CONVEGNO ANIMP Sezione Energia - ATI Lombardia con la collaborazione del Politecnico di Milano – Dip. Energia

DALLA SEN ALLA DECARBONIZZAZIONE POSSIBILE CON L'OBIETTIVO DELLA CRESCITA ECONOMICA

La ricaduta sul panorama industriale nazionale

Flessibilità della domanda per la fornitura di risorse di bilanciamento: valutazioni preliminari di profittabilità

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5 luglio 2018
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Agenda

- The **Ancillary Service Market (ASM)** in Italy
  → current status and recent evolution
  !!! Authority* Decision doc. n. **300/2017/R/eel**
  in agreement with technical requirements/specifications in ENTSO-E Network Codes (EU Regulations, e.g. Guidelines about balancing - 2017/2195)

- How can **demand supply flexibility to the network**?
  → Demand response **via balancing service** offered on the real-time stage of the ASM (**Balancing Market - BM**)
  → Preliminary economic analyses:
    - **Base Transceiver Stations (BTS)**
    - some **industrial and commercial loads**

- Conclusions

**Autorità per l'Energia Elettrica il Gas e il Sistema Idrico* (AEEGSI), now *Autorità di Regolazione per Energia Reti e Ambiente* (ARERA)

The Italian Ancillary Service Market: an evolving framework

Ancillary services in Italy: current status

Compulsory services

- primary reserve for voltage regulation
- secondary reserve for voltage regulation
- primary reserve for frequency control (with optional remuneration)

Ancillary Services (AS) traded on ASM

- secondary reserve
- tertiary reserve (15-minute reserve and replacement reserve)
- congestion relief in ASM scheduling stage
- balancing

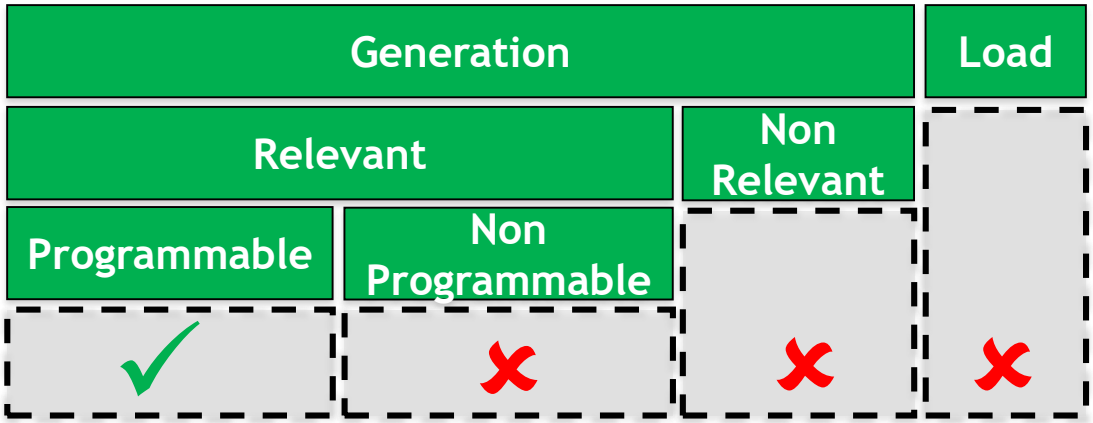
Services for emergency conditions

- remote tripping
- black start
- load rejection
- load interruption

- **Upward offers/ downward bids: quantity (MWh) and price (€/MWh)**
- Remuneration mechanism: **pay-as-bid** and **energy only**
- **Procurement via forward contracts: not excluded** (cmp UVAC pilot projects started by Decision 300/2017)

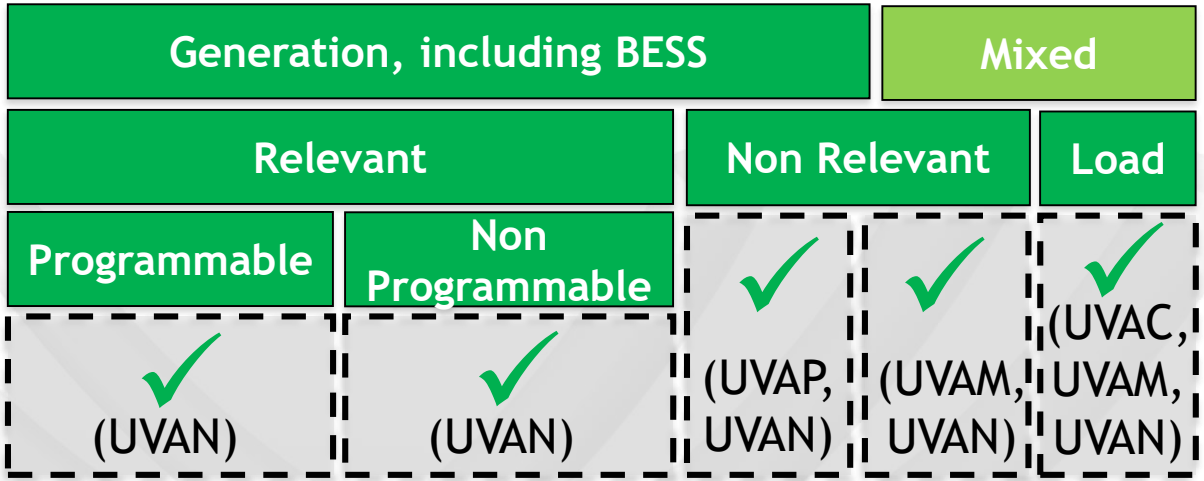
Changing requirements for ASM eligibility

ante Decision 300/2017



- Single eligible generation units
- Relevant ones: ≥ 10 MVA
- Minimal gradient: 10 MW in 15 minutes

post Decision 300/2017 (pilot projects)



- Also aggregated resources: «**Unità Virtuali Abilitate» - UVA: eligible virtual units**
- Aggregations refer to **geographical perimeters (network constraints)** and to **typologies of resources**

- **UVAC: consumption** eligible virtual units
- **UVAP: production** eligible virtual units
- **UVAM: mixed** eligible virtual units
- **UVAN: nodal** eligible virtual units: same electrical node of the transmission grid

UVAC projects started by Decision 300/2017: specifications

Service supplied:

- upward **tertiary replacement reserve** → reduction of absorption
- participation in the **Balancing Market (BM)**

Requirements for each UVAC:

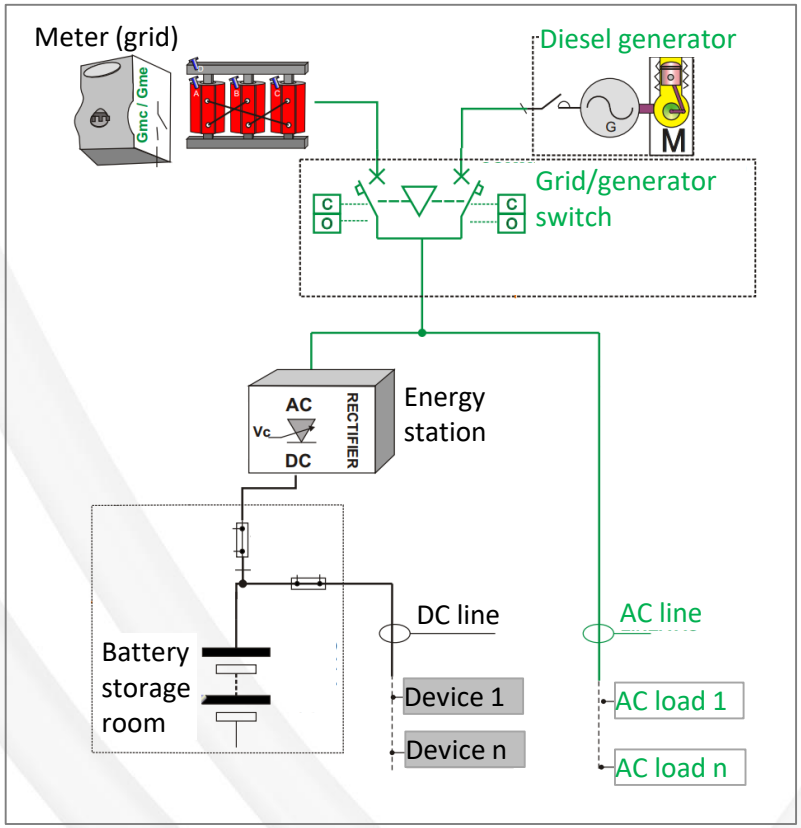
- max control power of the aggregation ≥ **1 MW**
- power of each aggregated point > **55 kW** (load unit with hourly measure)
- modulation of absorption by **15 minutes** from Terna's dispatching order
- ability to keep the reduction for **3 consecutive hours at least**
- load units within the same **geographical aggregation perimeter**

Remuneration:

- **forward contracts for procurement of capacity** in defined periods (e.g. Jun-Sep 2017 for units in the North and Centre North zones)
  - capacity payment: offers have to be presented from 14:00 to 20:00 for 3 consecutive hours at least
  - descending price auction mechanism starting from **30 k€/MW/y** (double if offer in all the 6 hours)
- **offers on BM and «pay as bid» remuneration of energy if the offer is accepted**
- **both choices**
- recall 400 €/MWh **cap (strike price)** on offer price

Case study:
flexibility service on the Balancing Market by multiple-site loads

Base Transceiver Station (BTS): typical layout and features

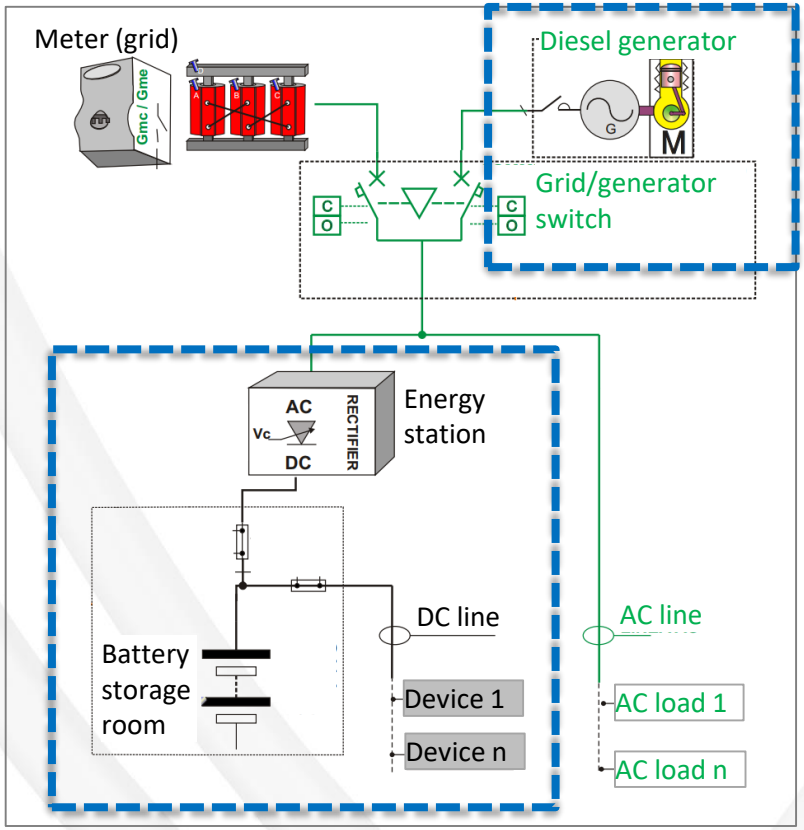


- **Loads**:
  - DC (data transmission devices),
  - AC (air conditioning, lighting)
- **Power sources**:
  - main one: the grid
  - auxiliary ones:
    Battery Energy Storage Systems (BESS) for DC loads, diesel generators for the station
- **Consumption profile**: almost constant (variability due to air conditioning)
- **Backup sources**: almost always in *standby*: 1 or 2 interruptions a year
- **BTS size**: few tens of kW to >1000 kW
- **Number of BTS** in Italy: > 50000, almost all connected to the transmission grid

Interesting!

- **Distributed resource…wide-spread indeed**
- **Highly controllable (centralized remote control)**
- **Very predictable load**
- **Backup sources almost always available (battery storage systems, diesel generators)**

Case study: assumptions



BESS:

- Nominal power (P_n): 50 kW
- Flexible power (fully utilized): around 85% P_n
- Efficiency: 85%
- Capacity fade rate: 10%/y @ 1 charge/discharge cycle/day
- Replacement cost: 270 €/kWh (VRLA)
- Energy capacity: (up to) 4 h
- Cost for charge restoration (absorption from the grid): 140 €/MWh (bill)
- Number of BTS: 1000 units

Diesel generators:

- Nominal power (P_n): 300 kW
- Flexible power (utilized at 25%): around 80% P_n
- Efficiency: almost 30% (4 kWh/l)
- Fuel cost: 1 €/l
- Number of BTS: 3000 units

Costs for ICT and plant upgrade

(measurement/monitoring, control, communication between plant and TSO/controller):

- ICT infrastructure: 250 k€
- monitoring and remote control device: 5 k€/plant with BESS, 9 k€/plant with diesel generator
- OPEX: 5% investment for plant remote control, 8% investment for ICT platform management

Assumptions for economic evaluations

Service (ref. n. 300/2017):

- upward tertiary reserve: **balancing**
- **1 call a day**: the **first one** composed of **consecutive quarters of an hour** and with max duration X = 1, 2, 3, 4 h
- **ex-post acceptance criterion**: in each quarter of an hour *q*, an offer at price *p* is accepted if $p \leq p_{max}$, with p_{max} the maximum historical price which was actually accepted in *q*
- if BTS with BESS: subsequent SoC restoration (later on), with no increase of costs wrt load contract with the trader

Remuneration:

- **Case 1**:
  - offer service in the **1-24 h time interval**
  - pay-as-bid energy exchange on the market
    - profit = sum(remuneration from market – unique national price PUN)
- **Case 2**:
  - offer service in the **14-20 h time interval**
  - pay-as-bid energy exchange on the market
    AND
    capacity payment: 25-30 k€/MW/y, 400 €/MWh strike price

Simulations

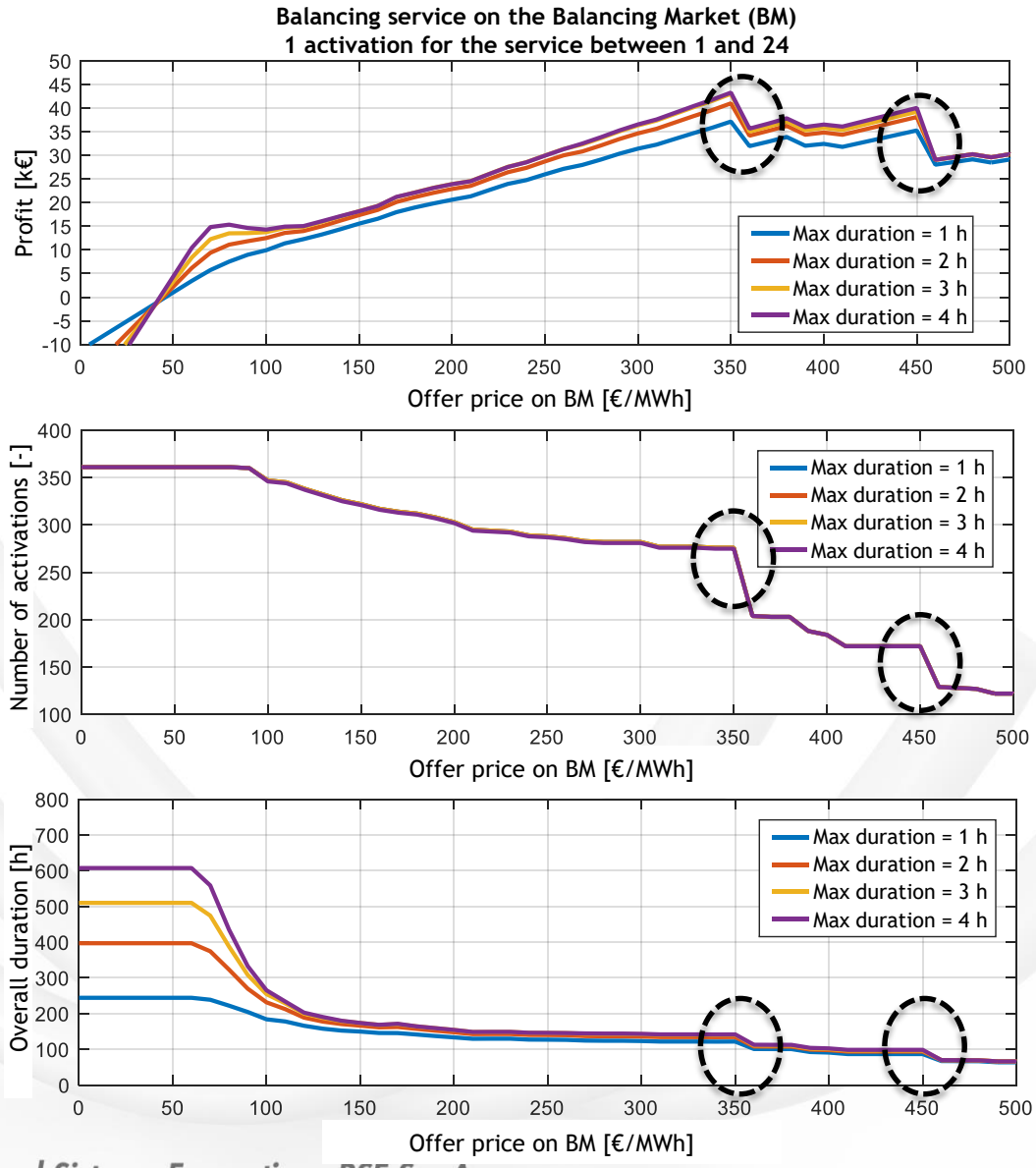
- **Highlight the most rewarding price levels**
  Simulate **offer, for 1 MW load reduction, at fixed price *p*** for 1 year (Aug 2016-Jul 2017)
  - Profit = sum(remuneration from market – unique national price PUN) per year
  - Number of interruptions per year
  - Duration (h) of interruptions
- **Assess investment profitability**
  Compute **PayBack Period (PBP), with BESS or diesel generator backup source**

Costs and Revenues	
C1	ICT upgrade
C2	plant upgrade
C3	OPEX for ICT upgrade and plant upgrade
C4	increased absorption for SoC restoration, due to battery storage losses
C5	fuel for diesel generator
C6	cost for battery elements replacement
C7	fee for BSP (here 10% of net revenue from energy exchanges on market)
R1	energy exchange on BM (Case 1 and Case 2)
R2	capacity payment (Case 2)

PBP with battery storage = (C1+C2)/(R1+R2−C3−C4−C6−C7)

PBP with diesel generator = (C1+C2)/(R1+R2−C3−C5−C7)

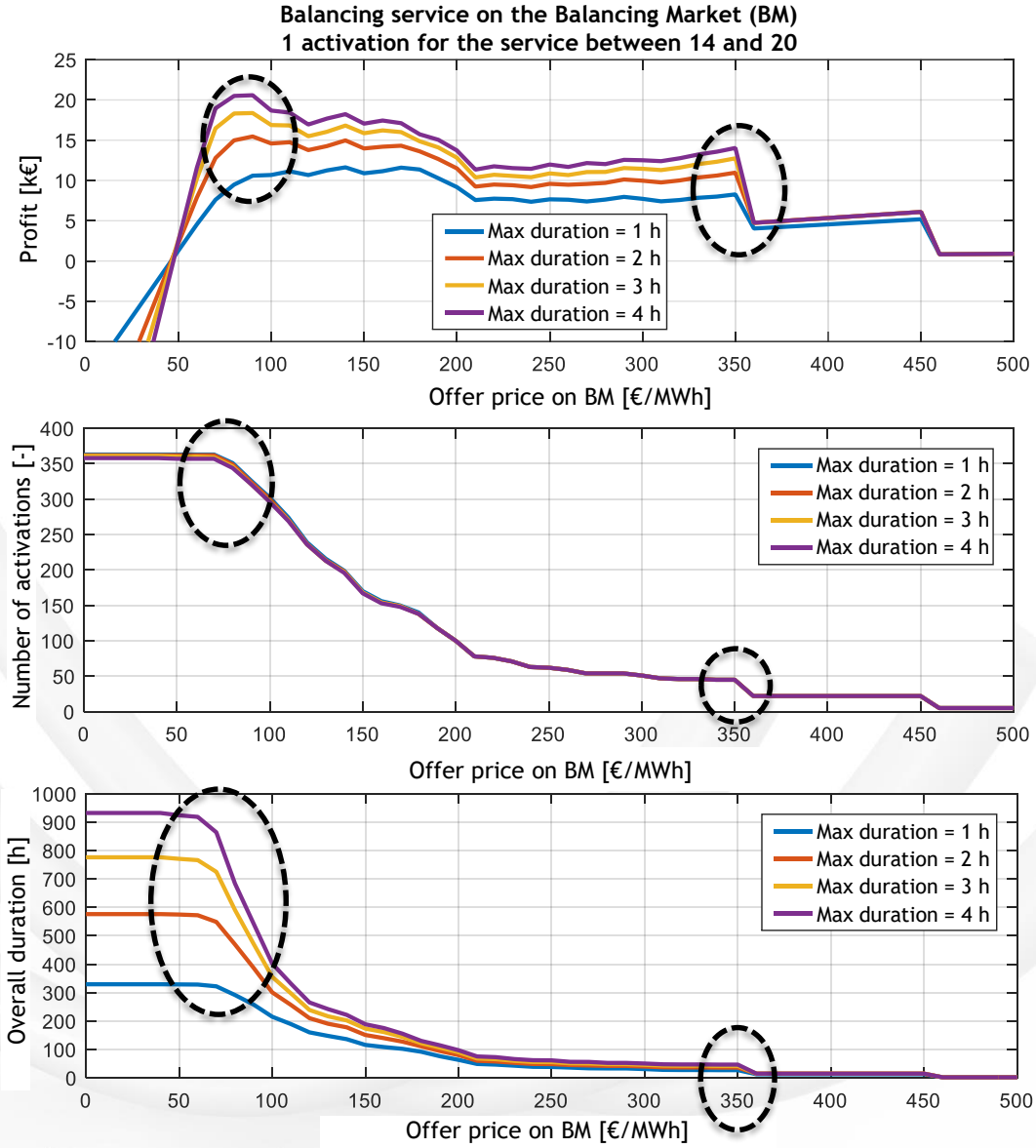
Results: Case 1



Most rewarding prices

- p_1=350 €/MWh:
  - 275 calls (activations)
  - mean duration ≤ 0.5 h
- p_2=450 €/MWh
  - 170 calls (activations)
  - mean duration around 0.5 h

Results: Case 2



Most rewarding prices

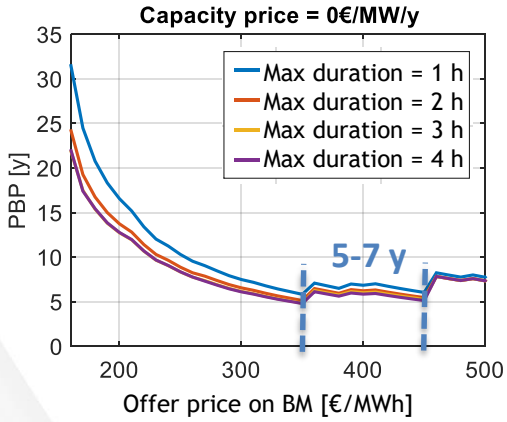
- p_3=80 €/MWh
  - 350 calls (activations)
  - mean duration around 1 h, 1.3 h, 1.7 h, 2 h, for X = 1 h, 2 h, 3 h, 4 h
- p_4=350 €/MWh
  - 50 calls (activations)
  - mean duration from around 0.5 h to 1 h, according to X

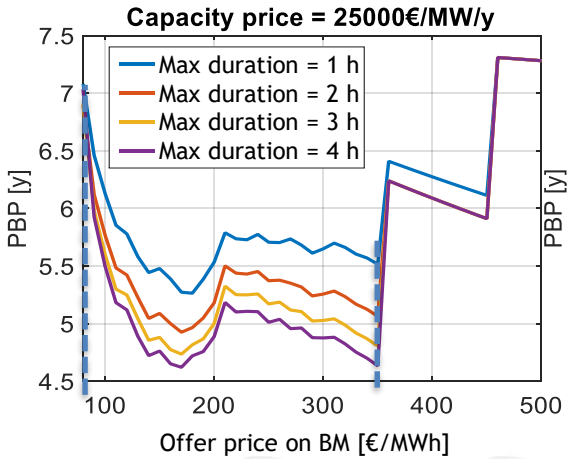
Results: PBP in Case 1 and 2

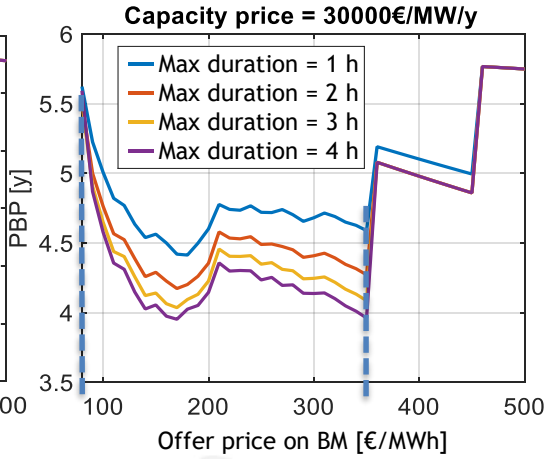
Case 1

Case 2

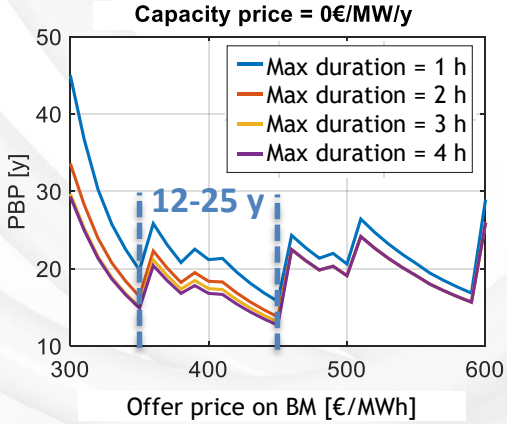
Battery storage

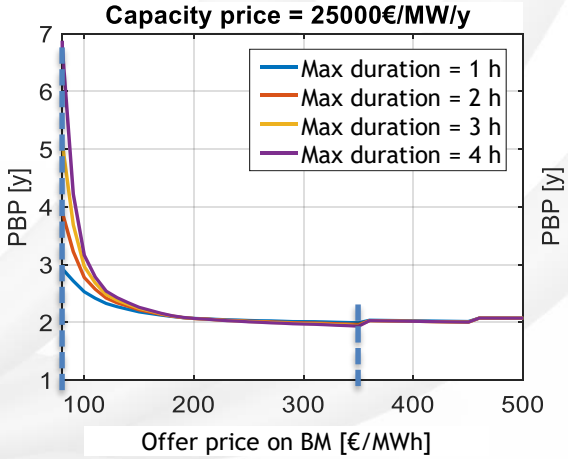


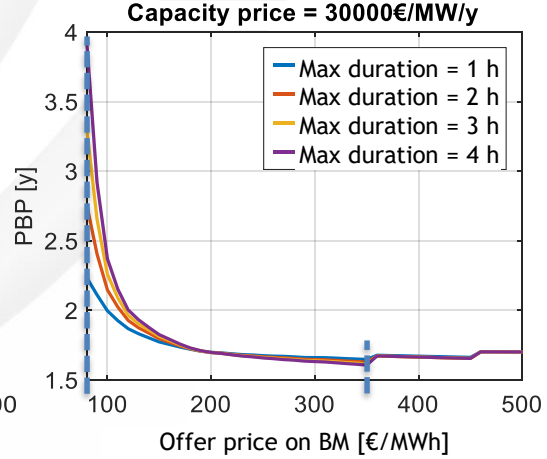




Diesel generator







Flexibility service on the Balancing Market by a constant load/real loads

Premise: data about real loads

Data:

- **28 loads** in Italy:
  - 5 energy-intensive loads: foundries (F1 to F5);
  - 5 food industries (A1 to A5);
  - 2 supermarkets (D1 and D2);
  - 5 glassmakers (V1 to V5);
  - 6 technical gas industries (G1 to G6);
  - 5 cooling industries (R1 to R5).
- **Energy consumption** (in MWh)
  for each quarter of an hour
  over a six-month time interval T (1st January-30th June 2017)

Assumptions for economic evaluations

Service (ref. n. 300/2017):

- upward tertiary reserve: balancing
- 1 call a day: the first one composed of consecutive quarters of an hour and with max duration X = 1, 2, 3, 4 h
- ex-post acceptance criterion: in each quarter of an hour q, an offer at price p is accepted if $p \leq p_{max}$, with p_{max} the maximum historical price which was actually accepted in q
- subsequent absorption later on

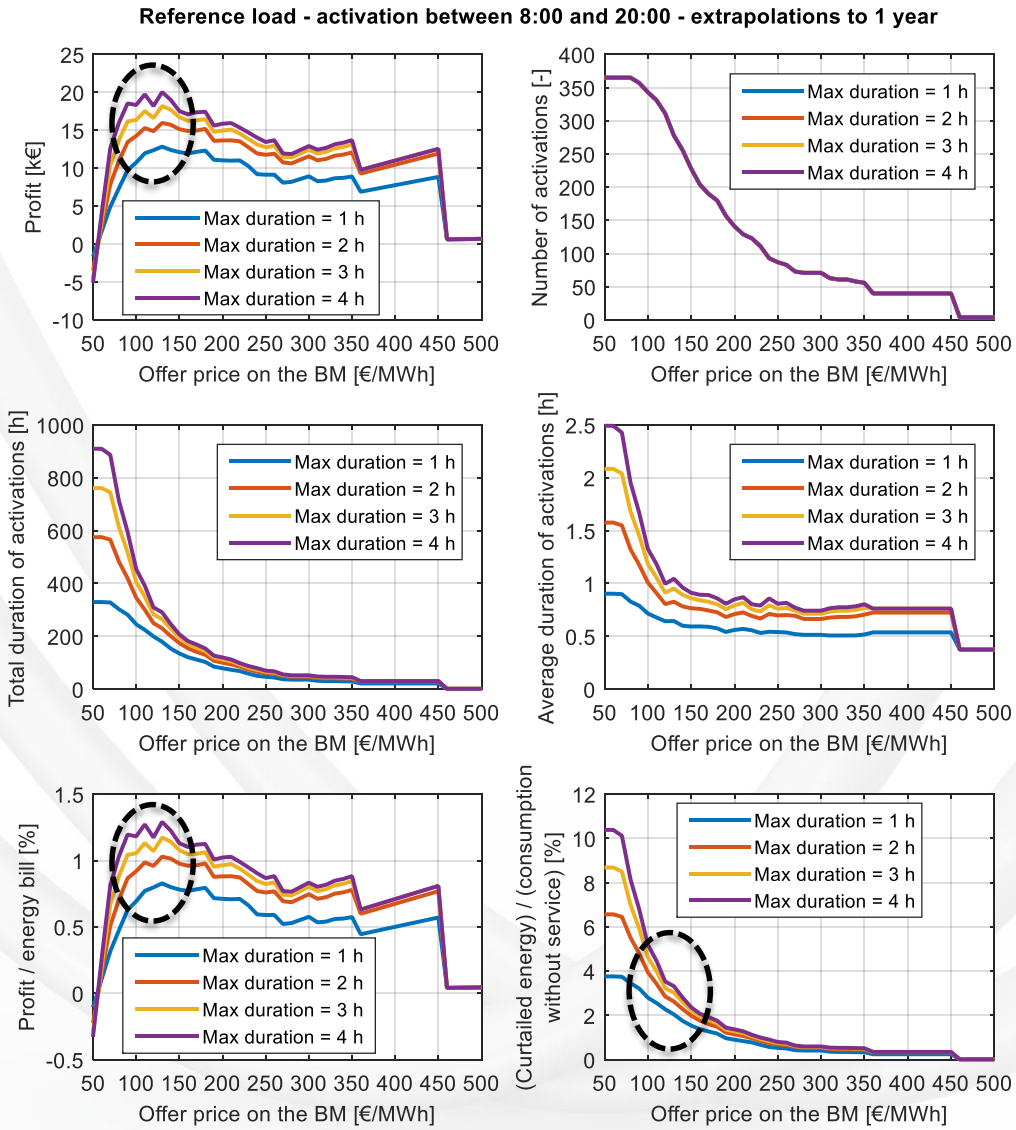
Remuneration:

- pay-as-bid energy exchange on the market
- net profit = sum(remuneration from market – unique national price PUN)
- to be compared to energy bill (177 €/MWh at medium voltage)

Sensitivity analysis:

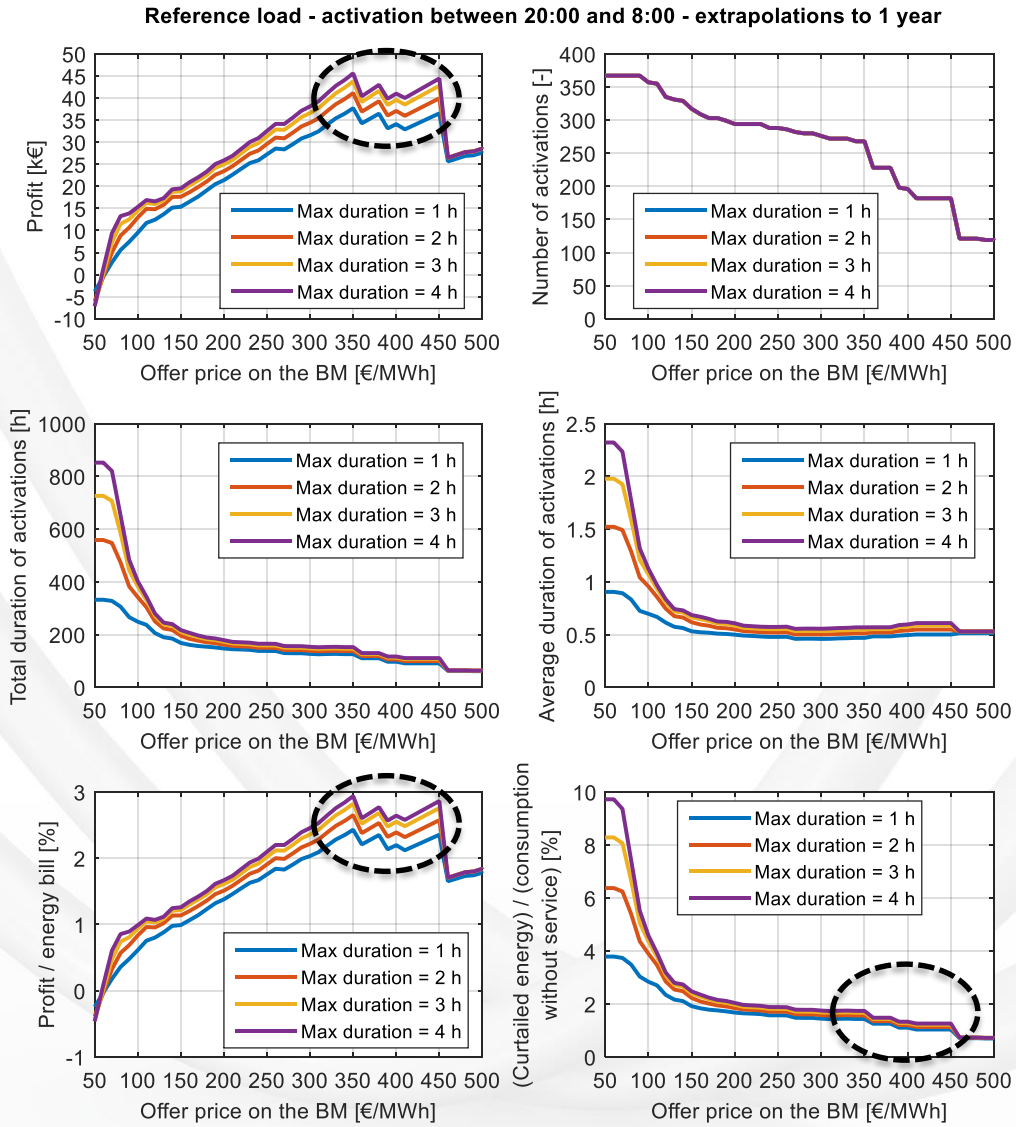
- offer service in
  - different twelve-hours time intervals h_{ini}-h_{end}: 1-13, 2-14,…
  - 1-24
  - 14-20
- fixed offer price p

Results – 1 MW constant load



- Number and total duration of service activations ↓ for offer price p ↑
- Maximum achievable profits: around 20 k€ per MW per year, for p around 100-150 €/MWh (365 down to 300 activations)
- Maximum profits < 1.3% of the load energy bill

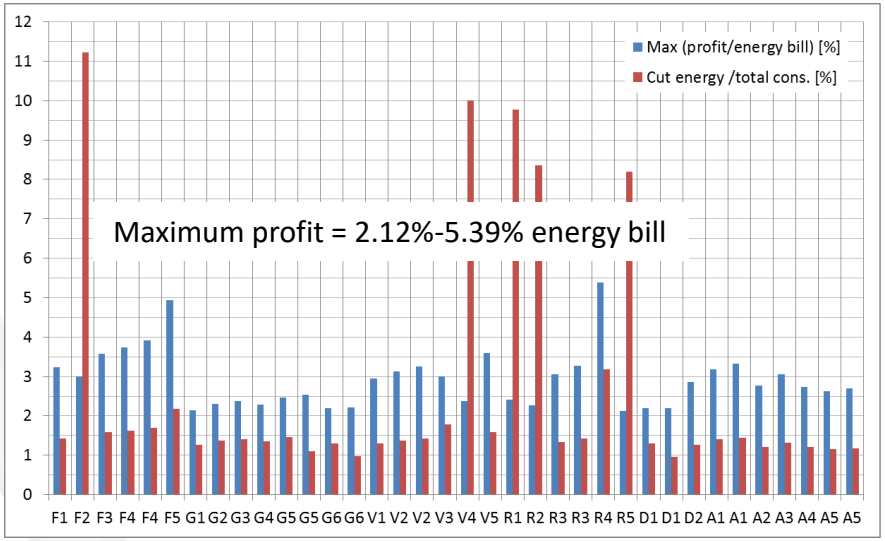
Results – 1 MW constant load

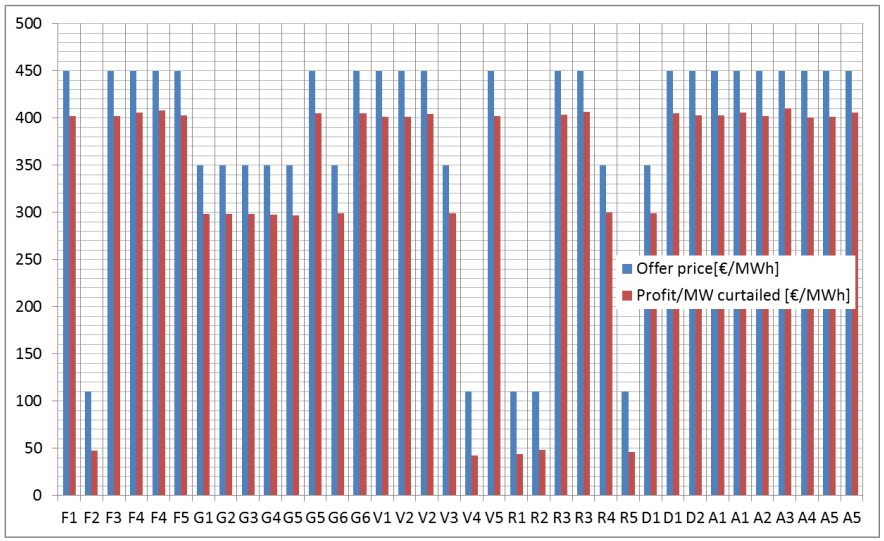


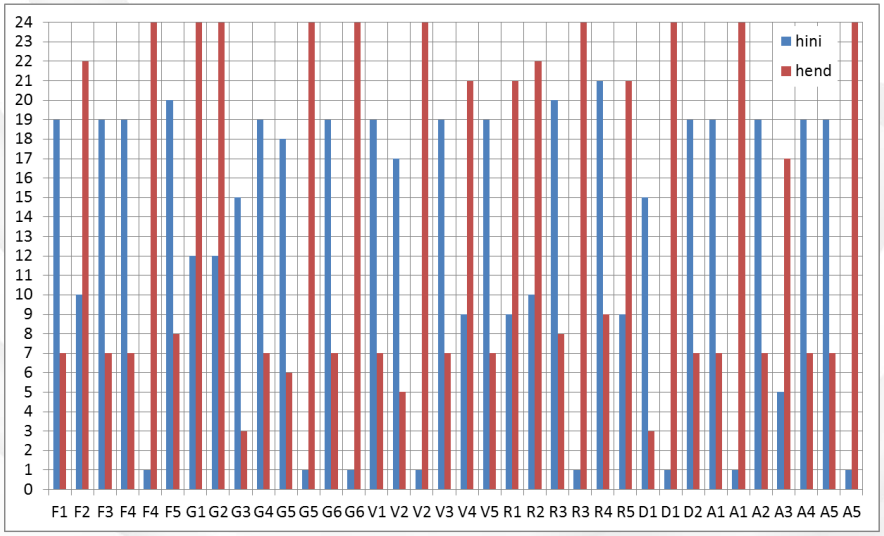
- Number and total duration of service activations ↓ for offer price p ↑
- Maximum achievable profits: around 35-45 k€ per MW per year, for p around 350-450 €/MWh (270 down to 180 activations)
- Maximum profits: up to 3% of the load energy bill

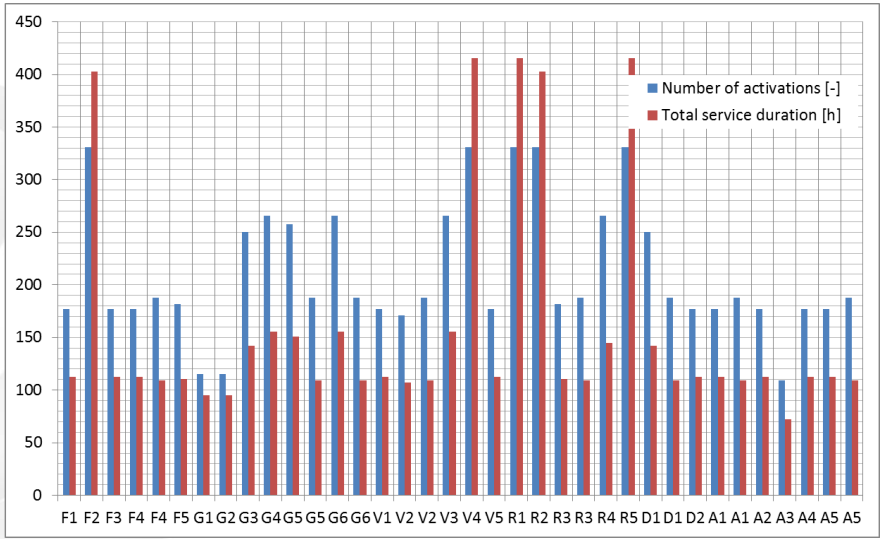
- The 20:00-8:00 range appears to be more rewarding…
  market historical prices for accepted offers higher in the 20:00-8:00 range than in the 8:00-20:00 one

Results – real loads: maximum profit to energy bill ratio



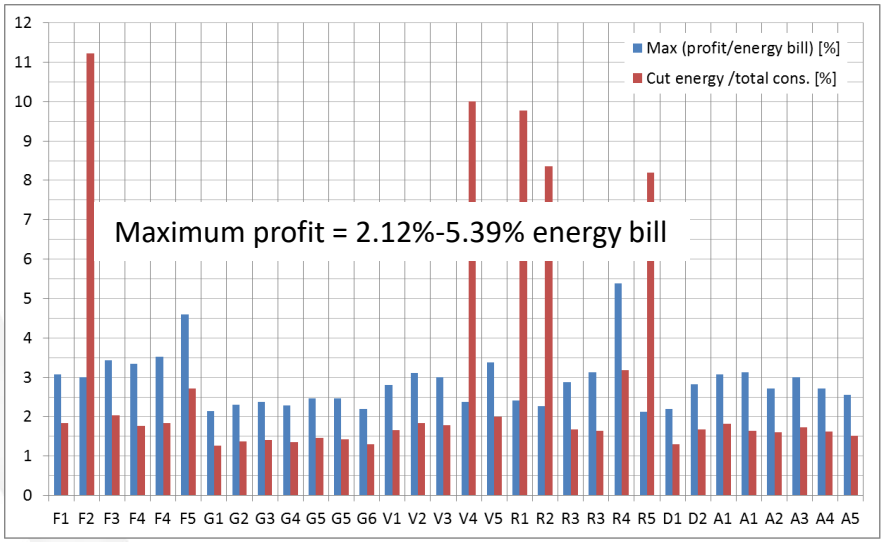


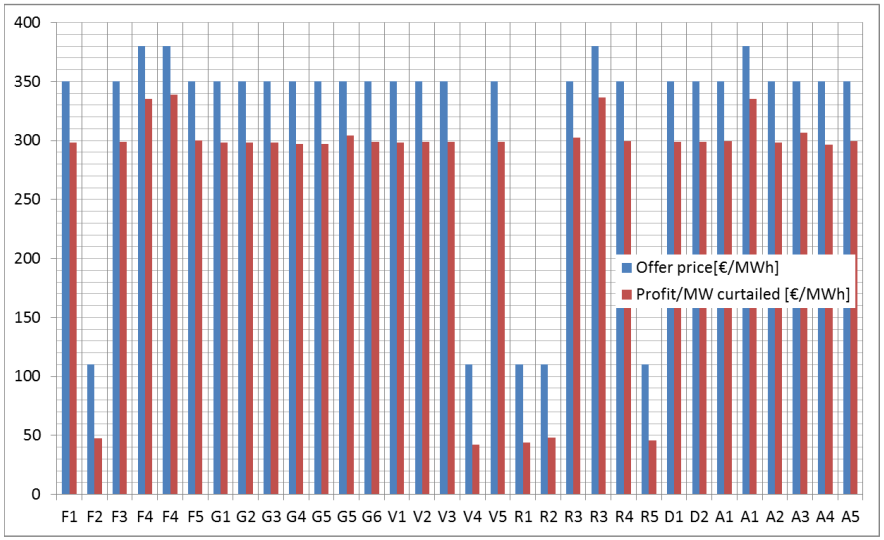


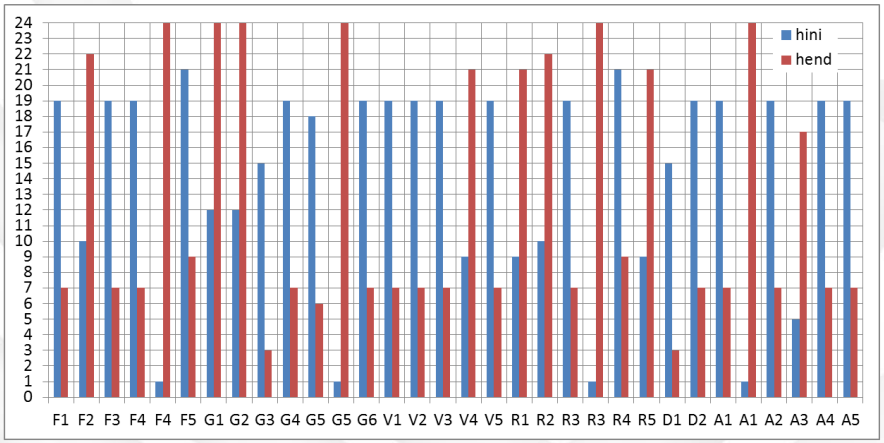


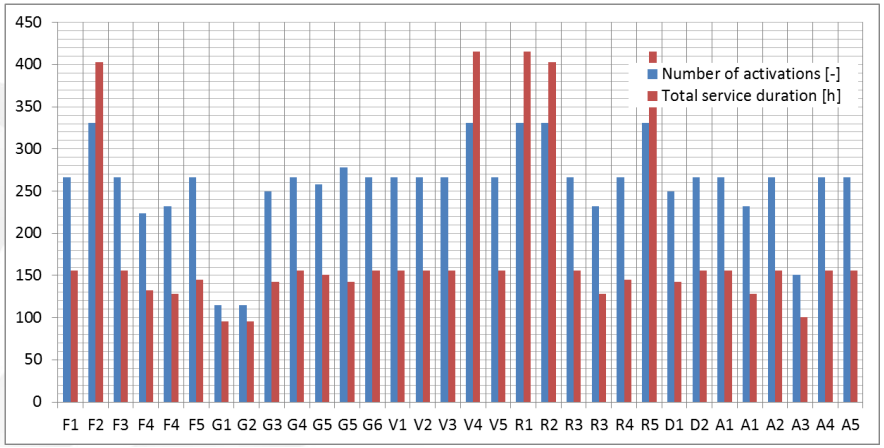
- Max profit/energy bill often for 1-24 and 19-7, mainly p = 450 €/MWh; also for 9-21 and 10-22, for p = 110 €/MWh.
- Max(max(profit/bill)): 5.39% for R4, 21-9 hour range; 4.93% for F5, 20-8 hour range (evening prices most rewarding)

Real loads: max profit/energy bill, 400 €/MWh strike price



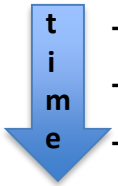






- Profit/bill often maximal for 19-7 and p = 350 €/MWh, and also for 1-24 and p = 380 €/MWh.
- Other optimal hour ranges (as without cap price): 9-21 and 10-22 for p = 110 €/MWh.
- Maximum values of profit/bill very similar to the previous ones:
  5.39%: R4, 21-9 hour range, 4.60%: F5, 21-9 hour range.

Conclusions

- Overall perspective:
  demand management already has a relevant role in the **Italian** power system and this role is **expected to widen in the future**:
  

  - **interruptible loads**
  - first steps taken by **flexible demand on ASM**
  - **participation in the forward market (capacity market)**
- Different **regulatory frameworks define players and service remuneration schemes** and can **affect demand participation**
  - choose e.g. interruptibility vs. participation in ASM?
  - revision/harmonization of different services supplied by demand?
- **Participation via aggregators** allows to include also subjects like small consumers, consumers available for limited time periods, etc.
  - but there are challenges for the aggregator…
- Dilemma: recognize the greater difficulties in regulation service supply by demand, wrt generation, or let the **technological neutrality** concept prevail?
- Practical issues…for more circumstantiated **cost-benefit analyses**:
  need to know the **underlying process**

Thank you for your attention!

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