Balancing and curtailment

Matteo Leonardi

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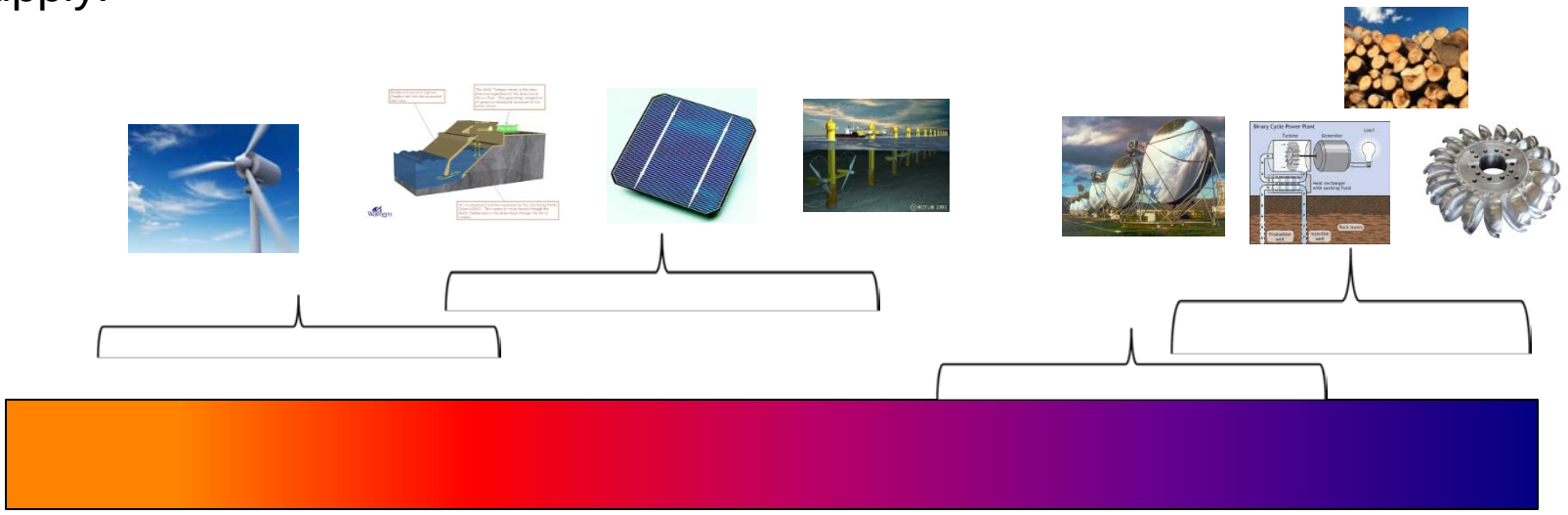
Technical and economic aspects of non-programmable RES.

- Renewable may be classified between programmable and non-programmable source of energy.
- Non-programmable RES may pose the system some fluctuation problems as they are weather dependent and are not able to operate as load-following entities.
- Photovoltaic and wind systems show the highest fluctuation within limited time whereas other technologies such as biogas, geothermal, biomass and hydro are easily predictable.

Capacity credit

Capacity credit is the peak demand less the peak residual demand, expressed as a percentage of the variable renewables installed.

As a general rule low capacity credit renewables should not exceed 20-30% of load in order to guarantee “acceptable” standards for security of supply.



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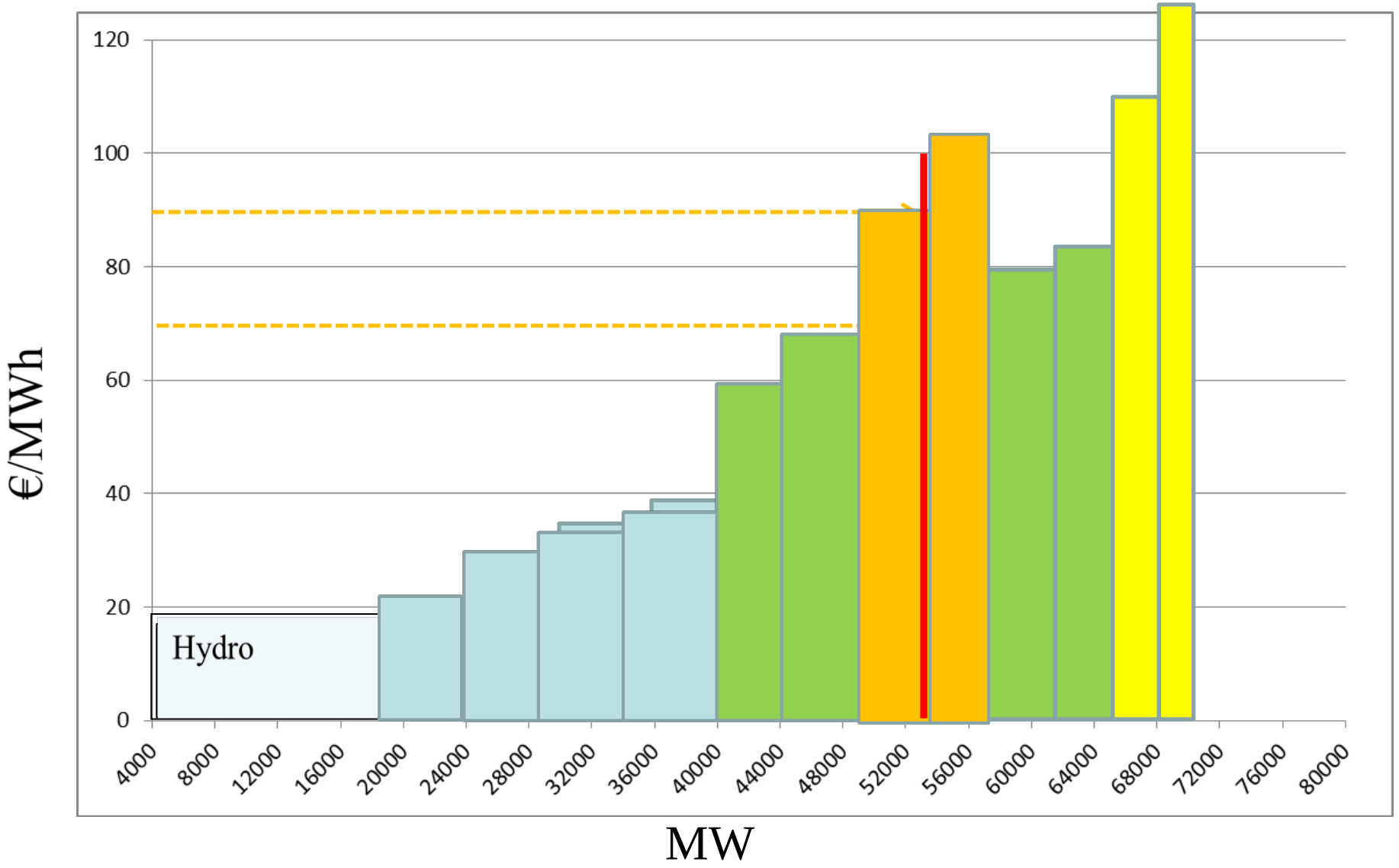

€/MWh
120
100
80
60
40
20
0
Hydro
4000
8000
12000
16000
20000
24000
28000
32000
36000
40000
44000
48000
52000
56000
60000
64000
68000
72000
76000
80000
MW

Balancing cost for renewable producers

Sign of the area	Renewable producer balance
+	+ the producer is supposed to pay full balancing service
	- The producers is compensated as his *mistake* has improved the overall balance
-	+ The producers is compensated as his *mistake* has improved the overall balance
	- the producer is supposed to pay full balancing service

Instruments to increase unpredictable RES penetration

- A better communication between plant operators and the SO improves system balancing. The RES owners and the SO have to be incentivized to improve their weather forecasting skills and to promptly communicate gaps.
- Price incentive mechanisms may be introduced in order to motivate renewable generators to better utilize weather forecast data. A premium may be introduced for accurate day ahead forecasts or a cost may be added to producers to compensate unbalanced quantities. In sophisticated electricity markets RES are asked to pay the cost of balancing the system for the quantities they are responsible for.

Increase storage capacity

- Storage may be considered a production or a transmission (system security) infrastructure.
  - In the first case (production) the electricity market needs to adequate price signals to remunerate storage infrastructures. Time of generation tariff, for instance, have to be in place. A specific market for reserve capacity will also help.
  - In the second option (transmission and security infrastructure) storage costs are recovered through the tariff.

Time of production FIT/premium may be introduced in order to orient programmable RES to produce during peak load

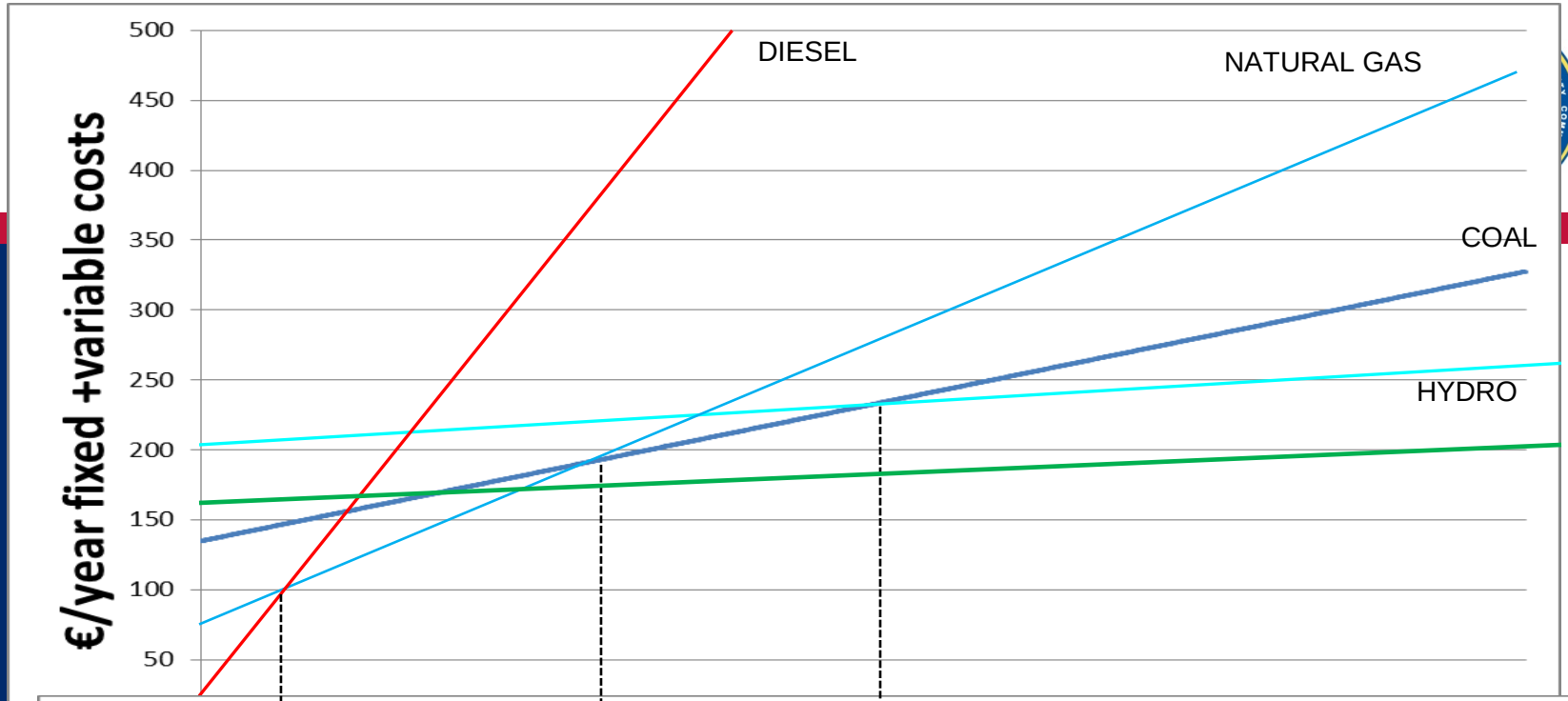
Year kWh generation	Peak hours	Base load
Up to 1 million	(28,39-Pp)/P+Pp	Pp
Over 1 up to 2 millions	(21,80-Pp)/P+Pp	Pp
Over 2 up to 3 millions	(19,94-Pp)/P+Pp	Pp
Over 3 up to 4 millions	(18,87-Pp)/P+Pp	Pp
Over 4 up to 5 millions	(17,94-Pp)/P+Pp	Pp
Over 5 up to 10 millions	(16,49-Pp)/P+Pp	Pp
Over ten millions	(15,01-Pp)/P+Pp	Pp

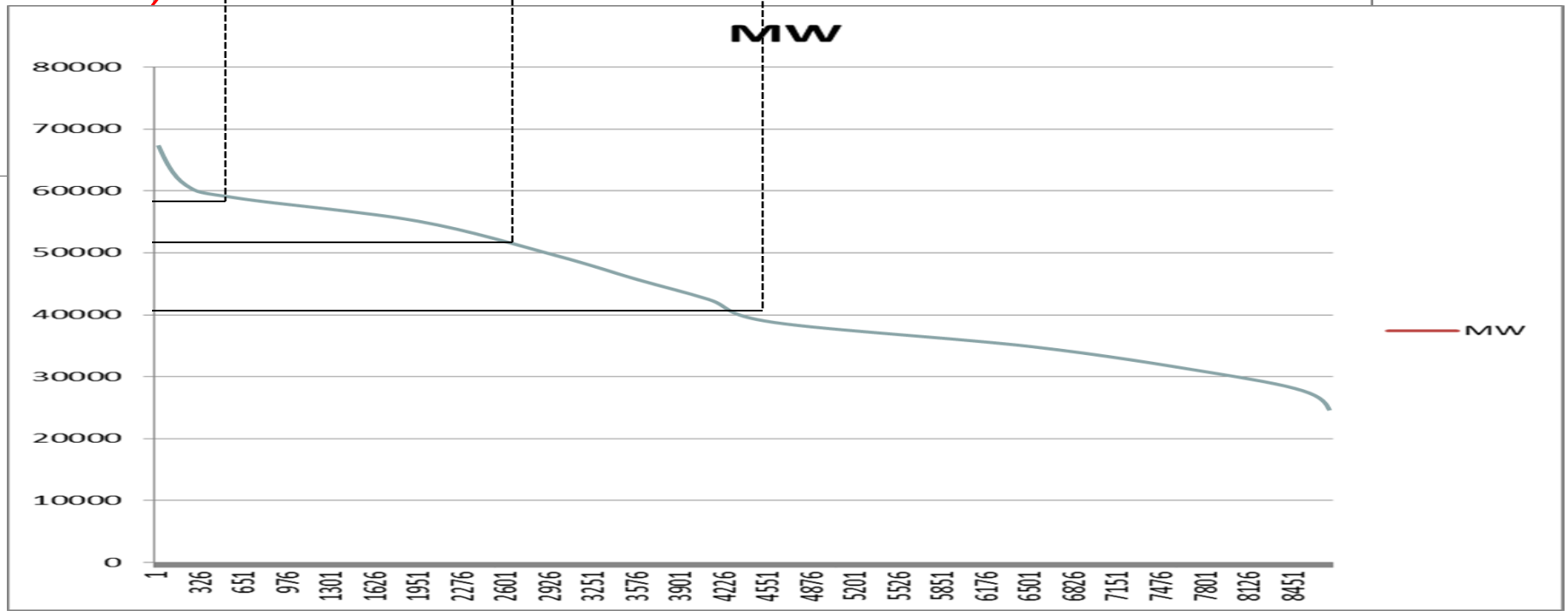
- Pp is the pool price
- P = 0.409 (ratio of peak hours / 8760)

Demand side management (DSM)

- Demand response and load management is an efficient option to balance the system. Larger consumers may be willing to cut their load when required by the system if adequately compensated. The load service may be purchased by a forfeit compensation or on a time basis. The cost of such services are normally recovered through tariff as system cost; in advanced markets demand loads may participate to capacity reserve market and get balancing system price for the service.

National Association of Regulatory Utility Commissioners





Specific DSM measures

- In some contexts intermittent sources of energy may be efficiently combined with some specific energy uses that can serve as storages: water industry, water treatment plants, water management. The water sector often benefits from discounted tariff options and incentives. The regulator may try to improve the overall system management by orienting tariffs to system efficiency. It may be possible to ask the water industry to offer balancing services in return of the existing tariff privileges.

Distributed generation

- The more distributed are the non-programmable renewable plants the lower is the risk of fluctuation. In principle the overall legislative framework should avoid the temptation to favor the commissioning for large size non-programmable RES plants and prefer a smaller scale distributed pattern of plants being installed in different area of the country. It is generally better to have a number of small size plants being distributed in the country and insisting on different balancing areas rather than a big one on a single balancing area.
- Net metering options are a good instrument to promote distributed generation. An additional measure may be the introduction of an additional tariff component to be added to feed-in tariffs for power plants directly connected at low or medium voltage. The component corresponding to avodied transmission costs (including losses).

Network development and integration

- The larger the balancing area, encompassing different production and load units, the lower the fluctuation risk. Penetration of renewable benefit from investment in network development and integration. Interconnection of larger systems, including cross border connection, is the most efficient solution to absorb local fluctuation problems. An effective instrument to incentive network expansion is to recognize a higher remuneration on investments in new lines as compared to existing capital remuneration of existing ones.

More flexible generation mix and 'hot reserve' access

- Increasing quick response reserve capacity is another solution to balance the system. Reserve capacity may be granted through administrative or market rules. Hydro basins or fossil fuel (hot reserve) may be asked to keep a percentage of their capacity available for reserve. Alternatively reserve capacity may be purchased on a competitive market.
- Finally as overall system stability is given by the mix and the flexibility of all generating units connected to the grid, the commissioning of CCGT plants, able to quickly respond to grid requirements, make the system generally more flexible.

2. Curtailment

- Two are the main reason for curtailment:
  - Unpredictable source of energy exceed the ‘safety’ quota in the system. There may be many plants in the interested area. They may have different sizes and belong to different owners.
  - Network instability or outage non caused by res generators. RES units will be automatically switched off by their protection systems and will be idle for the time the network parameters are not re-established.

Excess capacity

- Excess capacity may be determined by many variables renewable producers are not responsible for: lack of coordination between system monitoring and plant licensing offices, mistakes in demand forecasts, unexpected load reduction, delays in the construction of new network connections. Defining curtailment rules reduce investment risk. Criteria for curtailment have to be known, whether the SO proceeds by curtailing one plant at the time (which plant?) or to reduce electricity inputs by all market participants (when technically feasible) by a percentage of their load. It is possible to establish a compensation for non-dispatched electricity following curtailments. The compensation may be introduced on all losses or only when losses occur for a significant period of time. Compensation economic resources may be taken from all RES producers, non-predictable RES producers, or socialized into tariff.

Outages

- In the second case RES are curtailed because of network problems. It is the SO to fix the problem and it may take a longer time than needed. In vertically integrated market the SO may have little or no incentive to repair a line an IPP is connected to. This situation may discourage investment of IPPs. In RES plants investment remuneration is highly influenced by the plant load factor. Some compensation for non-dispatched electricity may be introduced especially when outages exceed a maximum period per year. Network quality standards are usually introduced to assure the SO receive the right economic signals to repair networks in time.