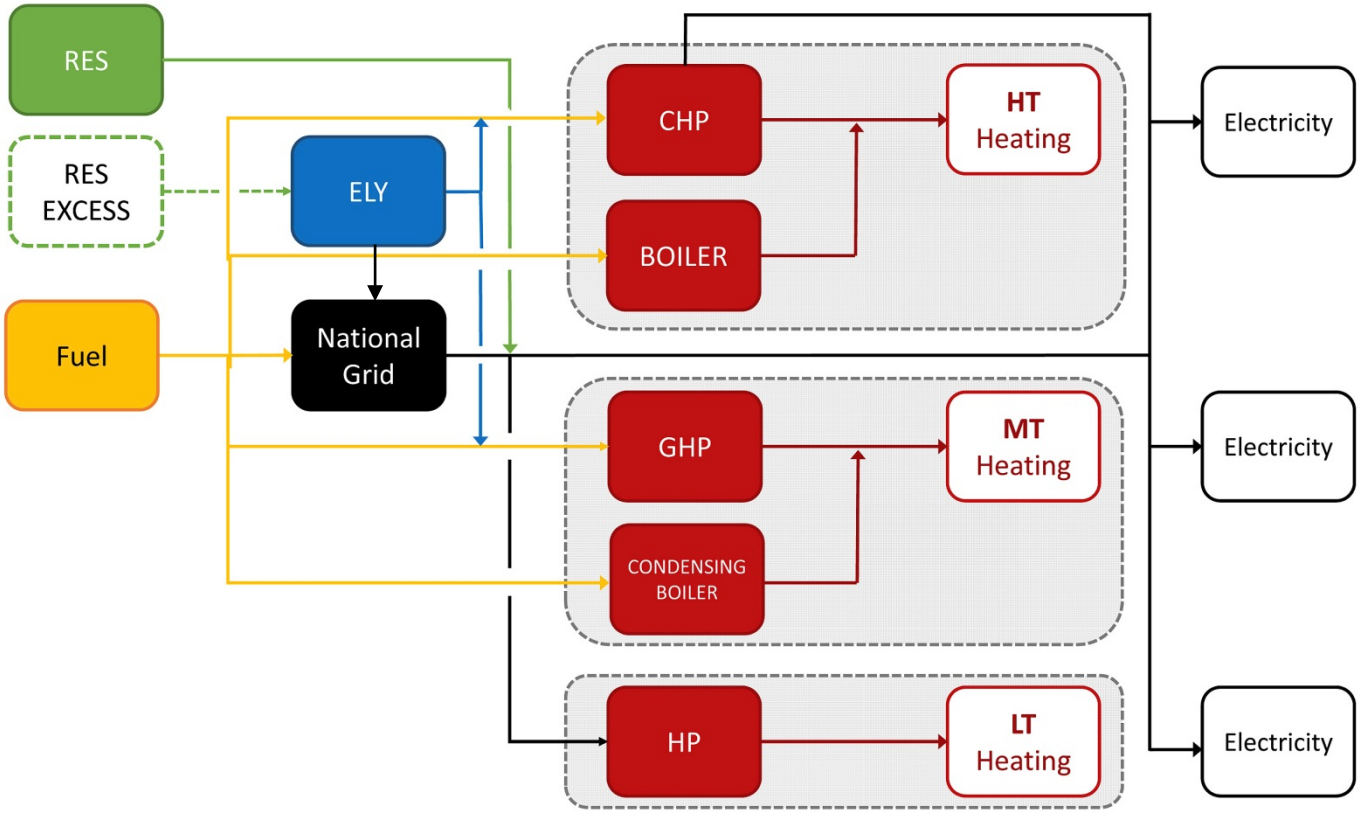
Methodology



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Methodology – Scenarios

Electrical and Heating demand of several buildings

Five scenarios for Integrating Solar Energy:

- **BAU** – Current fossil based generation & Grid
- **PV** – Photovoltaics installed on all the Buildings
- **ELY & FC** – Reversible Electrolyser & Fuel Cell
- **ELY & H2NG** – Solar H_2 injected into the Gas Grid
- **ELY & H2NG & FC** – Combination of FC and H2NG

Key Performance Indicators: Avoided **CO_2**, Avoided **Congestion**, RES **share**, RES **integrated**

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Methodology – Electricity Market in Italy

- **F1** - peak hours during a working day, from Monday to Friday.
- **F2** - the near-peak demand, from Monday to Saturday.
- **F3** - the off-peak demand.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
L	F3	F3	F3	F3	F3	F3	F3	F2	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F2	F2	F2	F2	F3
M	F3	F3	F3	F3	F3	F3	F3	F2	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F2	F2	F2	F2	F3
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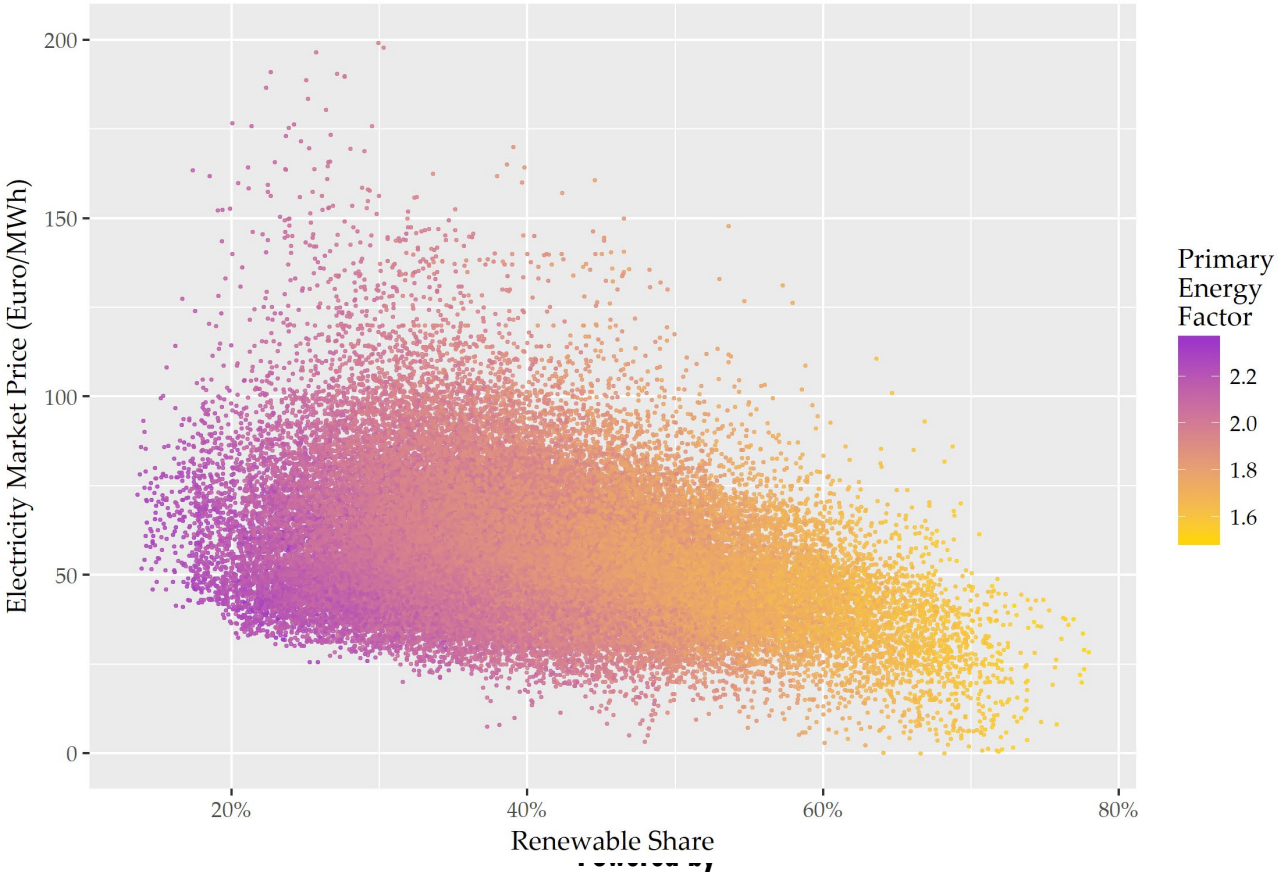
Methodology – Electricity Performance



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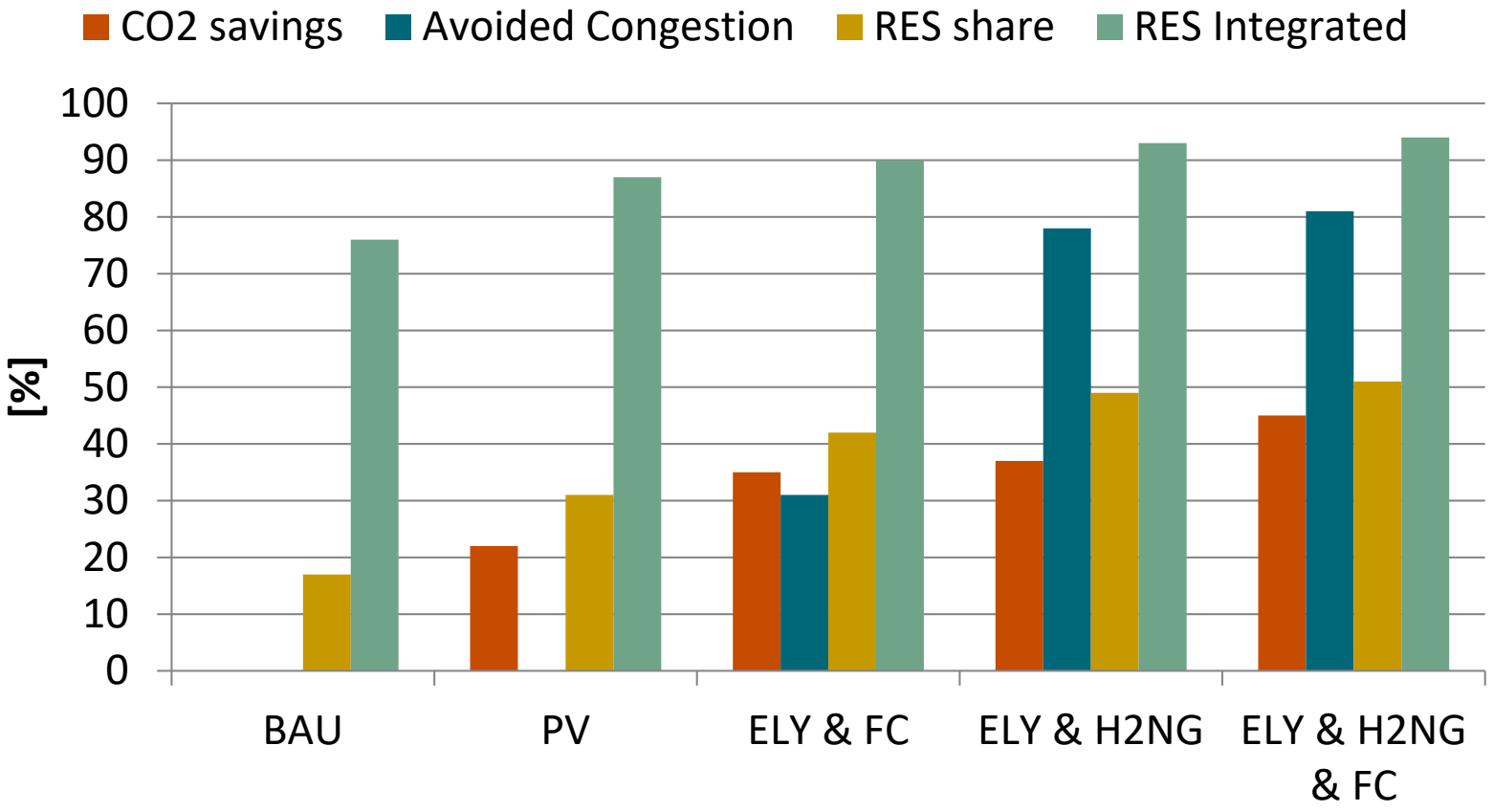
Results



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Conclusions

- **Hydrogen plus Natural Gas for the transition**
- **Avoiding congestion by interacting with Gas Grid**

✓ **Partial substitution as ready solution**

- **Solar energy is already enough to H2NG @5%**
- **Solar Hydrogen for RES capacity firming**

✓ **Interaction between heat and electricity**

→ **Dedicated RES-based electro-fuel for Grid security**

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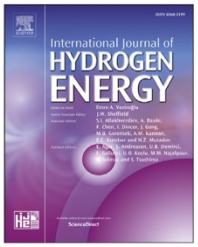

Power-to-Gas integration in the Transition towards Future Urban Energy Systems

CrossMark

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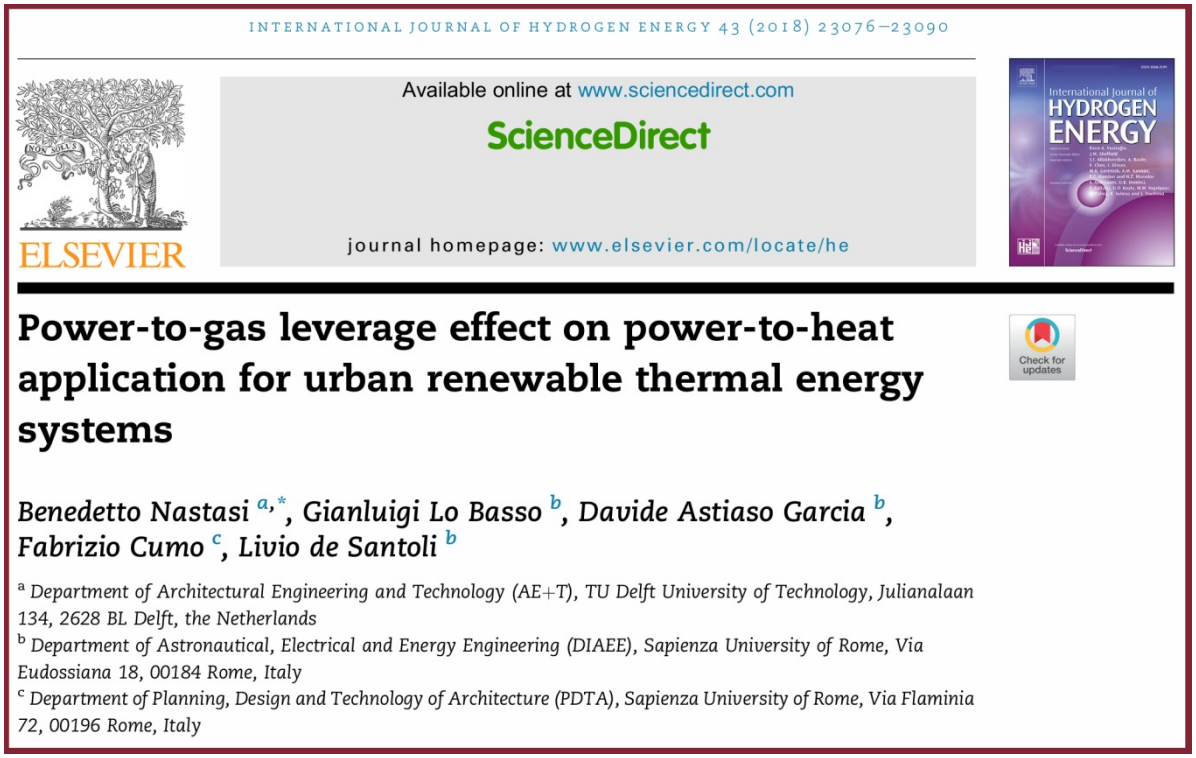

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Power-to-gas leverage effect on power-to-heat application for urban renewable thermal energy systems

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CHAPTER 2

Hydrogen policy, market, and R&D projects

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Contents

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