Modelli di produzione fotovoltaica e di domanda elettrica residenziale e industriale

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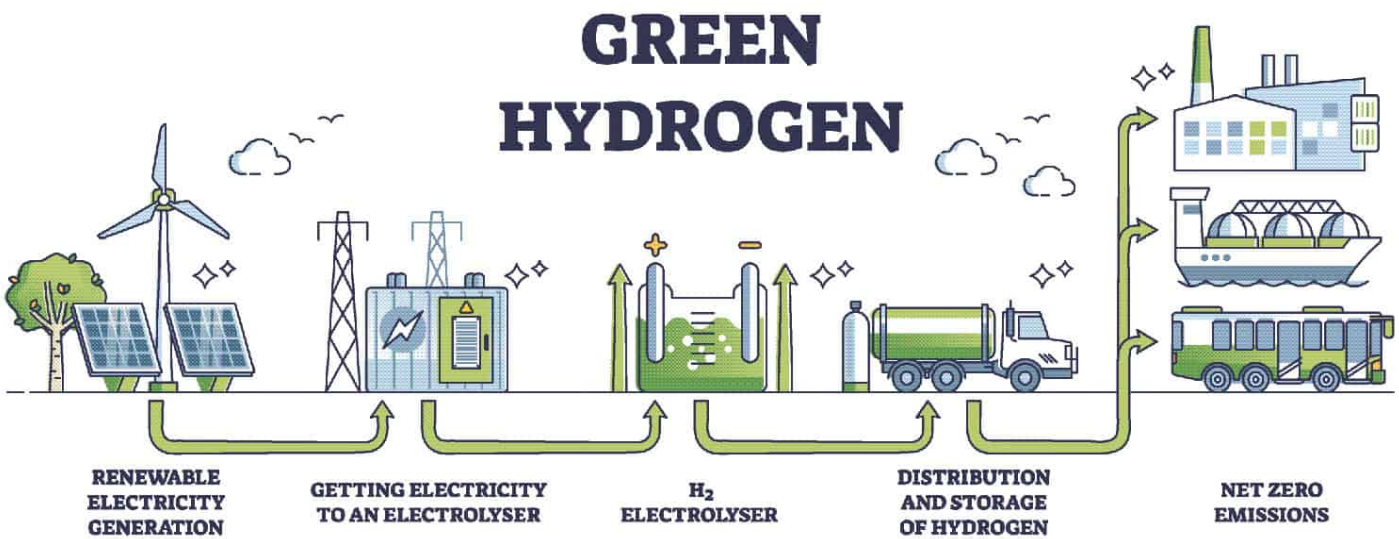
Dataset (I)

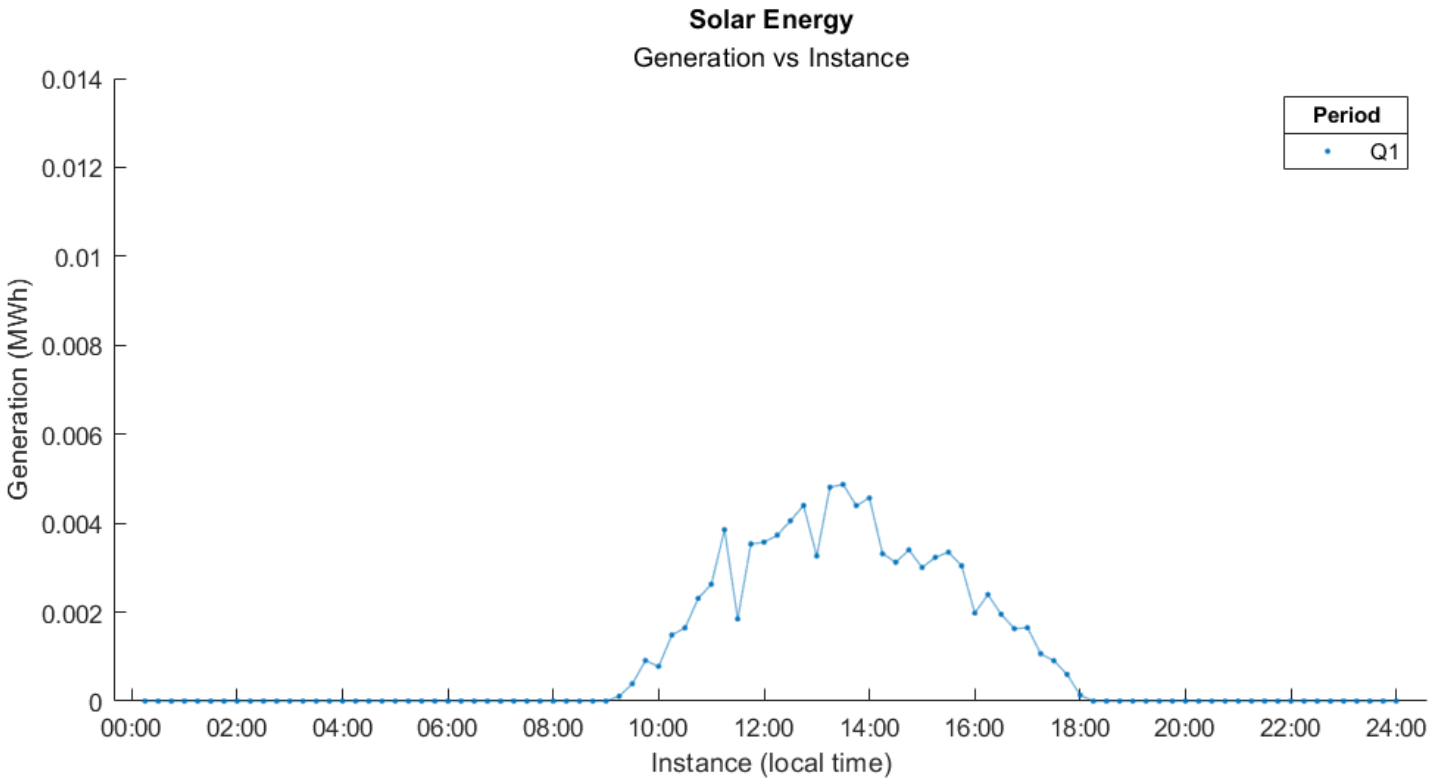
AIMMS-MOPTA 2024 Competition

- Modeling and Optimization: Theory and Applications Conference
- Lehigh University (USA)
- "Would a Fully Renewable Energy Grid benefit from adding Green Hydrogen as a Supplemental Power Source?"



Dataset (II) - Produzione fotovoltaica

- Totale campioni: 384 (Generation)
  - Quarter: 4 giornate
  - Instance: 96 rilevamenti (15 m)



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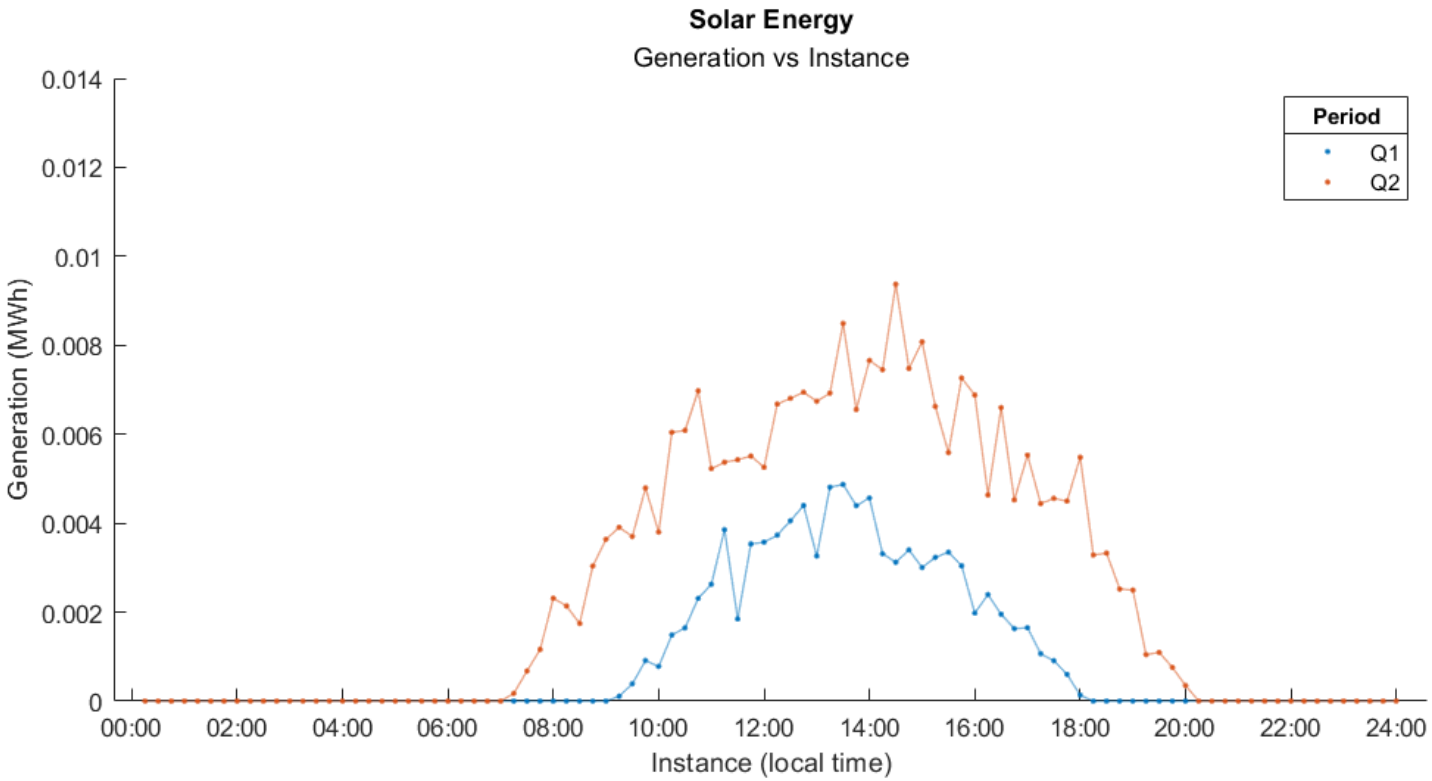

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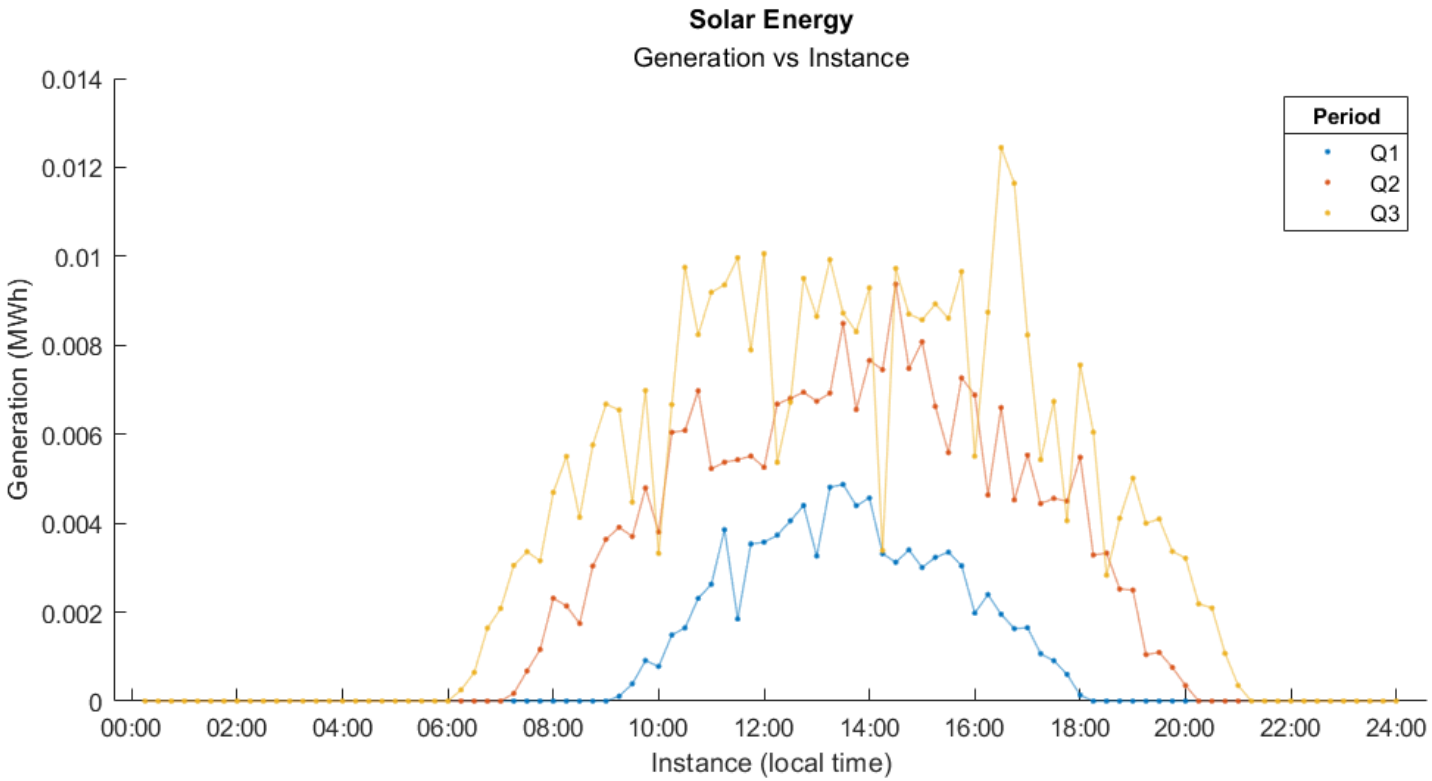

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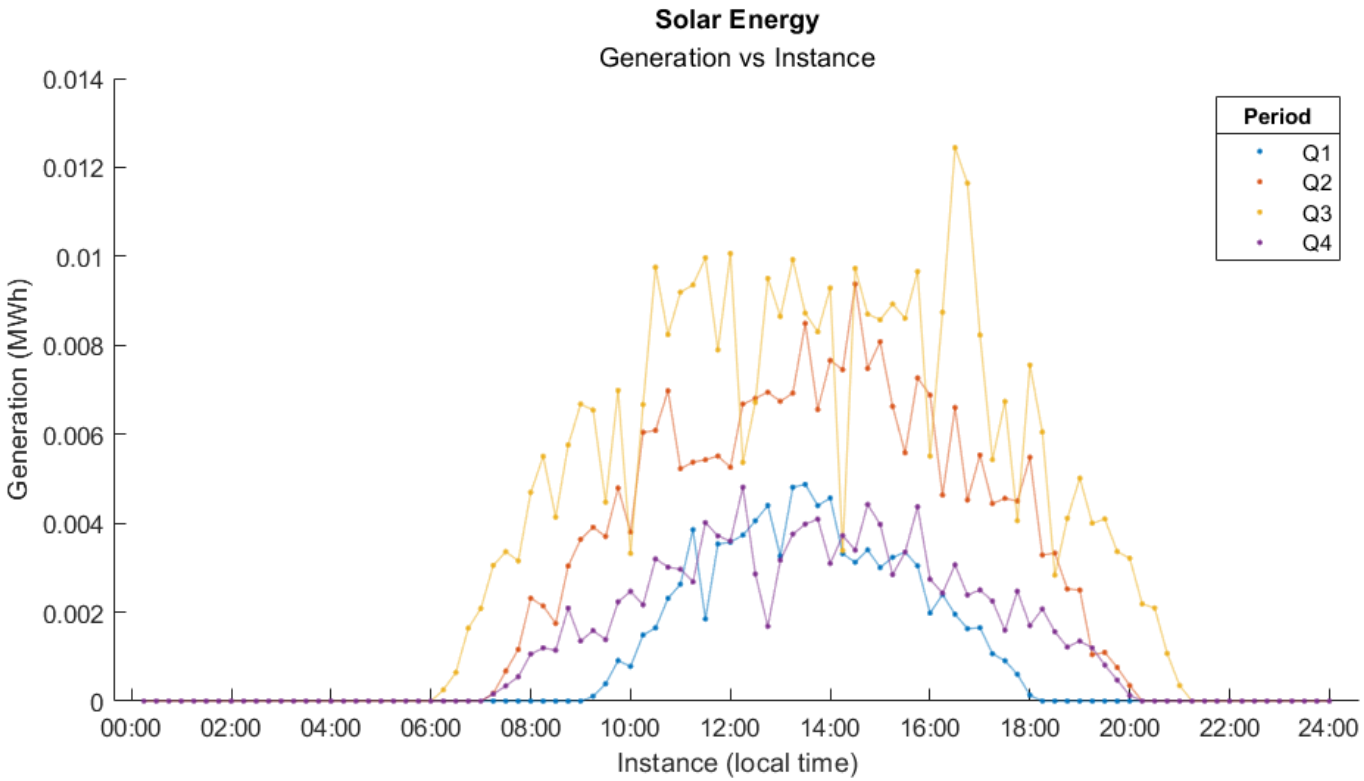
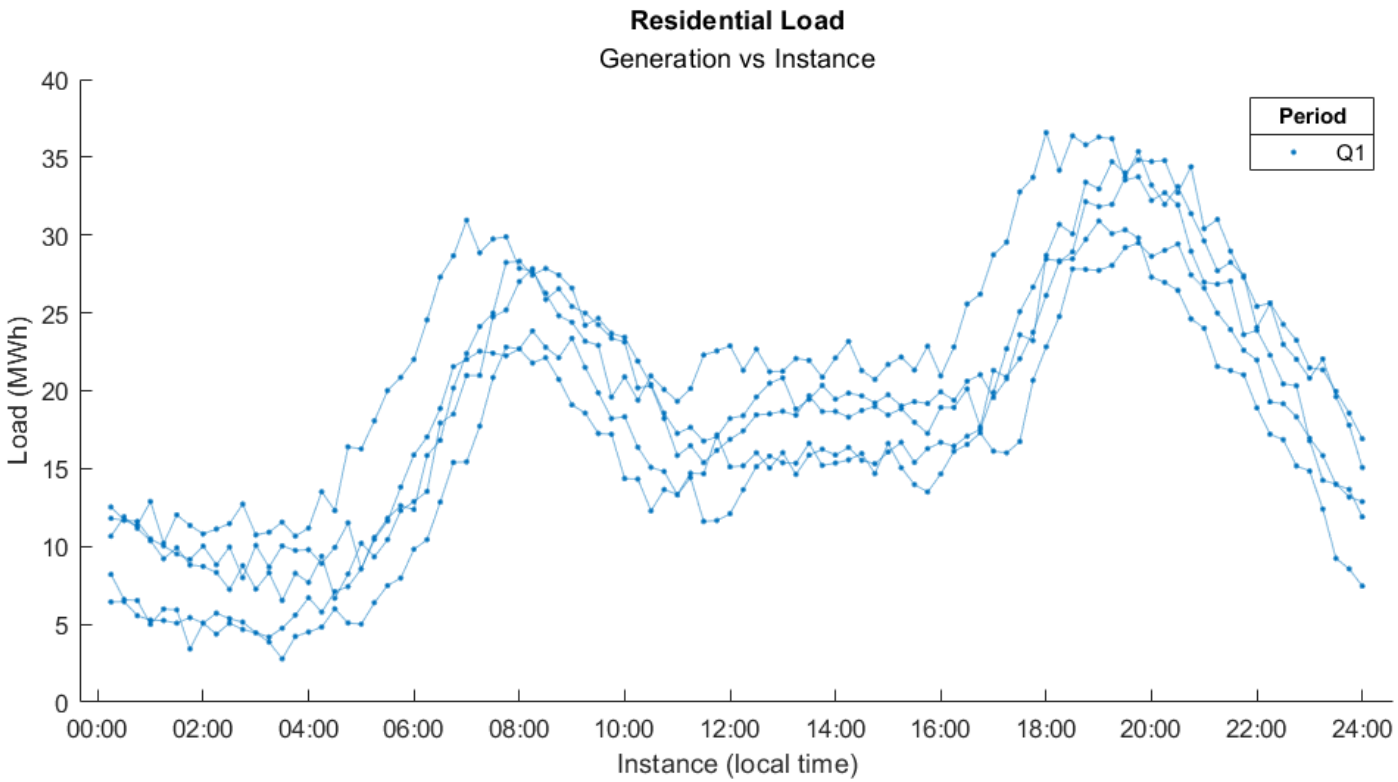


Dataset (III) - Consumi elettrici

- Totale campioni: 2688 (Load)
  - Quarter: 4 giornate
  - Location: 7 posizioni
  - Instance: 96 rilevamenti (15 m)



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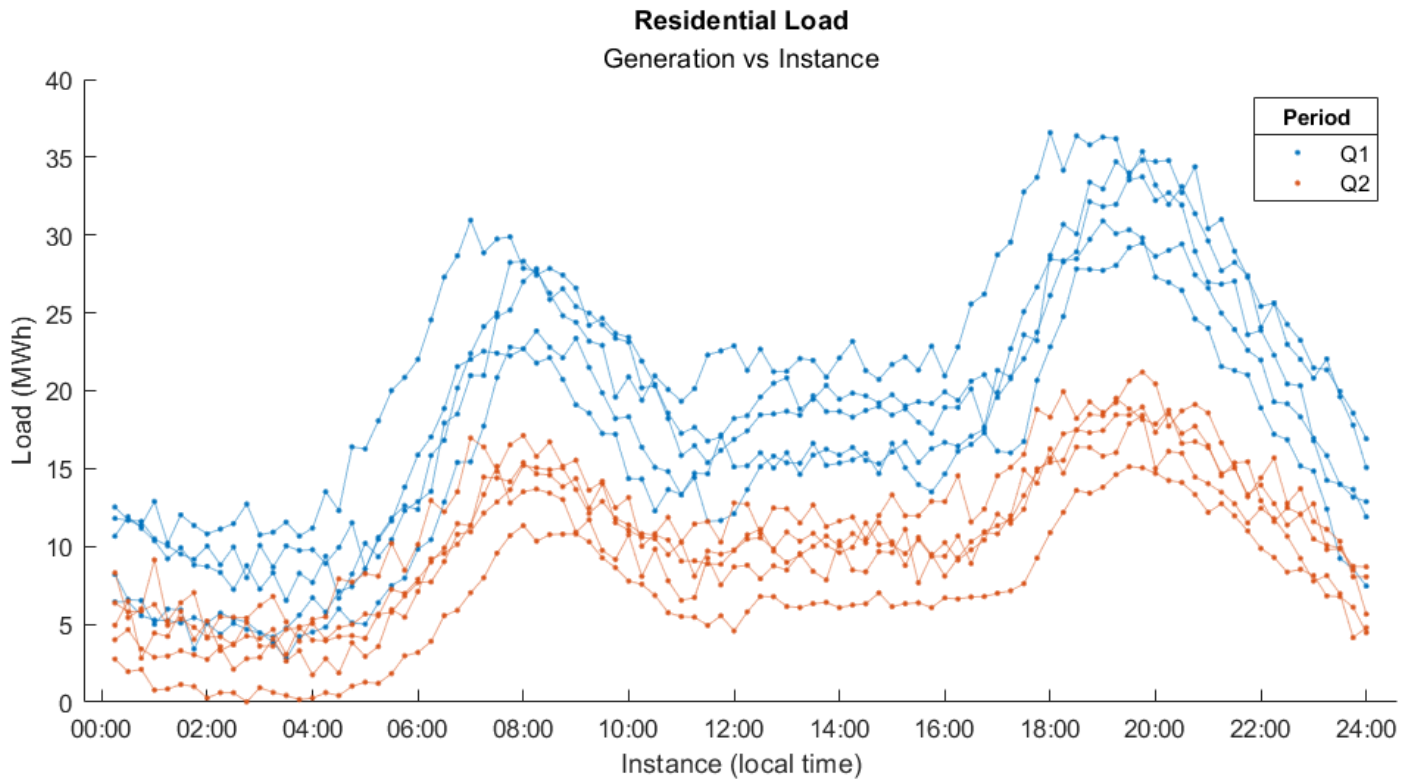

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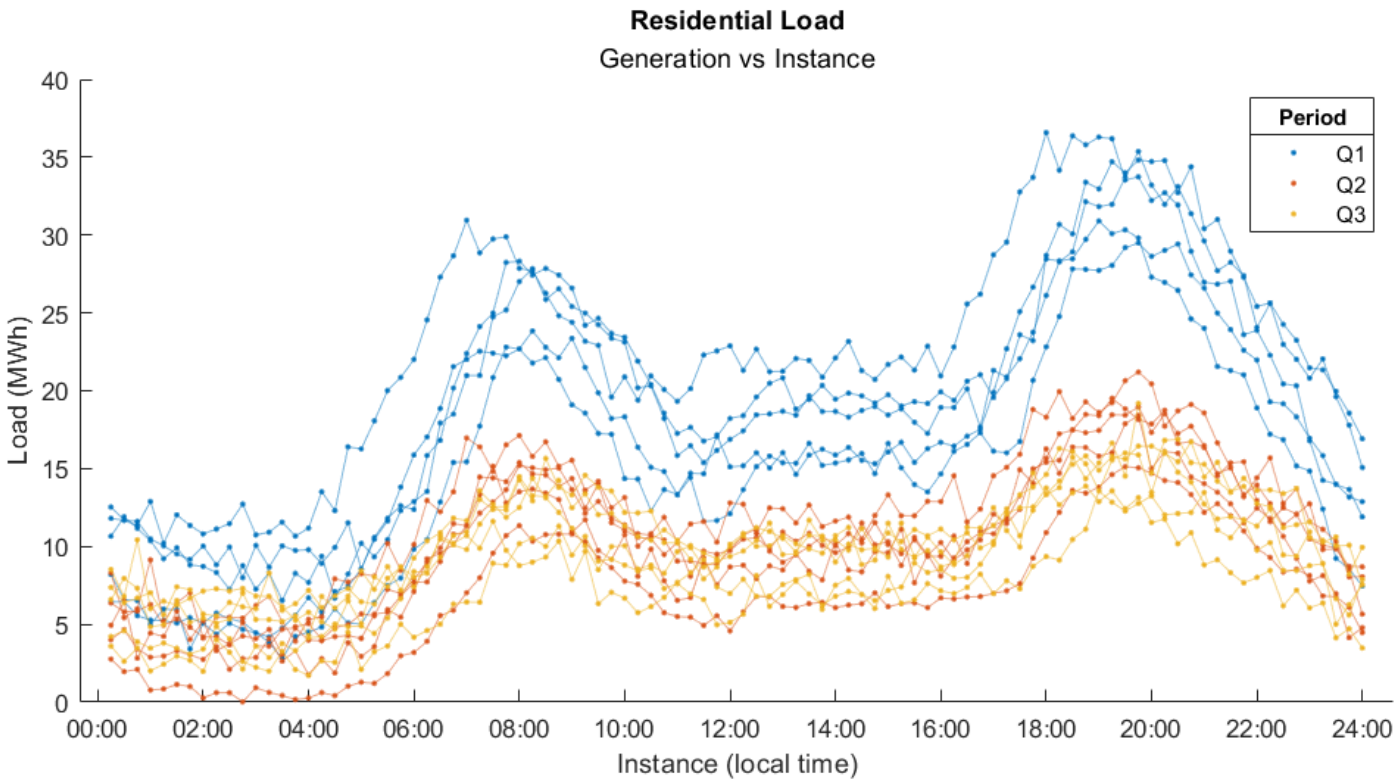

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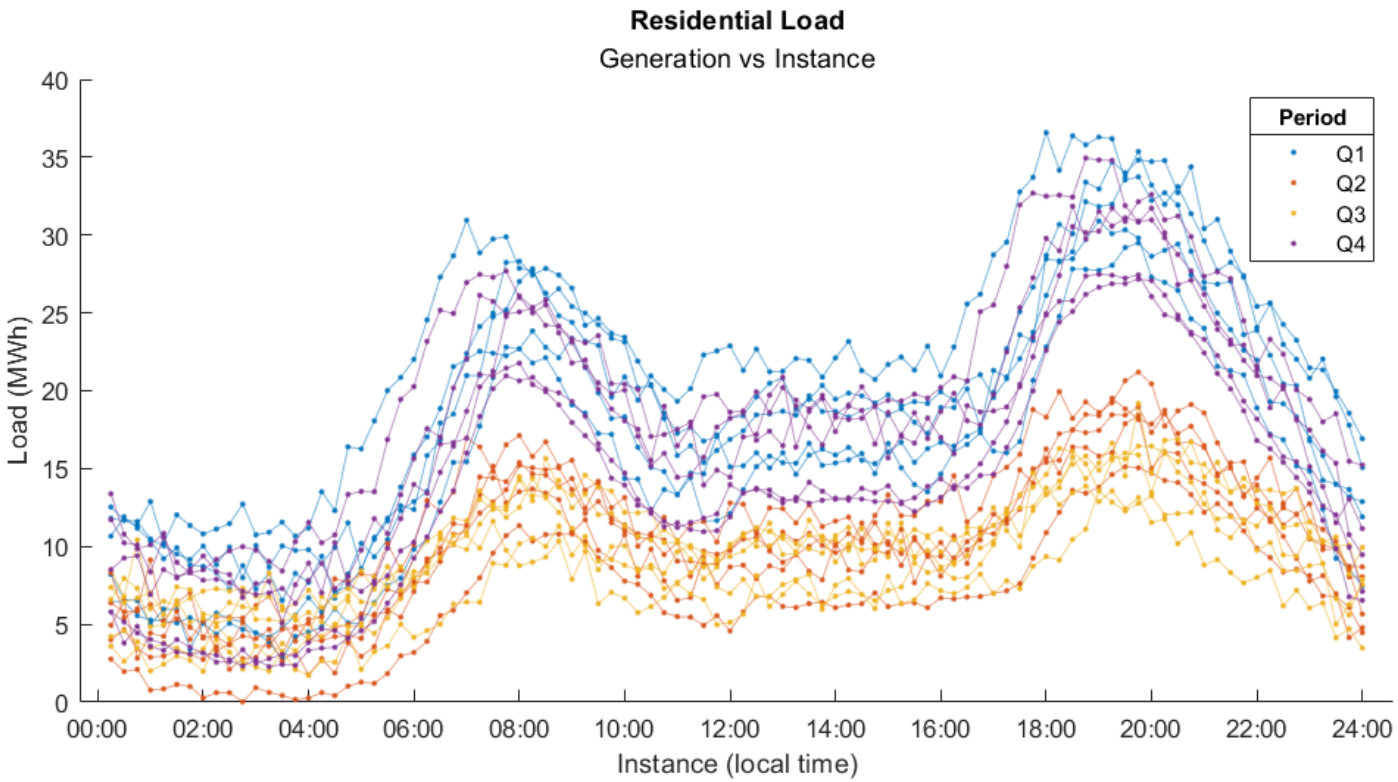

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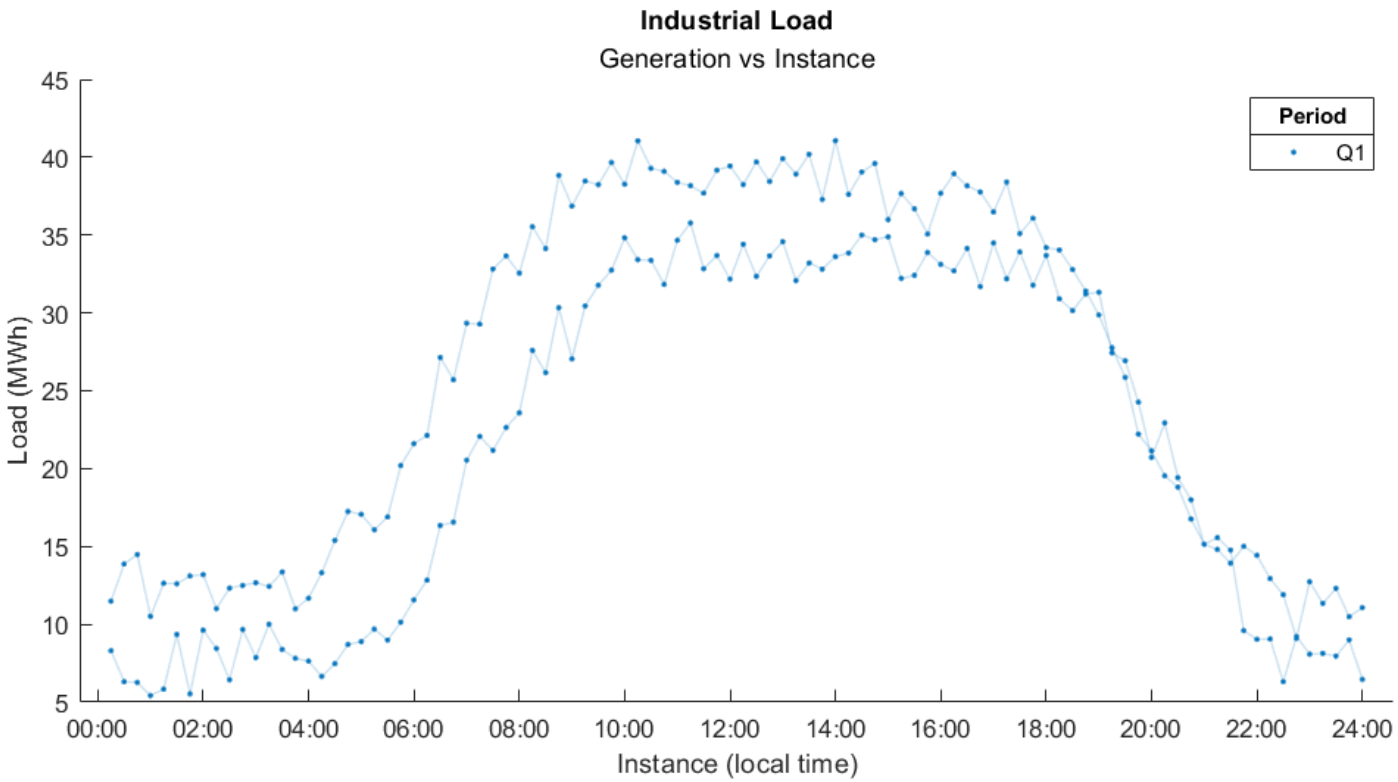

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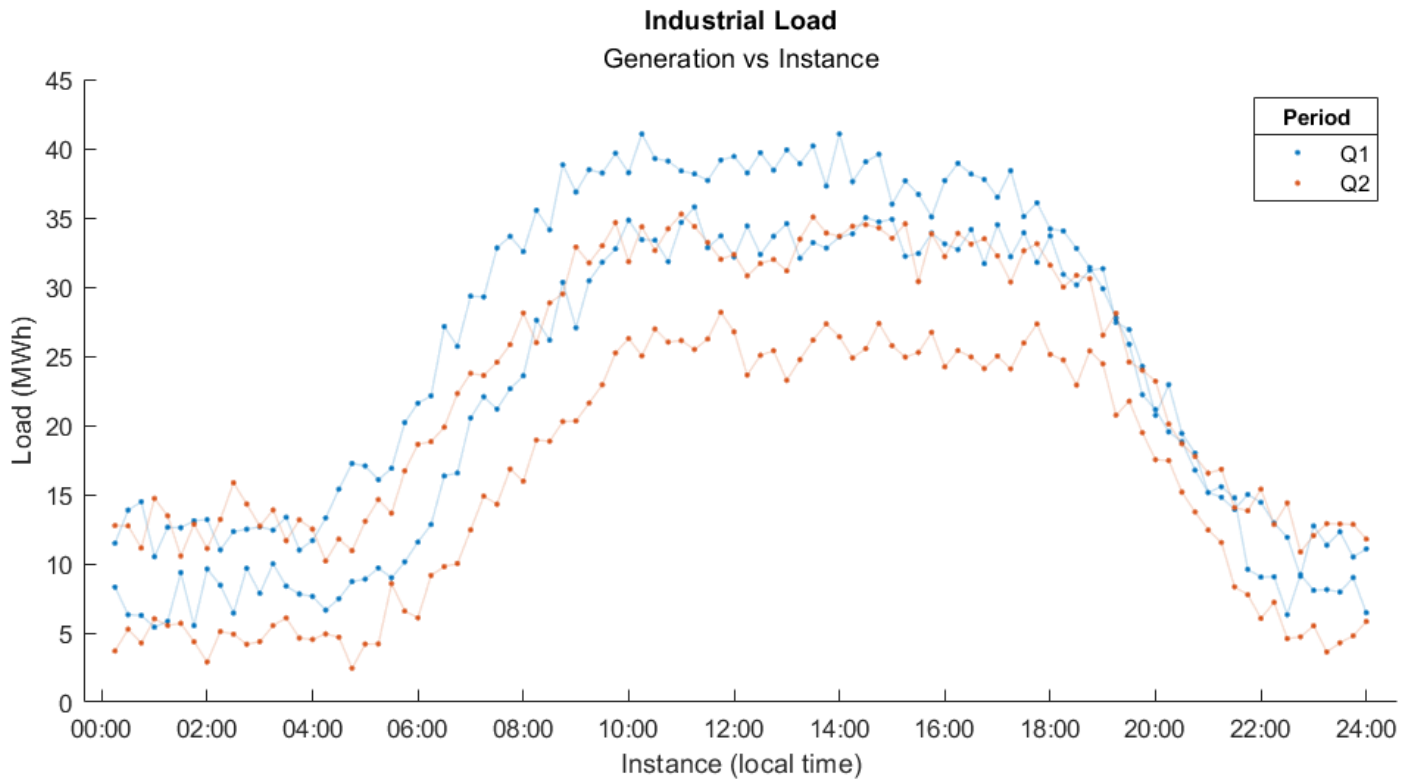

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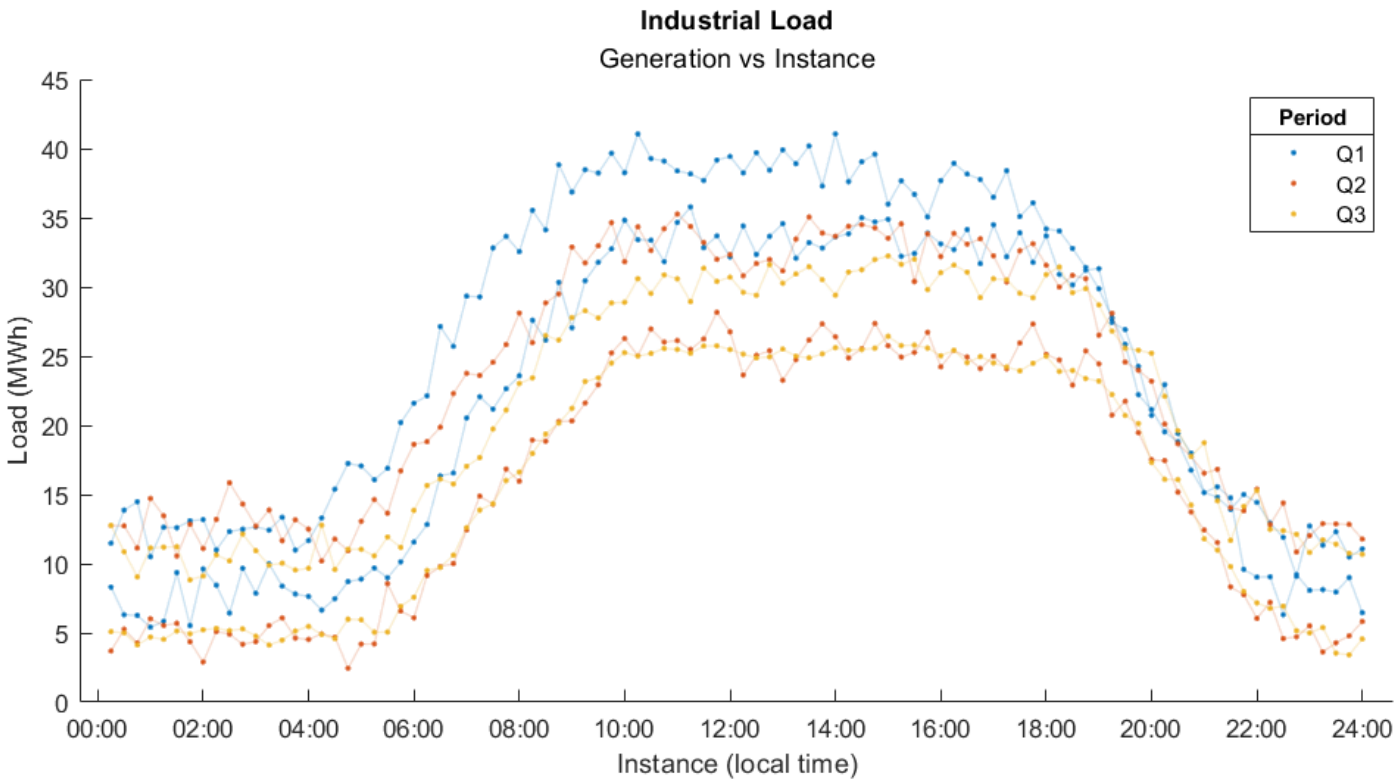

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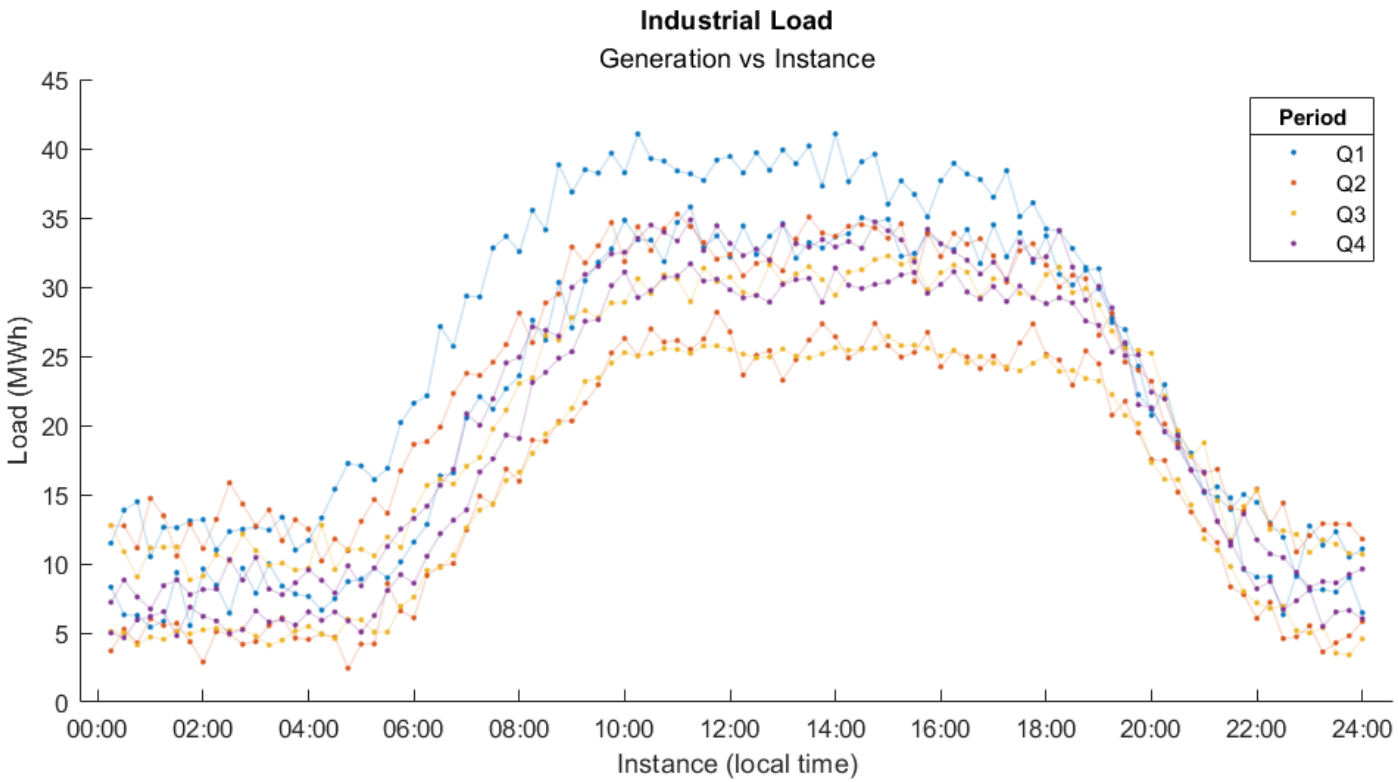
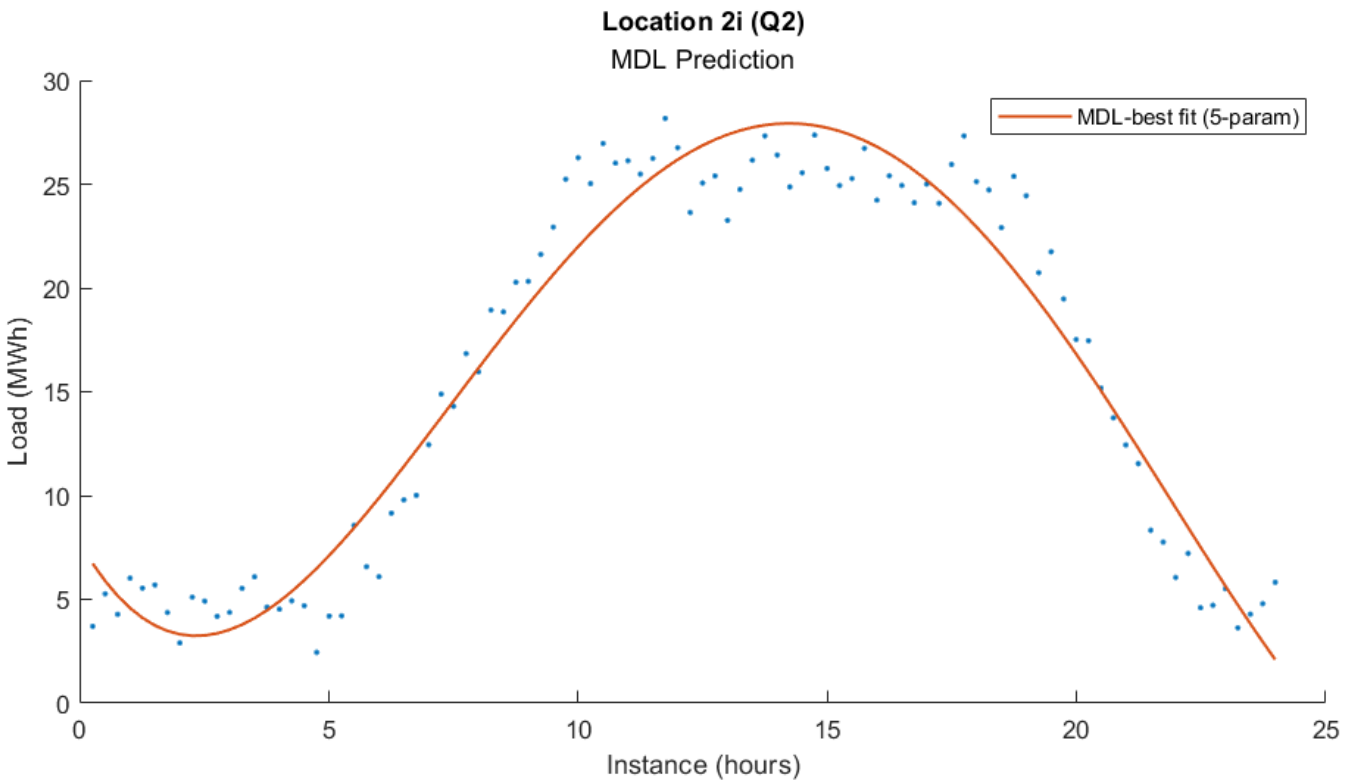


Consumi elettrici - Modelli polinomiali

- Minimi quadrati
- $F(x) = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4 \ldots$
- Scelta modello: *Test F*, *FPE*, *AIC*, *MDL*, *Crossvalidazione*



5 parametri, $MSE = 5.47\text{MWh}^2$ e $R^2 = 0.95$

Consumi elettrici - Modelli polinomiali

- Minimi quadrati
- $F(x) = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4 \ldots$
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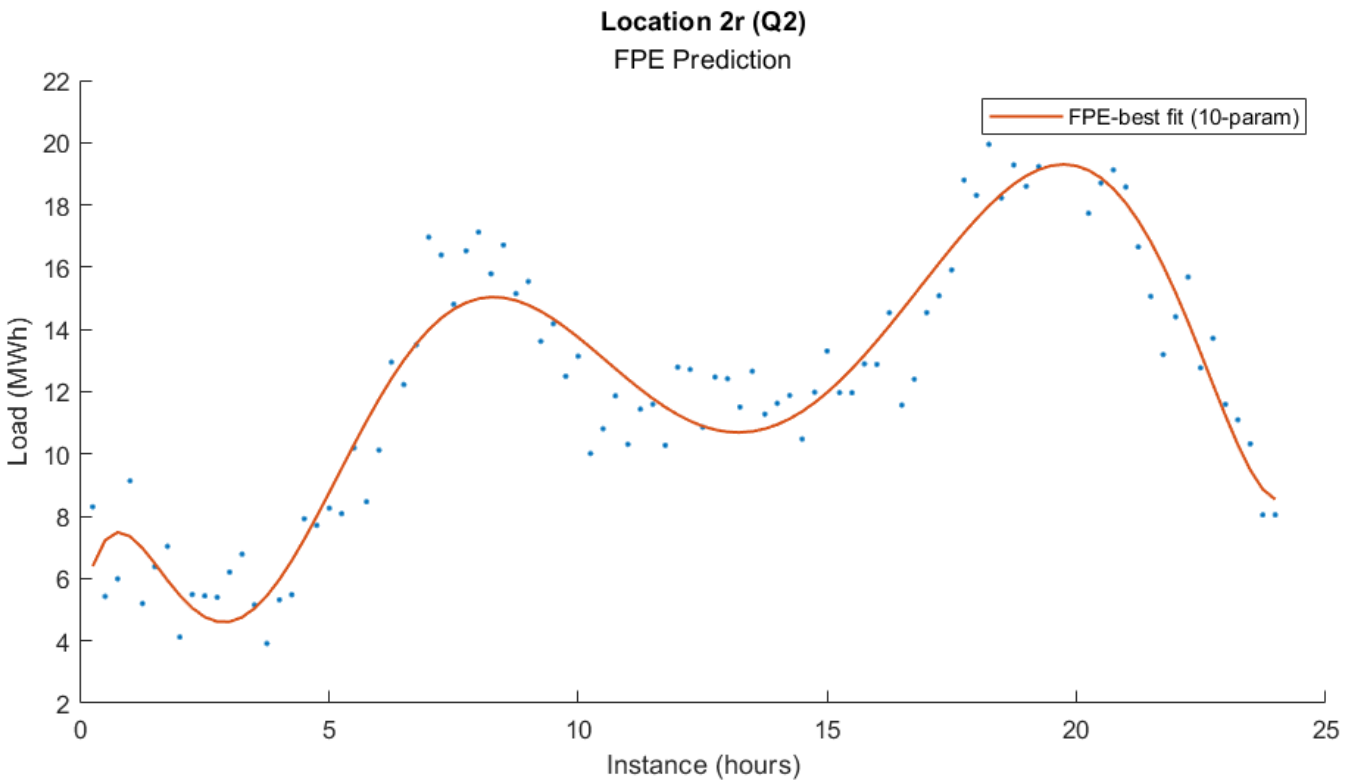
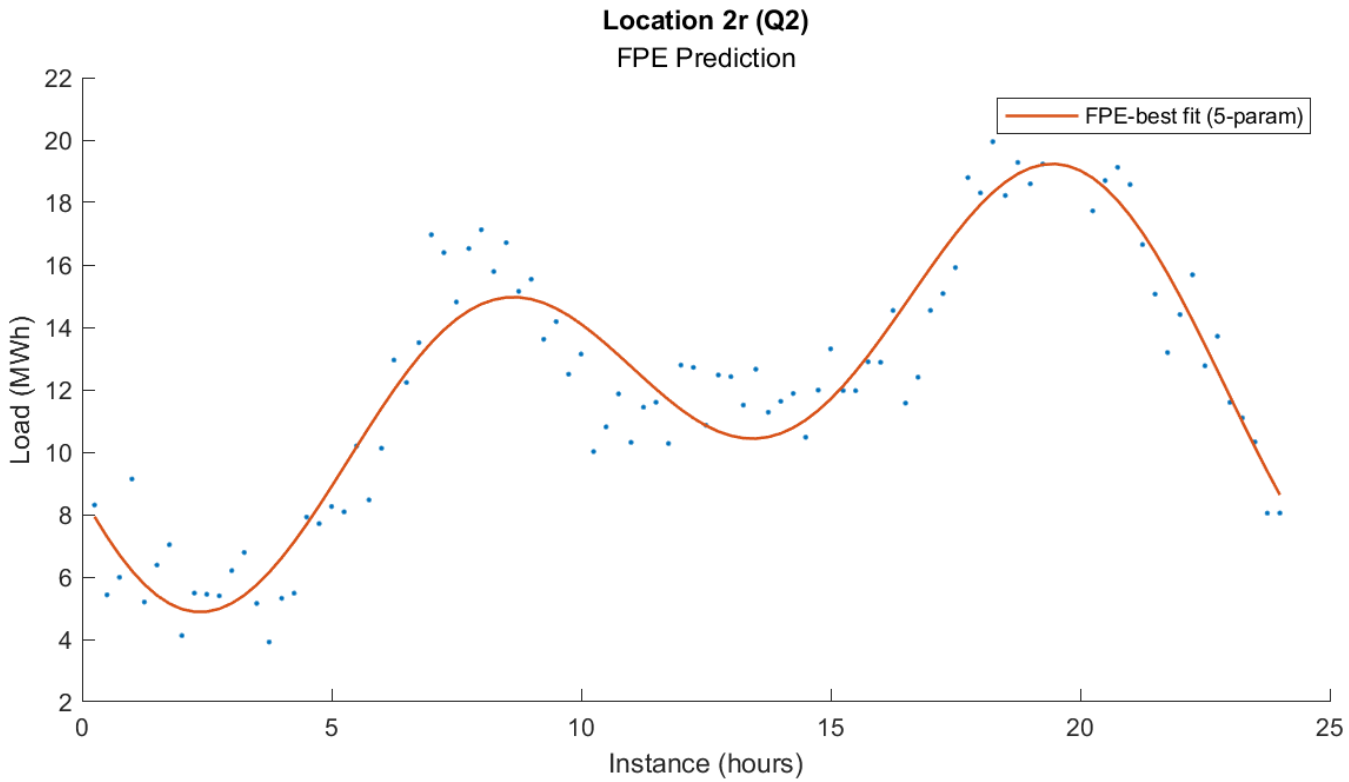


10 parametri, $MSE = 1.80\text{MWh}^2$ e $R^2 = 0.90$

Consumi elettrici - Serie di Fuorier

- $F(x) = b_0 + b_1 sin\left(\frac{2\pi}{T}x\right) + b_2 cos\left(\frac{2\pi}{T}x\right) + ... + b_{2k-1} sin\left(k\frac{2\pi}{T}x\right) + b_{2k} cos\left(k\frac{2\pi}{T}x\right)$



5 parametri, $MSE = 2.01 \text{MWh}^2$ e $R^2 = 0.89$

Consumi elettrici - Serie di Fuorier

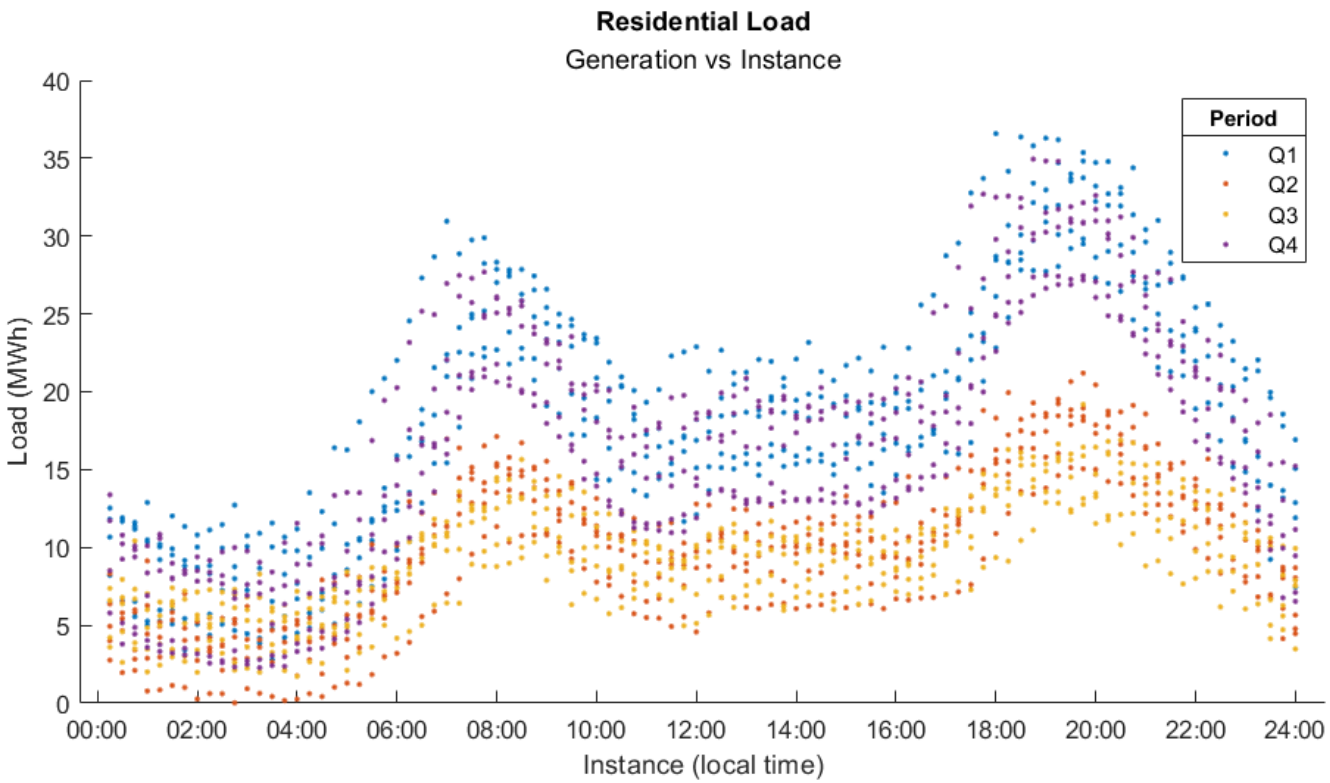
- $F(x) = b_0 + b_1 sin\left(\frac{2\pi}{T}x\right) + b_2 cos\left(\frac{2\pi}{T}x\right) + ... + b_{2k-1} sin\left(k\frac{2\pi}{T}x\right) + b_{2k} cos\left(k\frac{2\pi}{T}x\right)$

- Confronto performance e flessibilità *polinomi* vs *serie di Fourier*:

Location	**Quarter**	**Model**	**N-params (FPE)**	R^2
i1	Q1	Fourier	13	0.9907
i2	Q2	Poli	5	0.9464
r1	Q3	Fourier	5	0.8752
r2	Q2	Poli	10	0.9035

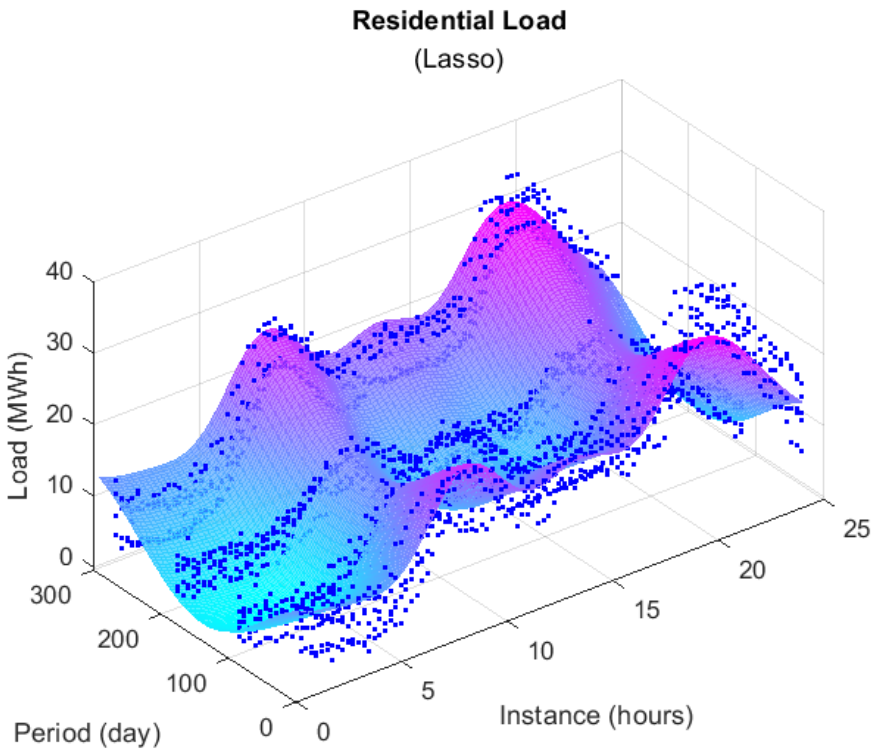
Consumi elettrici - Modelli additivi 2D

- Modello in *Instance* (hours) e *Quarter* (days)
- $F(h,d) = F_i(h) + c(d)$



Consumi elettrici - Modelli additivi 2D

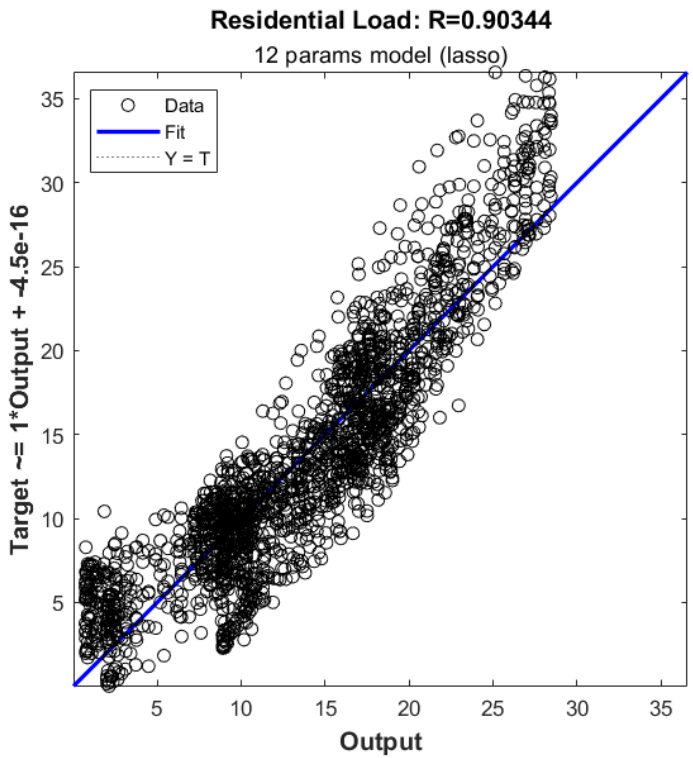
- Modello in *Instance* (hours) e *Quarter* (days)
- $F(h,d) = F_i(h) + c(d)$
- $c(d)$ di tipo polinomiale o periodico



12 parametri, $MSE = 10.2\text{MWh}^2$ e $R^2 = 0.81$

Consumi elettrici - Modelli additivi 2D

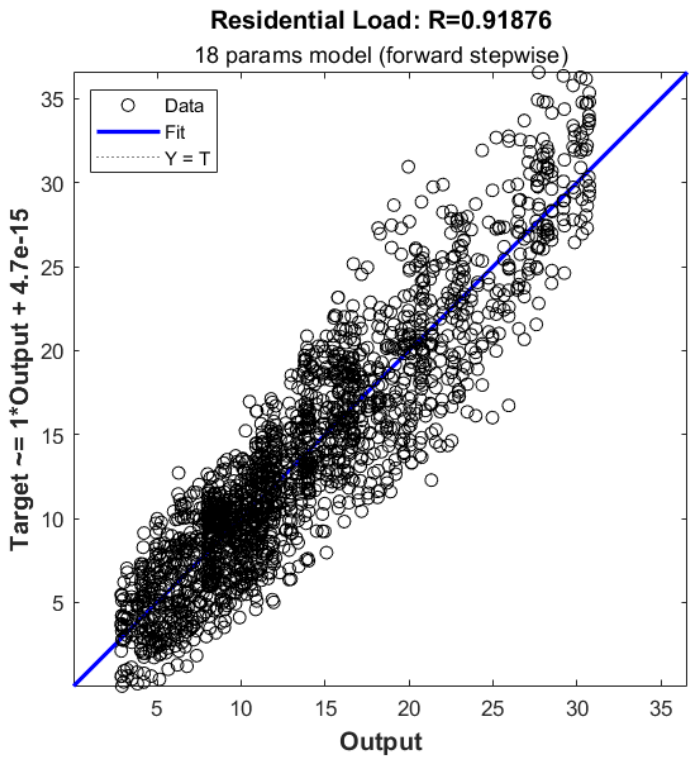
- Modello in *Instance* (hours) e *Quarter* (days)
- $F(h,d) = F_i(h) + c(d)$
- $c(d)$ di tipo polinomiale o periodico



12 parametri, $MSE = 10.2\text{MWh}^2$ e $R^2 = 0.82$

Consumi elettrici - Modelli additivi 2D

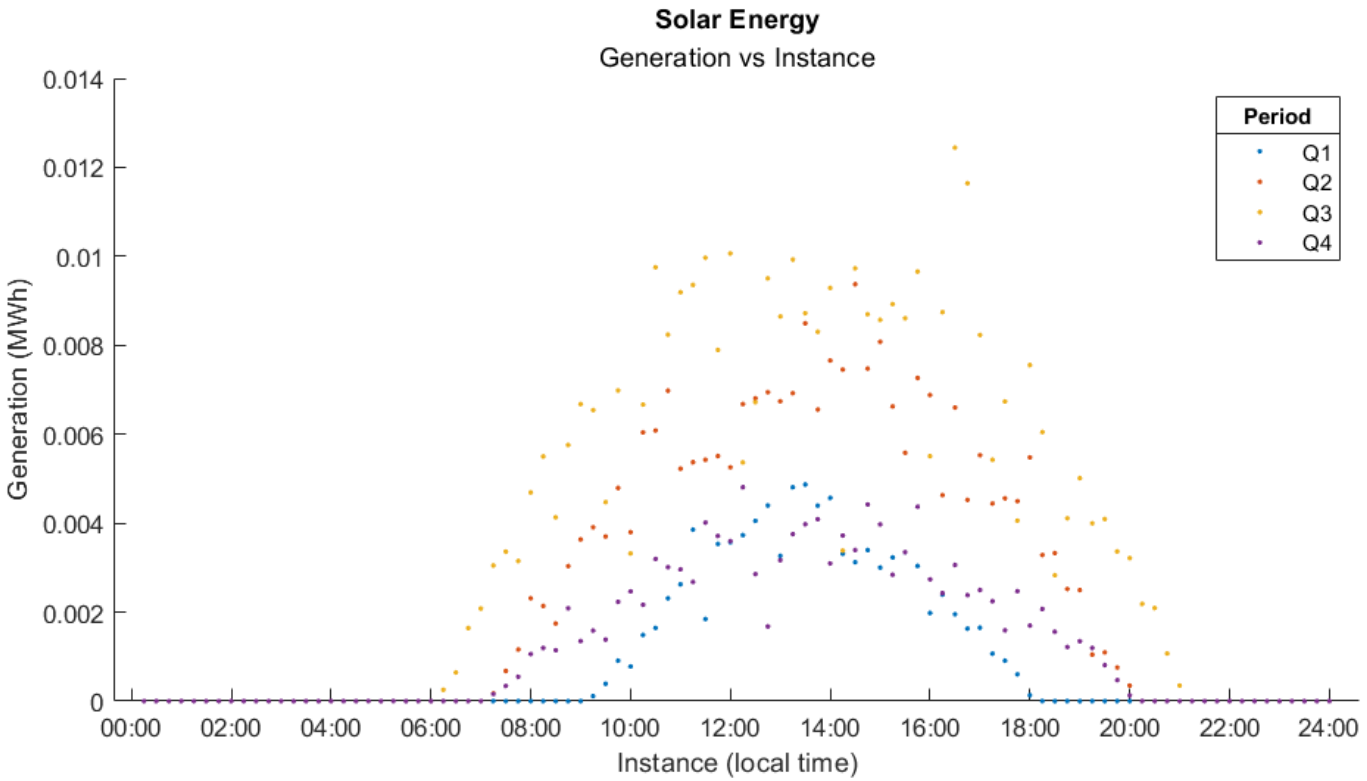
- Modello in *Instance* (hours) e *Quarter* (days)
- $F(h,d) = F_i(h) + c(d)$
- $c(d)$ di tipo polinomiale o periodico



18 parametri, $MSE = 8.72\text{MWh}^2$ e $R^2 = 0.84$

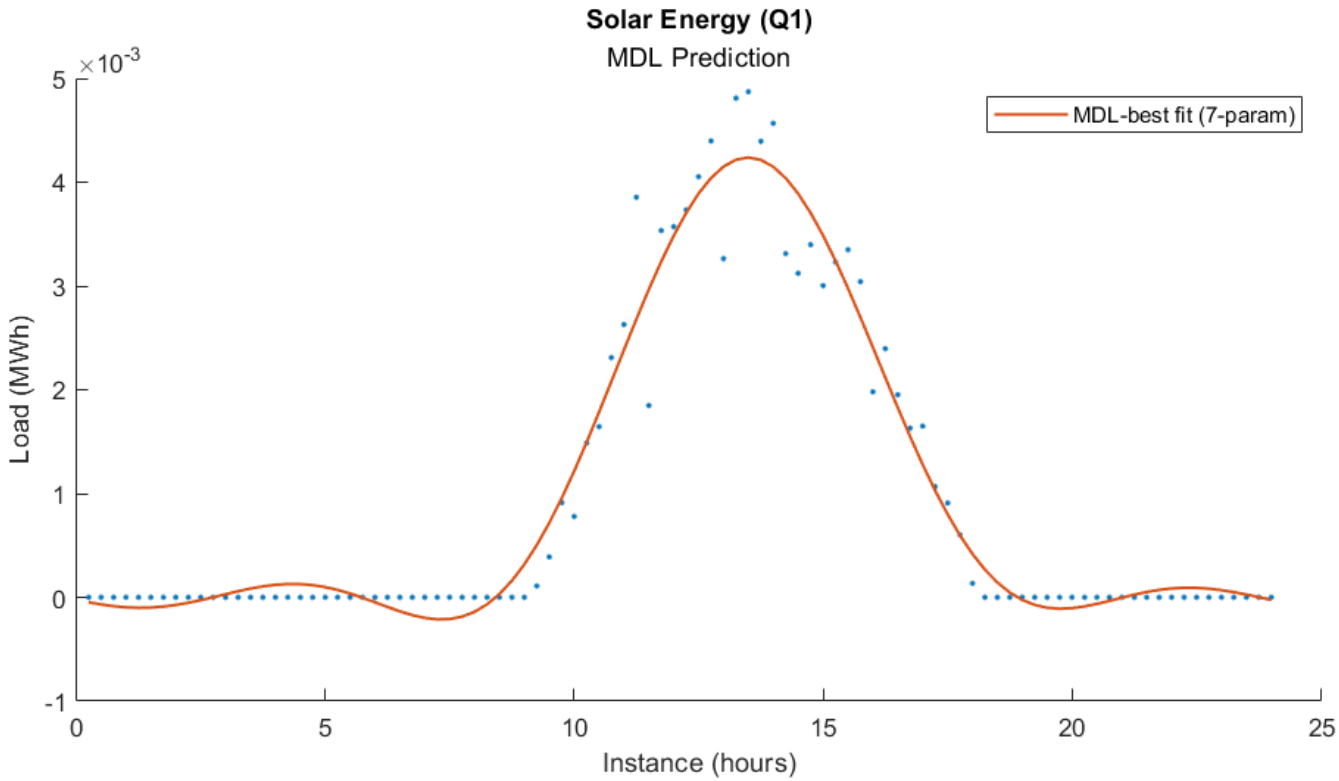
Generazione solare - Modelli 2D

- Una sola Location



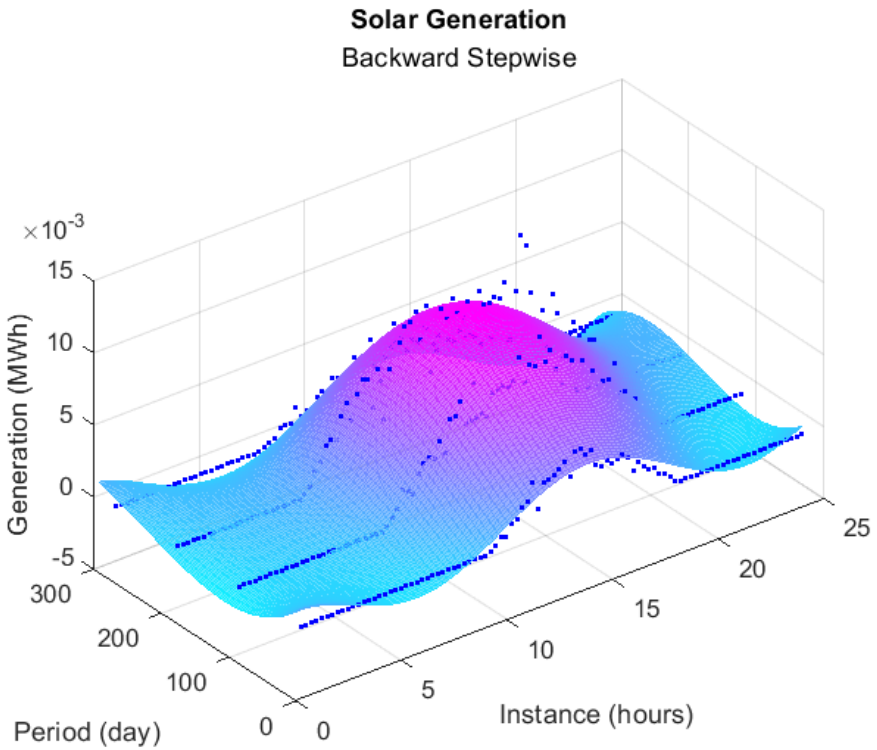
Generazione solare - Modelli 2D

- Una sola Location
- Problematiche di derivabilità



Generazione solare - Modelli 2D

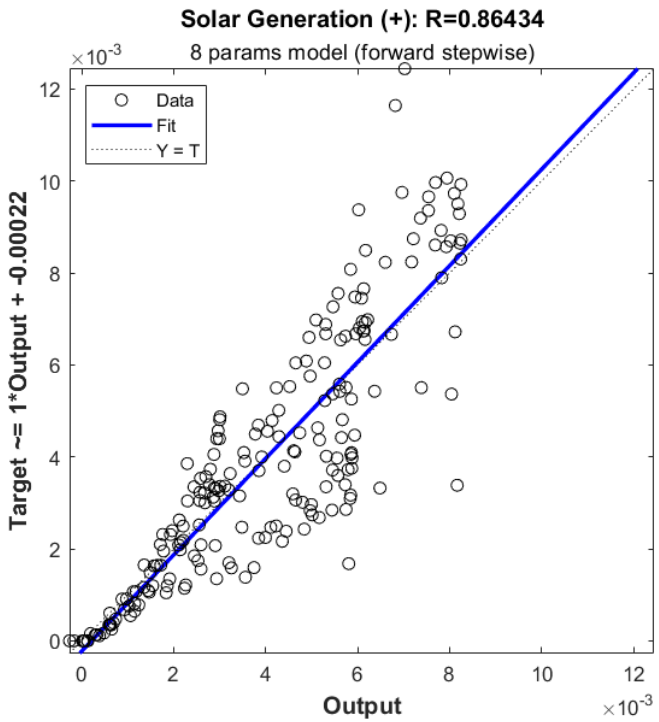
- Una sola Location
- Problematiche di derivabilità
- Feature selection: *Lasso*, *Forward stepwise*, *Backward stepwise*



15 parametri, $MSE = 9.43 \cdot 10^{-7}\,\mathrm{MWh}^2$ e $R^2 = 0.89$

Generazione solare - Generazione positiva

- $\{G|G(h,d) > 0\}$
- Teorema di Gauss-Markov
  - $\theta^{blue} = (\Phi^T \psi^{-1} \Phi)^{-1} \Phi^T \psi^{-1} Y$
- $f_I(g) = k \cdot f_I(g|s) \cdot f_I(s)$



8 parametri, $MSE = 2.05 \cdot 10^{-6}\,\text{MWh}^2$ e $R^2 = 0.75$

Generazione solare - Generazione positiva

- $\{G|G(h,d) > 0\}$
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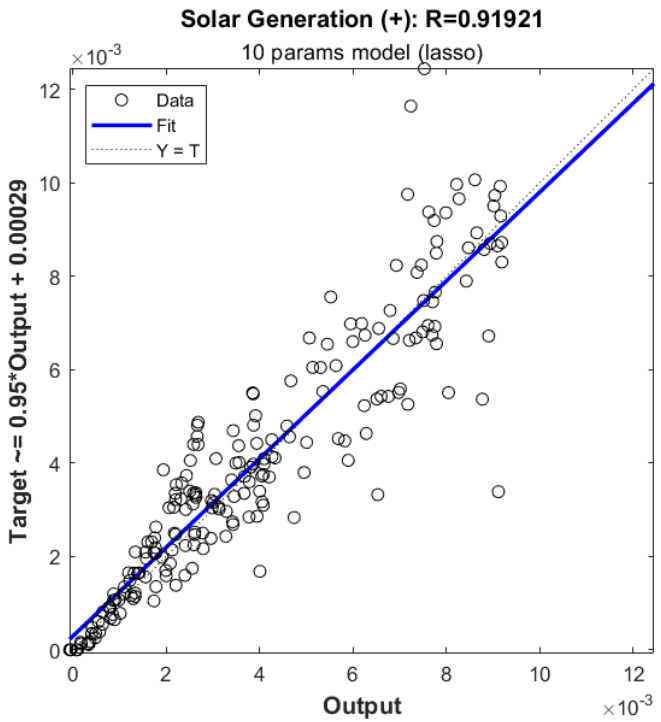
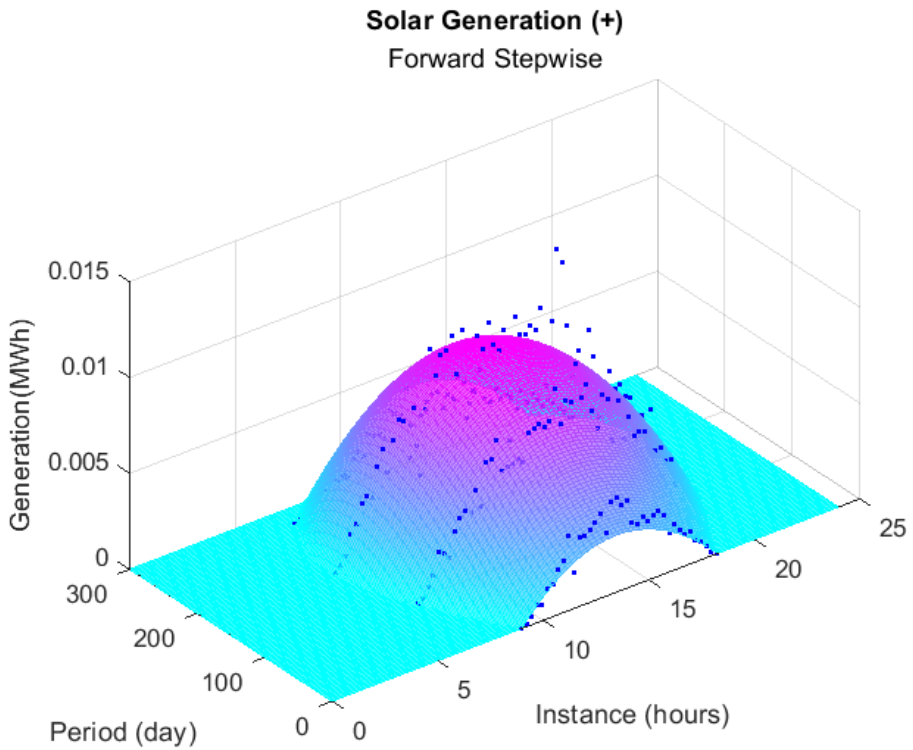


10 parametri, $MSE = 1.29 \cdot 10^{-6} \text{MWh}^2$ e $R^2 = 0.84$

Generazione solare - Generazione positiva

- $\{G|G(h,d) > 0\}$
- Teorema di Gauss-Markov
  - $\theta^{blue} = (\Phi^T \Psi^{-1} \Phi)^{-1} \Phi^T \Psi^{-1} Y$
- $f_I(g) = k \cdot f_I(g|s) \cdot f_I(s)$



8 parametri, $MSE = 2.05 \cdot 10^{-6} \text{MWh}^2$ e $R^2 = 0.75$

Grazie per l'attenzione

Esempio matrice di sensitività Φ

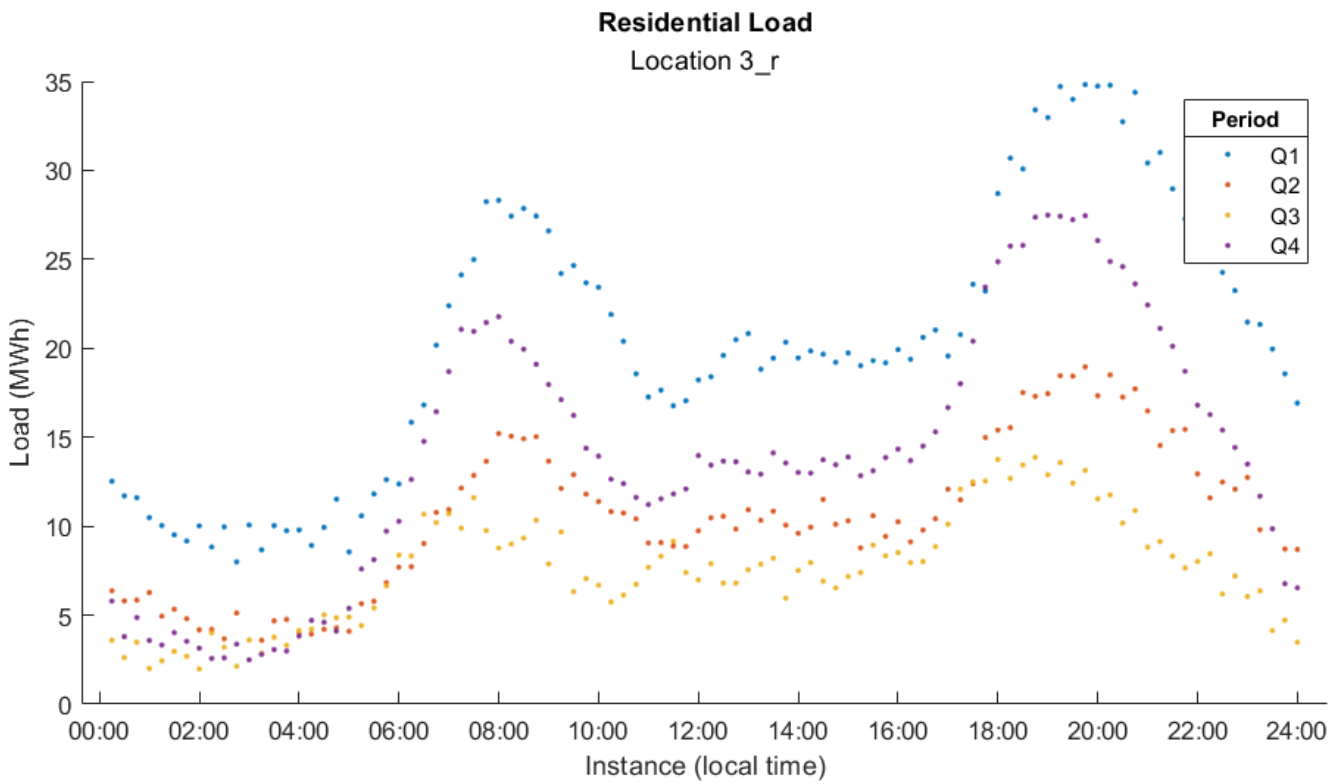
```
1  Ty = 365;
2  Td = 24;
3
4  Phi=@(instances, periods)[
5       instances.^0 ... % cost
6       ... % 1 ord
7       cos(1*2*pi/Td*instances) sin(1*2*pi/Td*instances)...
8       cos(1*2*pi/Ty*periods) sin(1*2*pi/Ty*periods)...
9       cos(1*2*pi/Td*instances).*cos(1*2*pi/Ty*periods) sin
            (1*2*pi/Td*instances).*cos(1*2*pi/Ty*periods)...
10      cos(1*2*pi/Td*instances).*sin(1*2*pi/Ty*periods) sin
            (1*2*pi/Td*instances).*sin(1*2*pi/Ty*periods)...
11      ... % 2 ord
12      cos(2*2*pi/Td*instances) sin(2*2*pi/Td*instances)...
13      cos(2*2*pi/Ty*periods) sin(2*2*pi/Ty*periods)...
14      ... % altri ordini
15      ]
```

Riferimenti

- MOPTA24 Competition Dataset, `https://coral.ise.lehigh.edu/~mopta2024/`.
- *MOPTA Competition Optimization Problem*, Marco Capelletti, Luca Danna, Anna Sacilotto.
- *The Elements of Statistical Learning*, Trevor Hastie, Robert Tibshirani, Jerome Friedman.

Load Quarter - Problemi

- “This demand data can be considered indicative of a typical demand pattern for the region during that quarter.” (AIMMS-MOPTA 2024 - "Data")
- Il testo della competizione non specifica la regolarità del campionamento durante l’anno.



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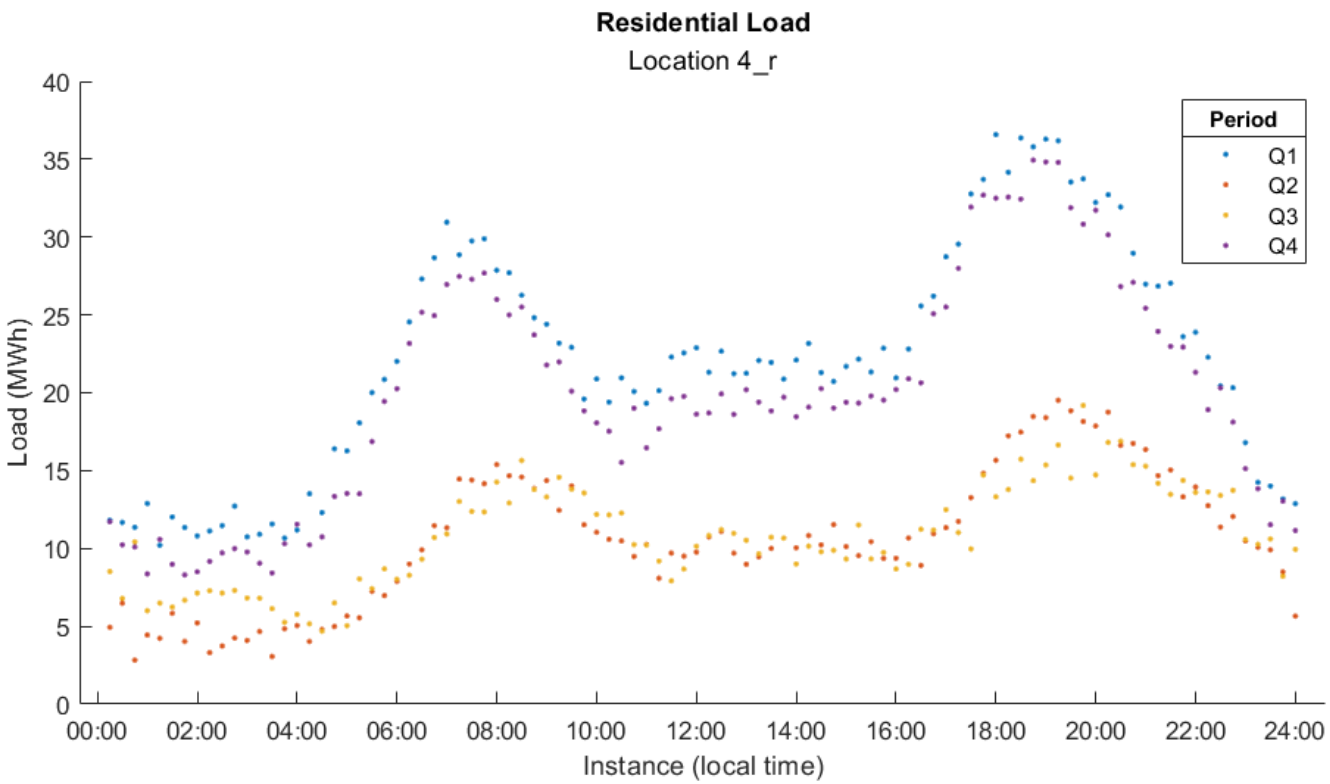

Blackout - Spagna

- Poco prima che si verificasse il blackout, si è avuto un picco di produzione di energia solare.
- Lunedì 28 alle 12.30