The value of wind revisited: A systems-planning perspective

Council for Scientific and Industrial Research (CSIR): Energy Centre

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Agenda

1. Methodology
2. Results
3. Conclusions

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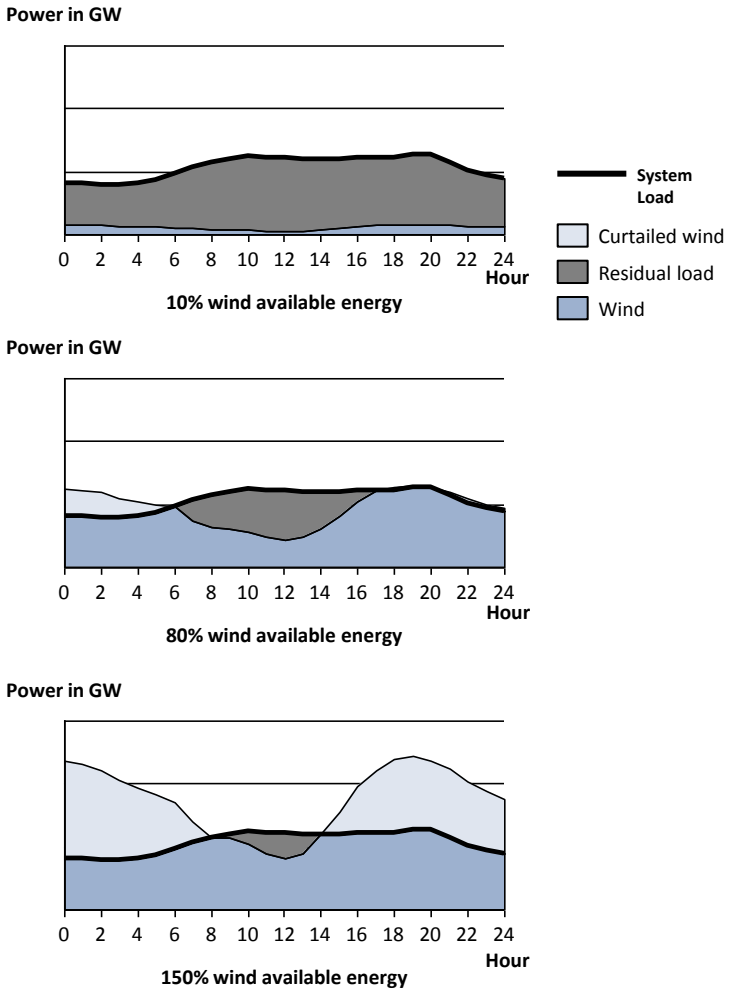
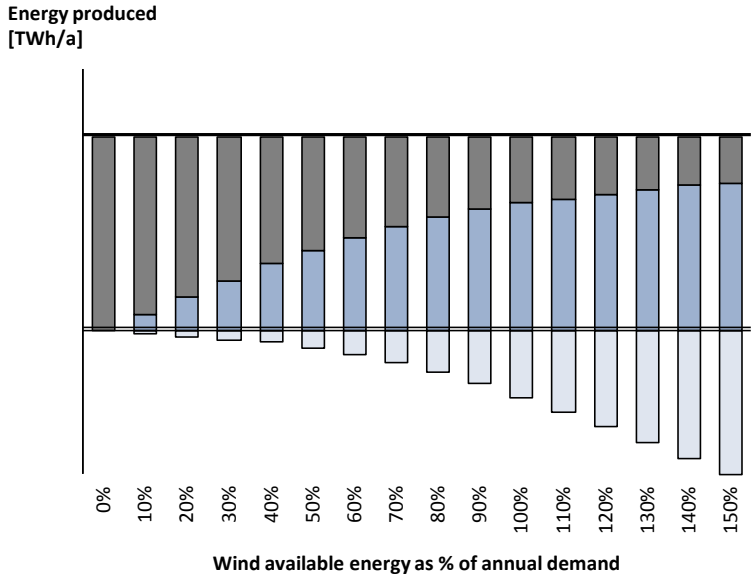
1. **Methodology**
2. **Results**
3. **Conclusions**

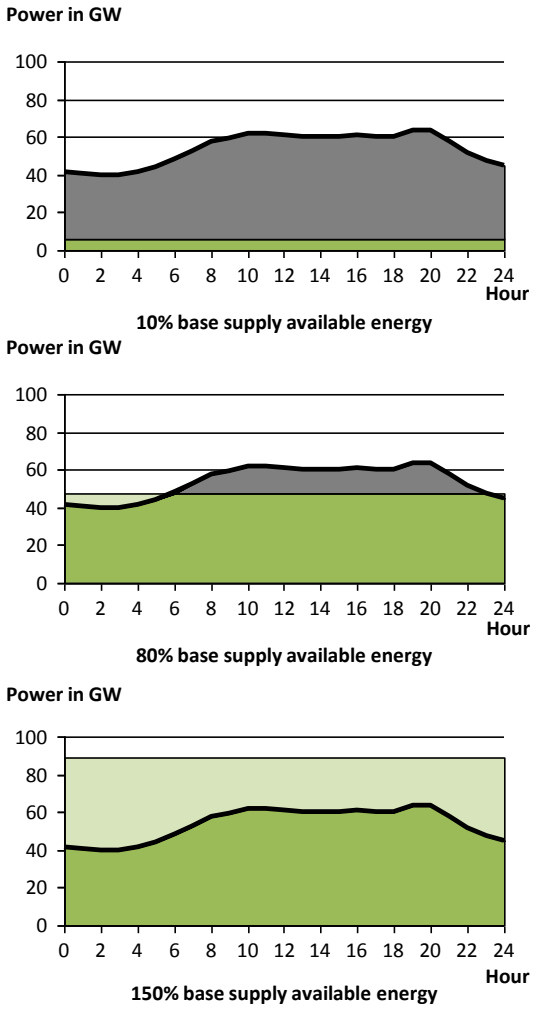
Methodology: Run LT least-cost expansion for increasing penetrations of wind energy in greenfield system (2017 demand & costs)

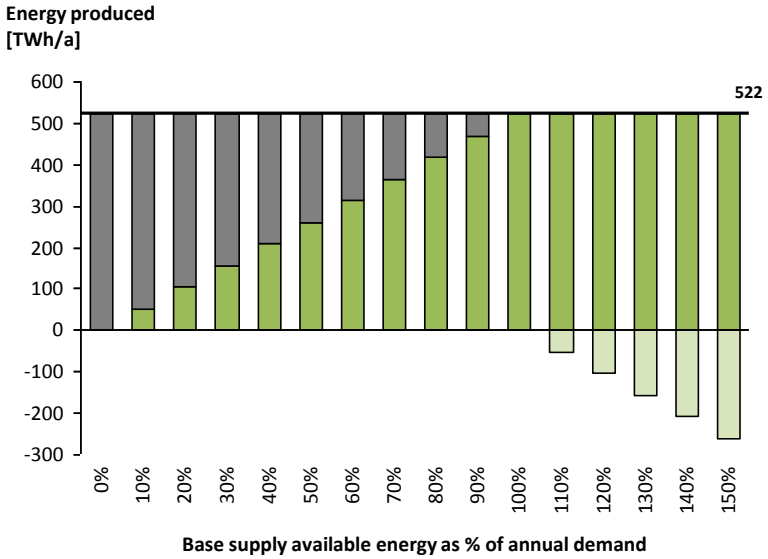




Adequacy = same for all wind penetrations; Full chronology (hourly)

Methodology: Run LT least-cost expansion for increasing penetrations of base supply energy in greenfield system (2017 demand & costs)





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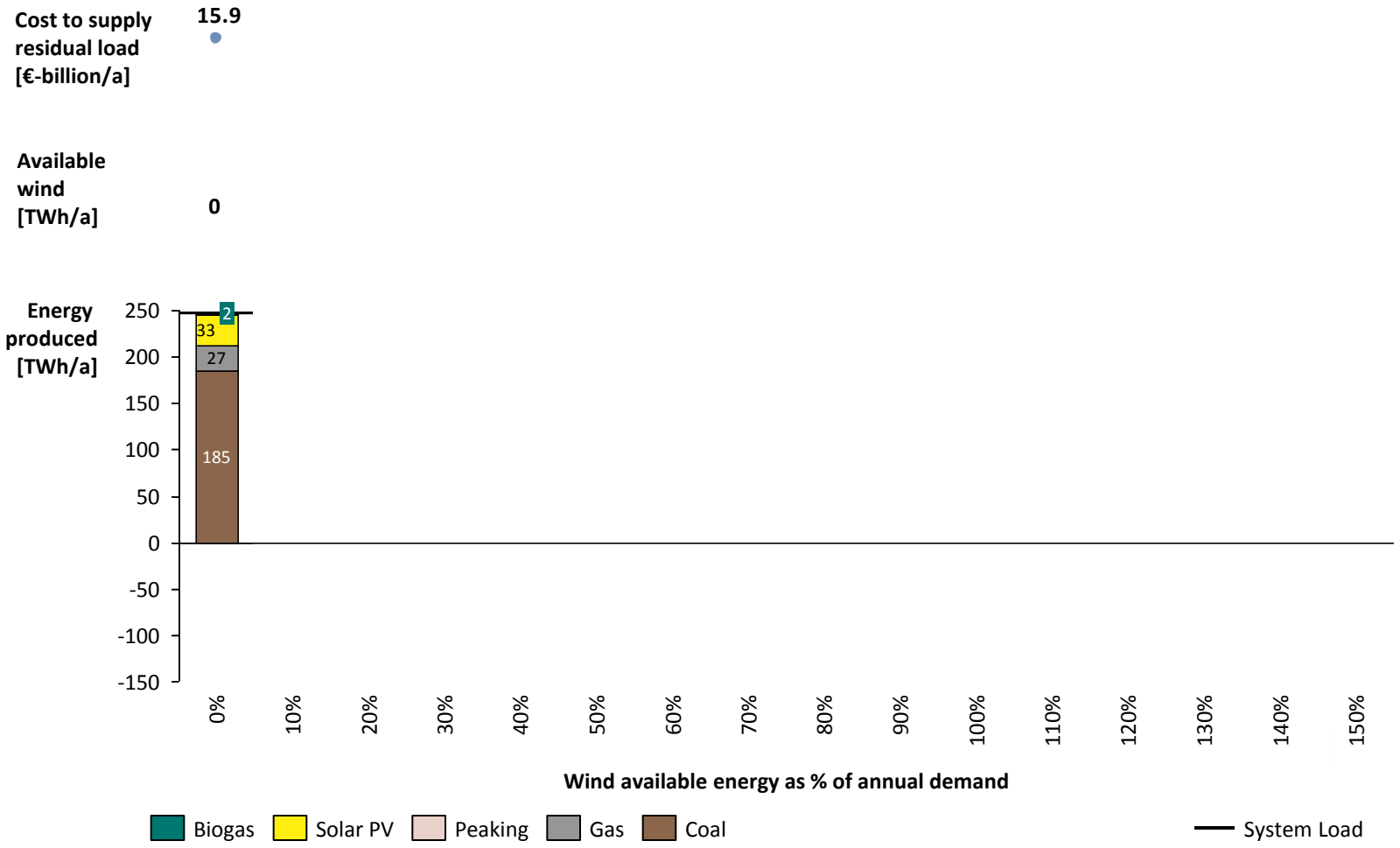
With no wind included as an expansion option, a particular portfolio of generators are built

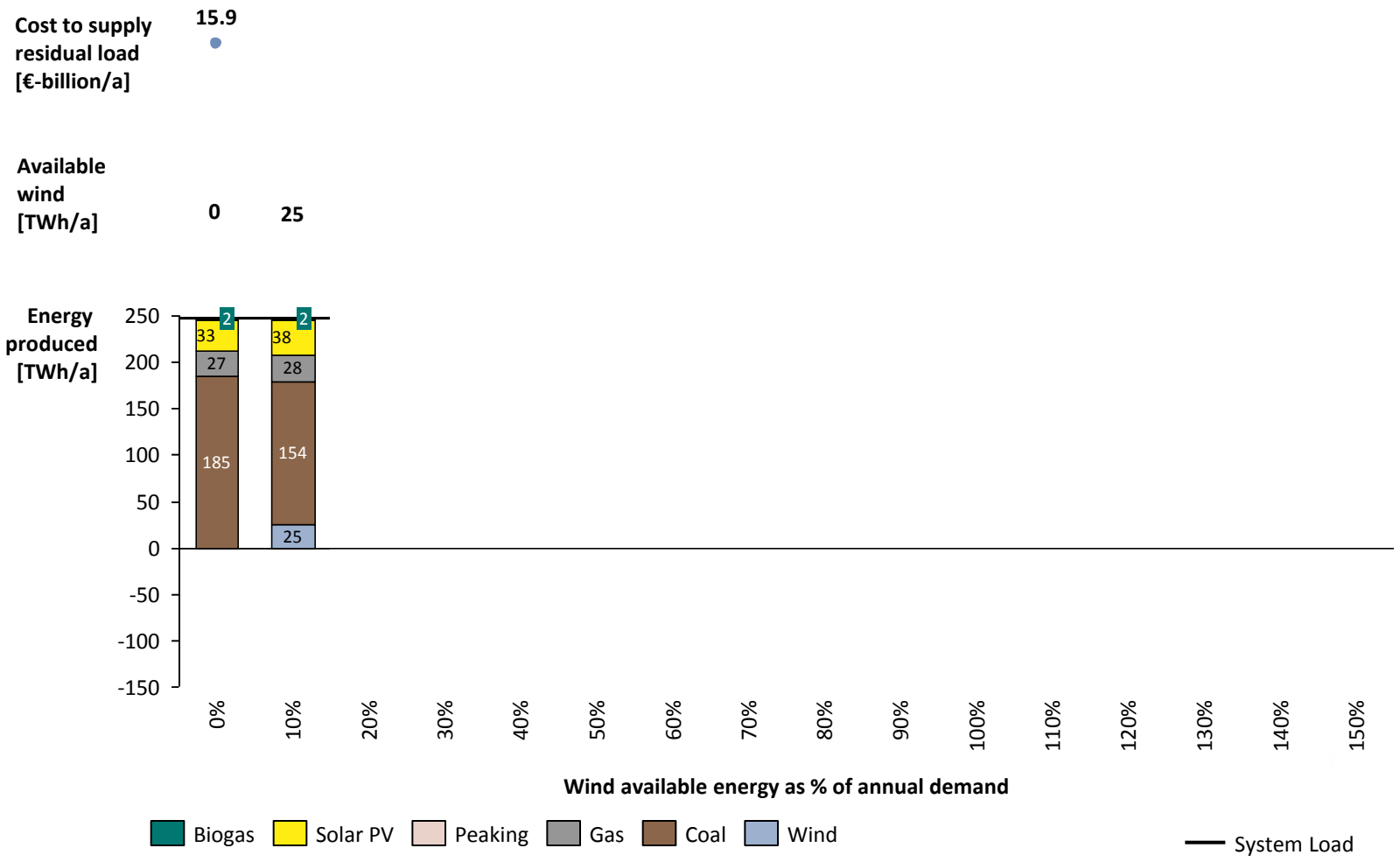
Greenfield system: LT least-cost expansion without wind



Adequacy = same for all wind penetrations; Full chronology (hourly)

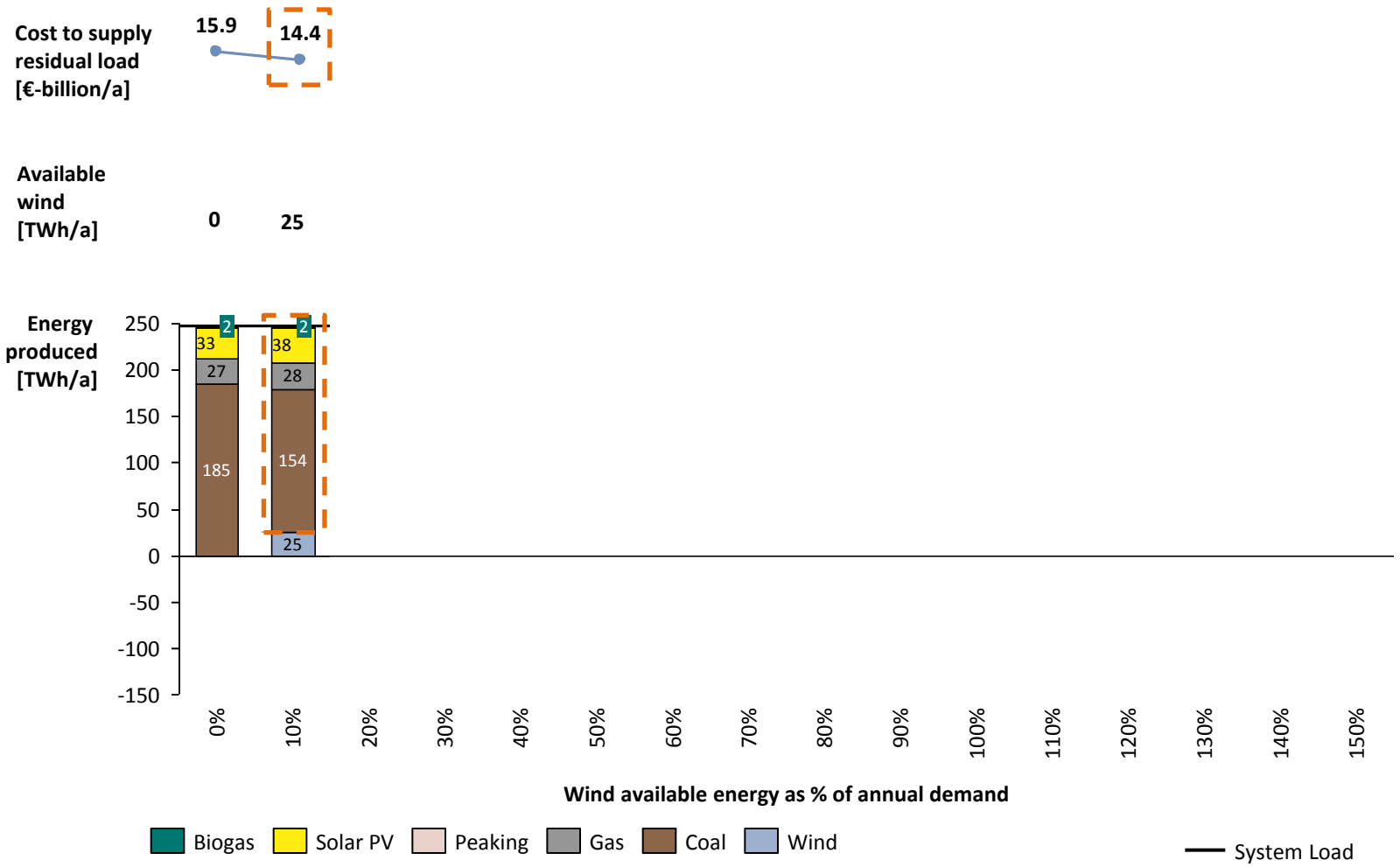
With a pre-defined amount of wind allowed - a new portfolio of generators is built

Greenfield system: LT least-cost expansion with 10% available wind



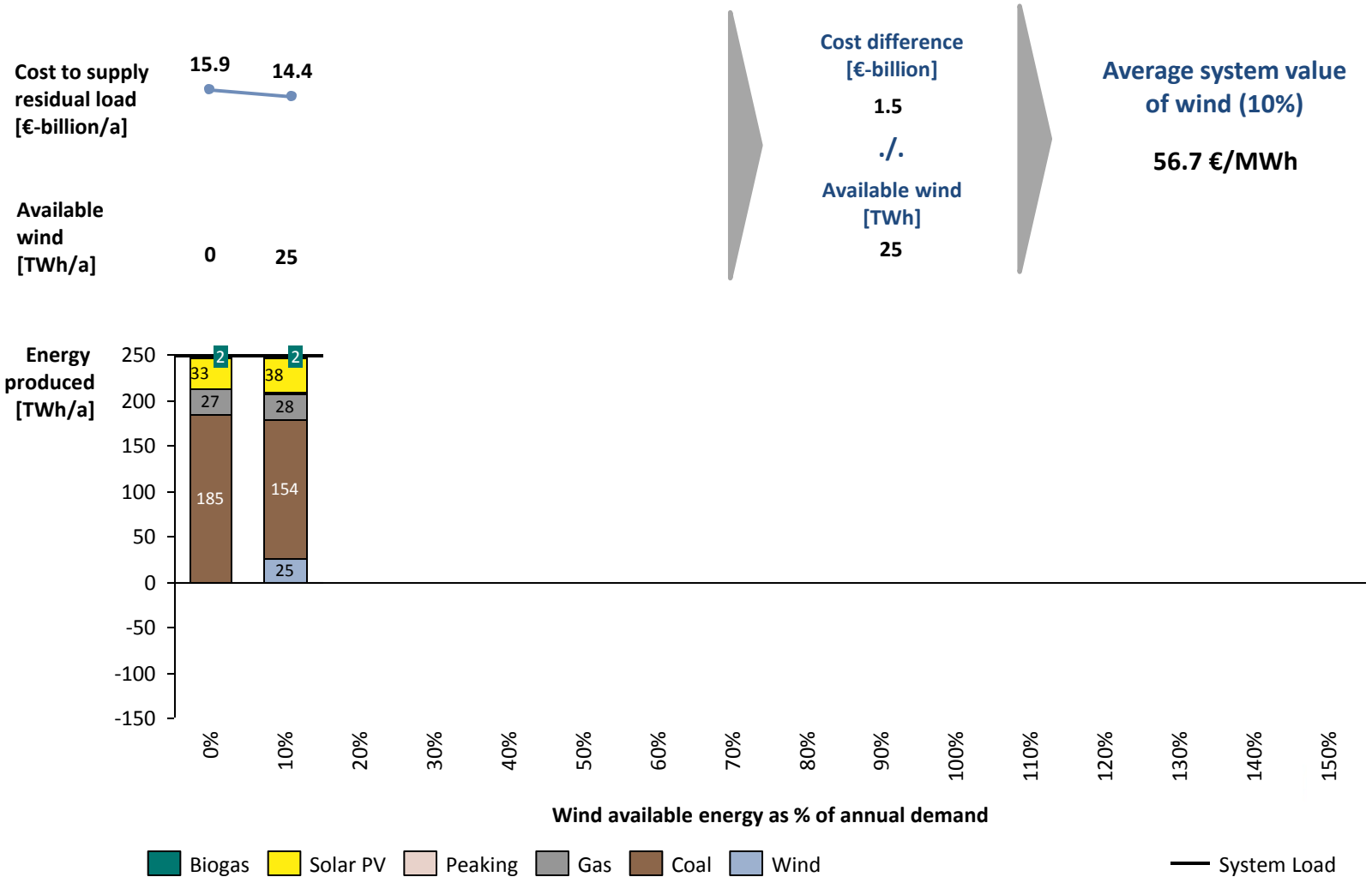
Adequacy = same for all wind penetrations; Full chronology (hourly)

The cost to supply the residual load after the pre-defined amount of wind is calculated for each penetration of wind



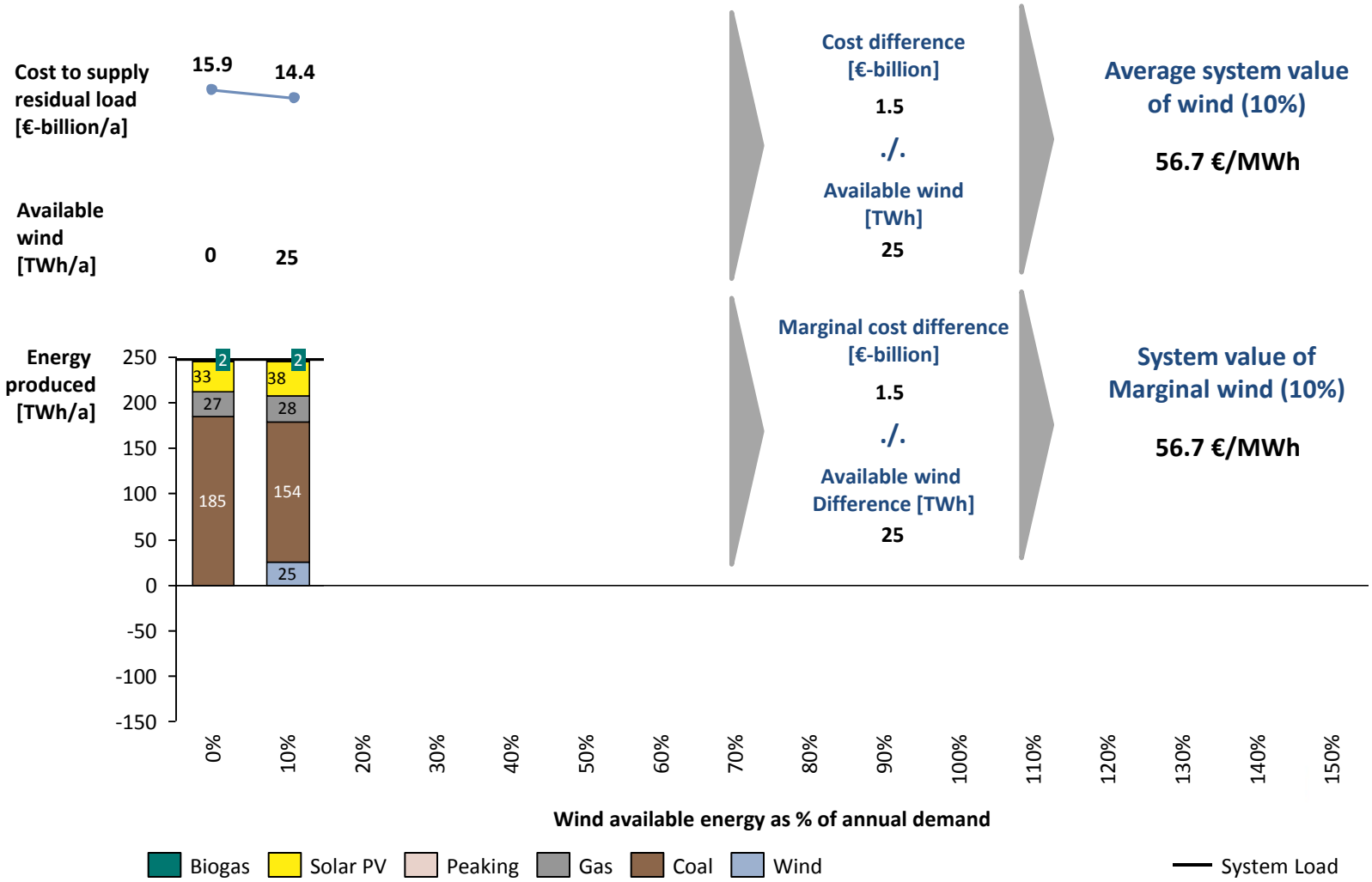
Adequacy = same for all wind penetrations; Full chronology (hourly)

Average system value is the cost difference relative to the cost to supply with no wind included (0% penetration)



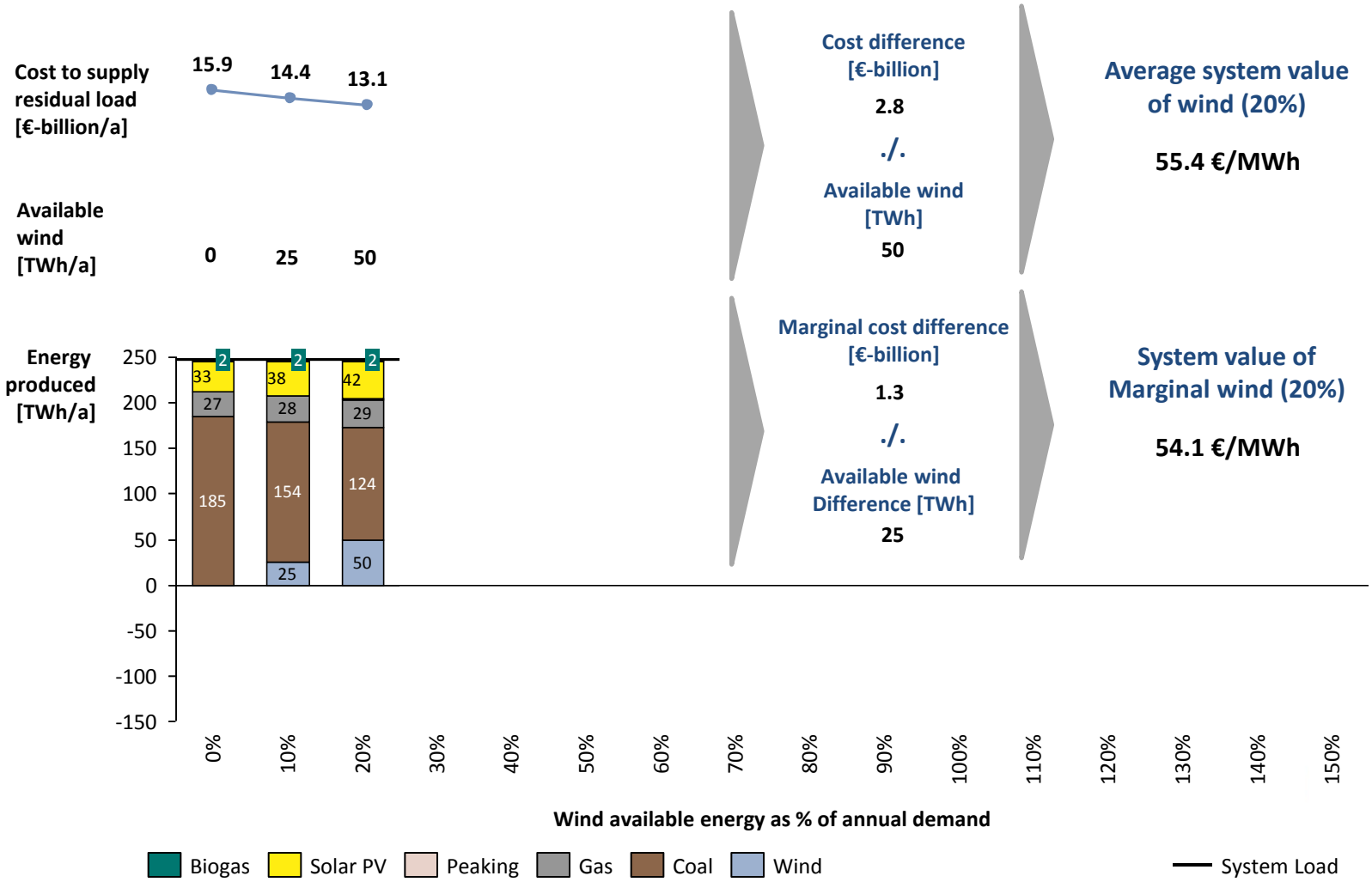
Adequacy = same for all wind penetrations; Full chronology (hourly)

Marginal system value is the cost difference relative to the previous penetration level



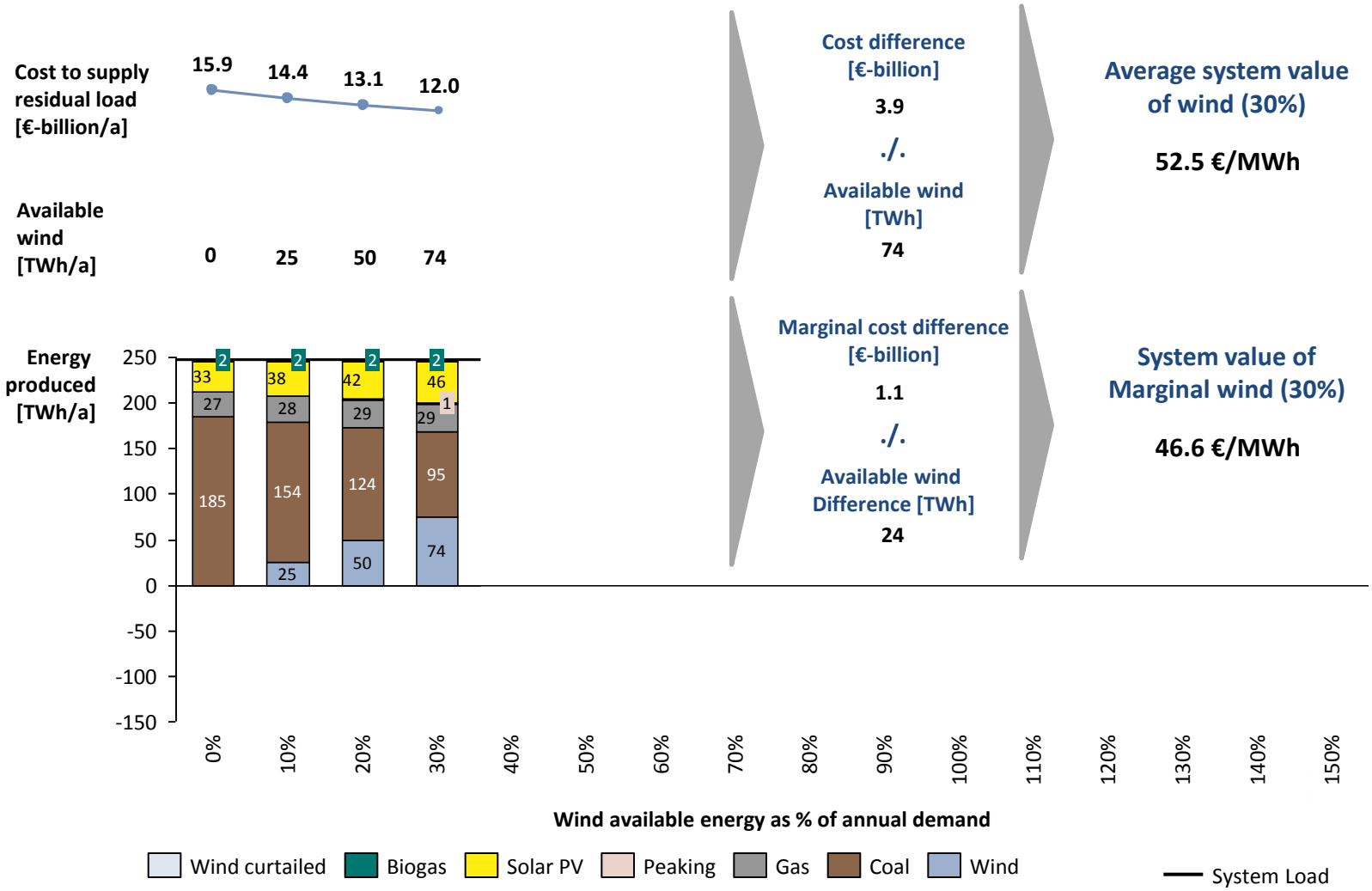
Adequacy = same for all wind penetrations; Full chronology (hourly)

Marginal system value declines quicker than average value (as expected)



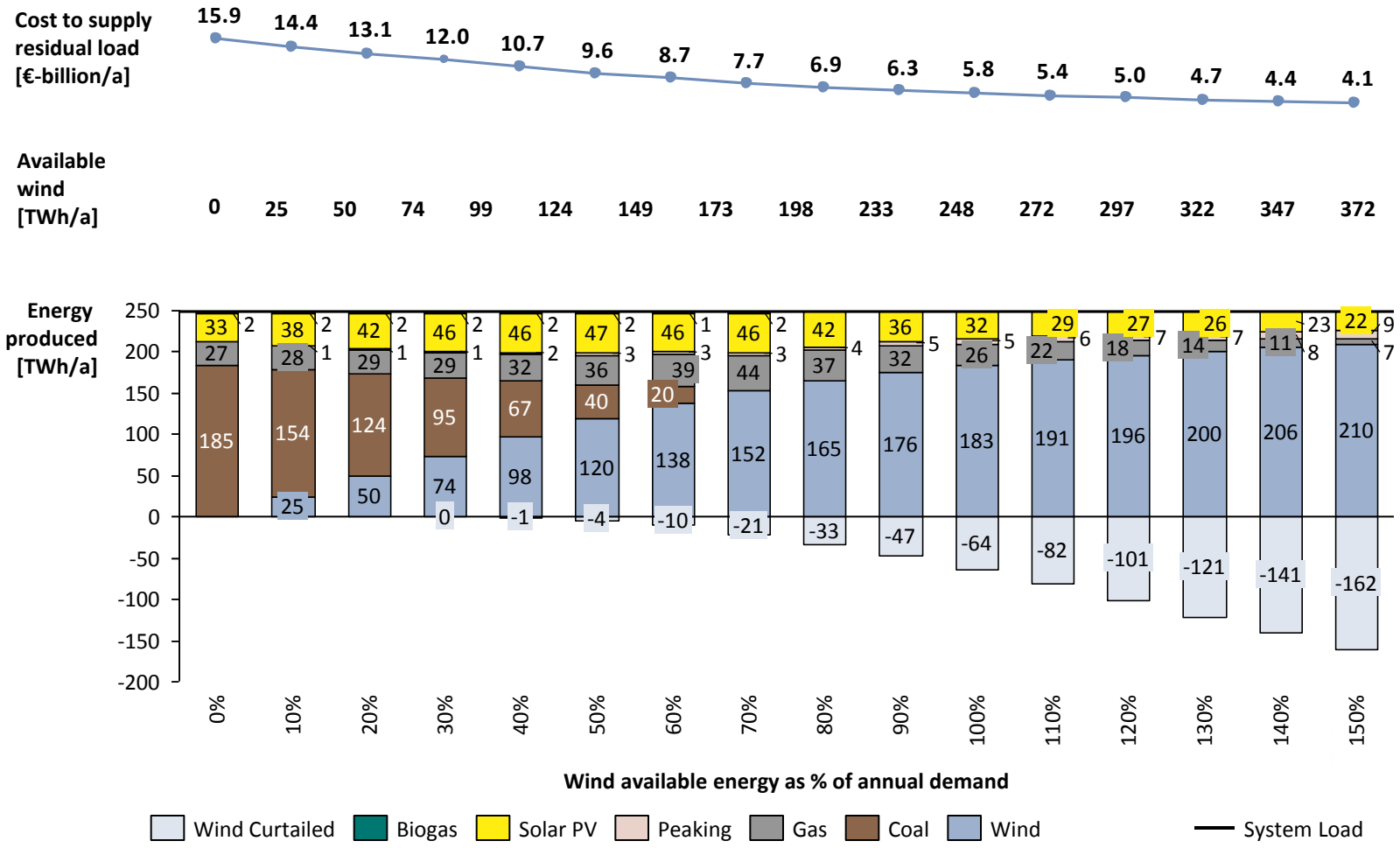
Adequacy = same for all wind penetrations; Full chronology (hourly)

Decline in average and marginal value as penetration level increases



Adequacy = same for all wind penetrations; Full chronology (hourly)

More notable degradation of wind value as soon as wind begins to be curtailed



Adequacy = same for all wind penetrations; Full chronology (hourly)

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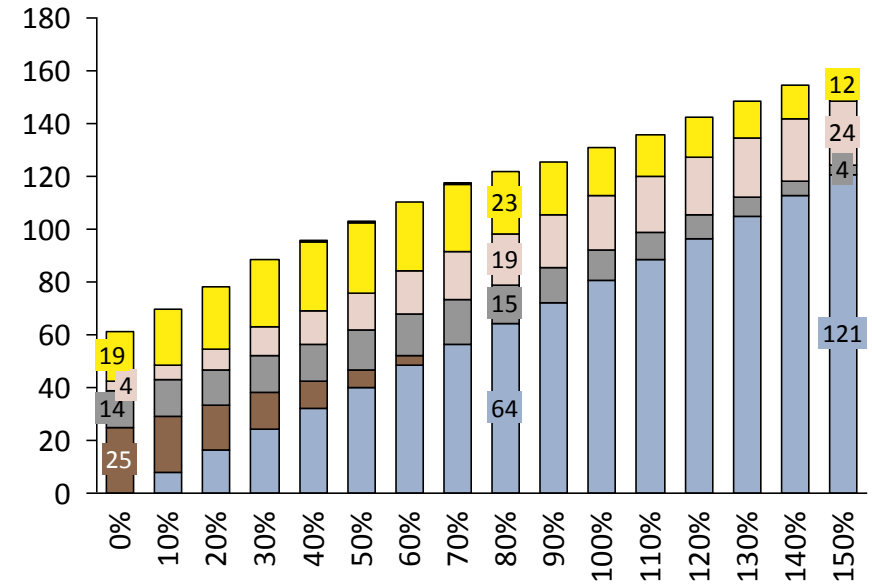
Initial residual portfolio is coal-based but changes as wind penetration increases where solar PV and gas-fired CCGTs/OCGTs are preferred

Total capacity and energy of residual load for each penetration level of wind

Capacity built to supply demand

Installed capacity [GW]

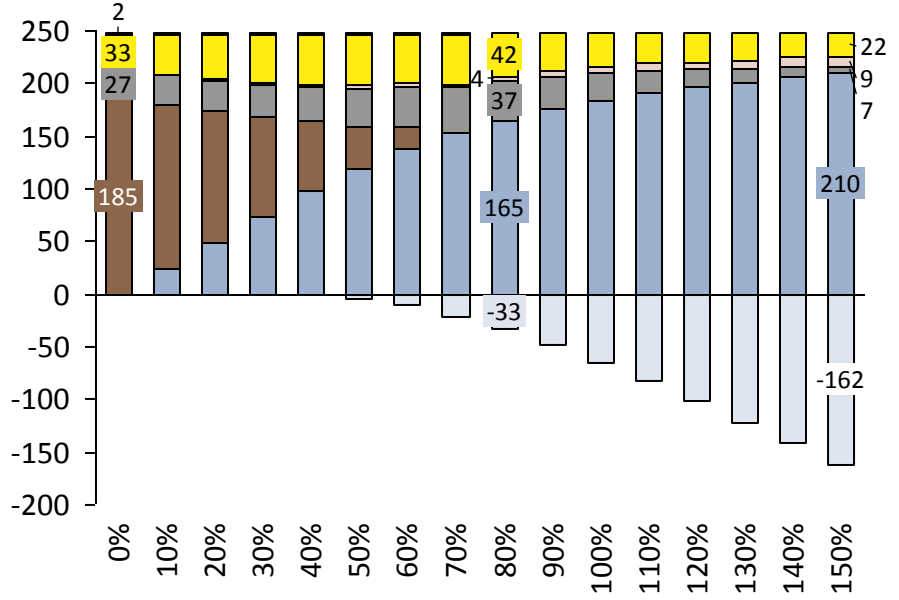
2017 Technology costs



Wind available energy as % of annual demand

Energy Produced

Energy produced [TWh/a]



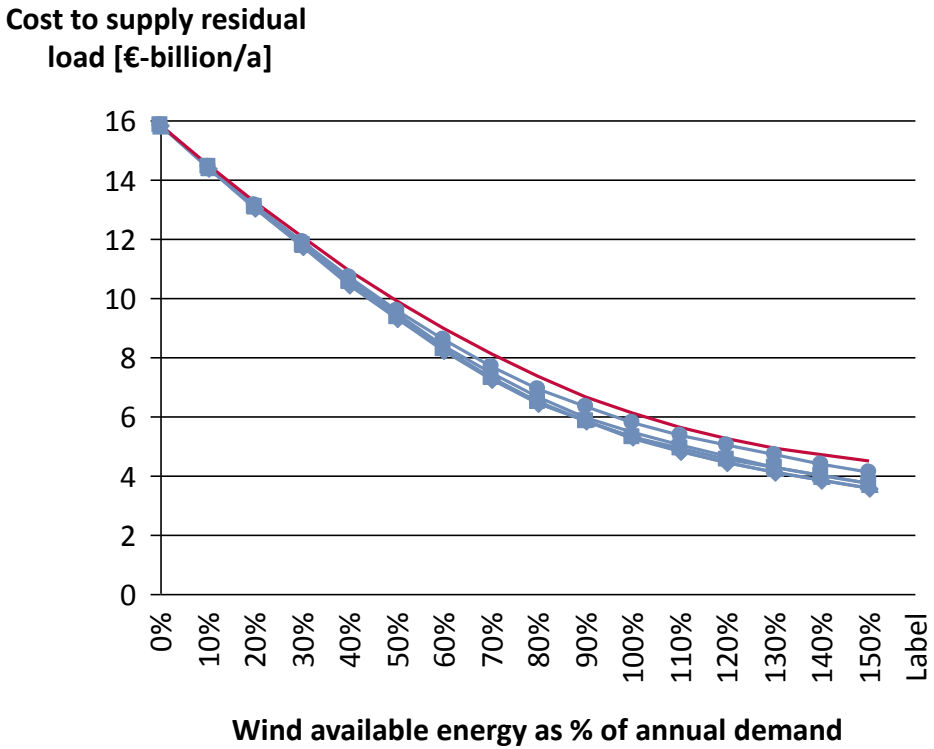
Wind available energy as % of annual demand

Wind Curtailed | Biogas | Solar PV | Peaking | Gas | Coal | Wind

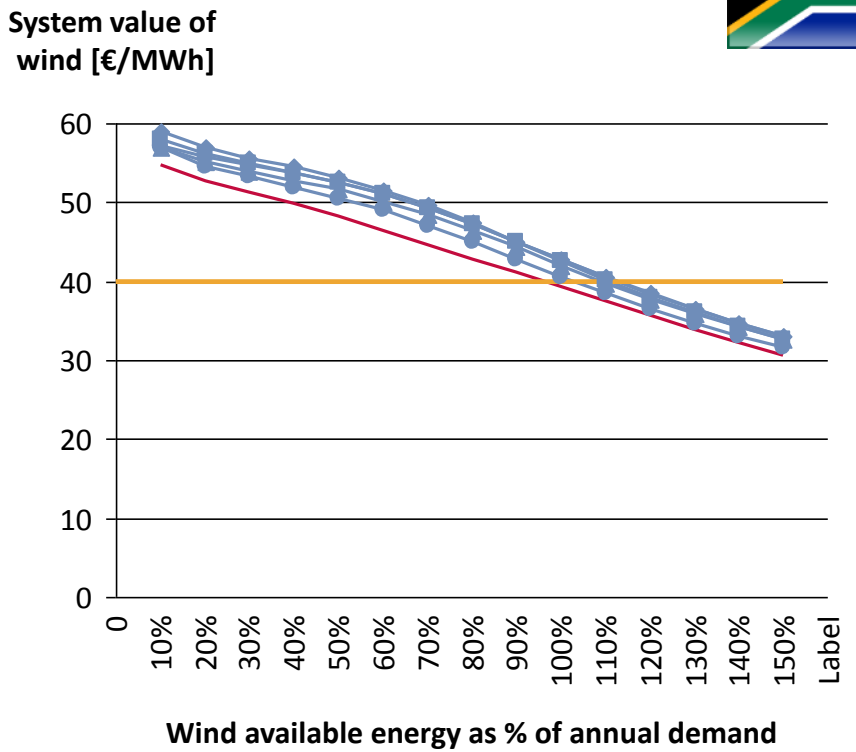
The effect of the wind profile is notable but not significant

Value of wind tested with multiple wind profiles from 2009 - 2013

Cost to supply residual load



Average system value



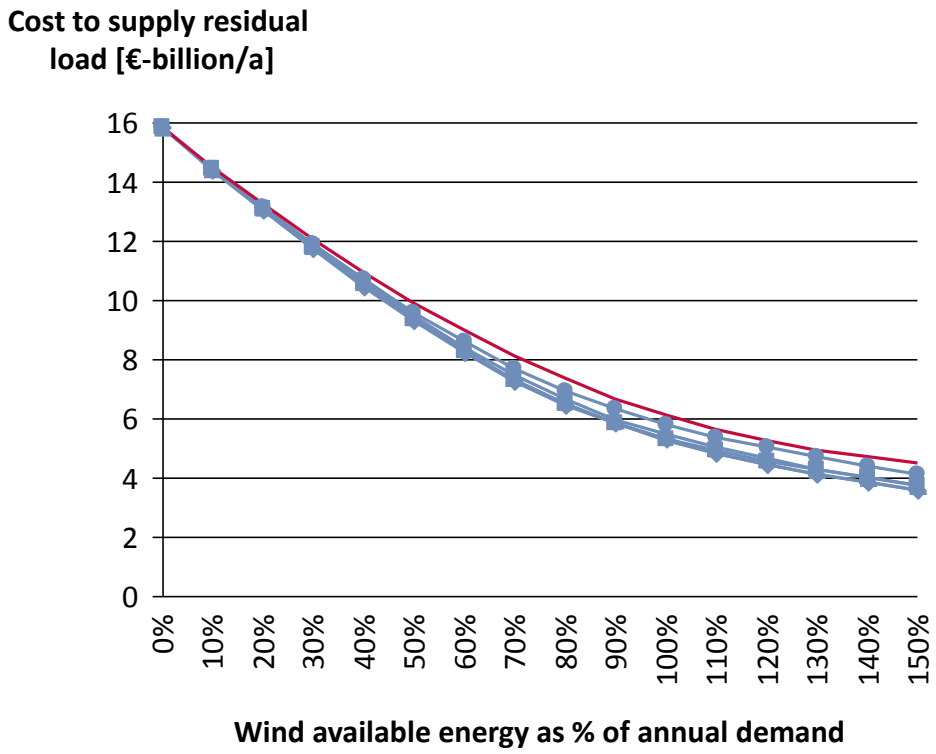
2011 wind profile (benchmark) | 2010 wind profile | 2013 wind profile | Cost of wind

2009 wind profile | 2012 wind profile | 2016 Actual wind

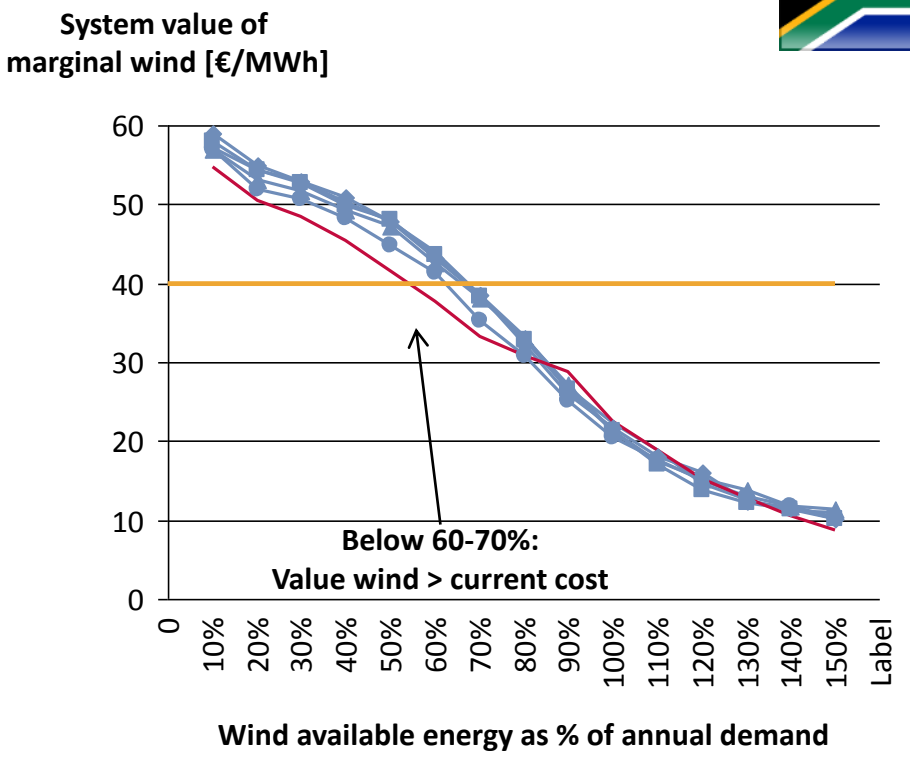
Marginal value of wind declines as expected but not as quickly as seen in previous literature

Value of wind tested with multiple wind profiles from 2009 - 2013

Cost to supply residual load



System value of marginal wind



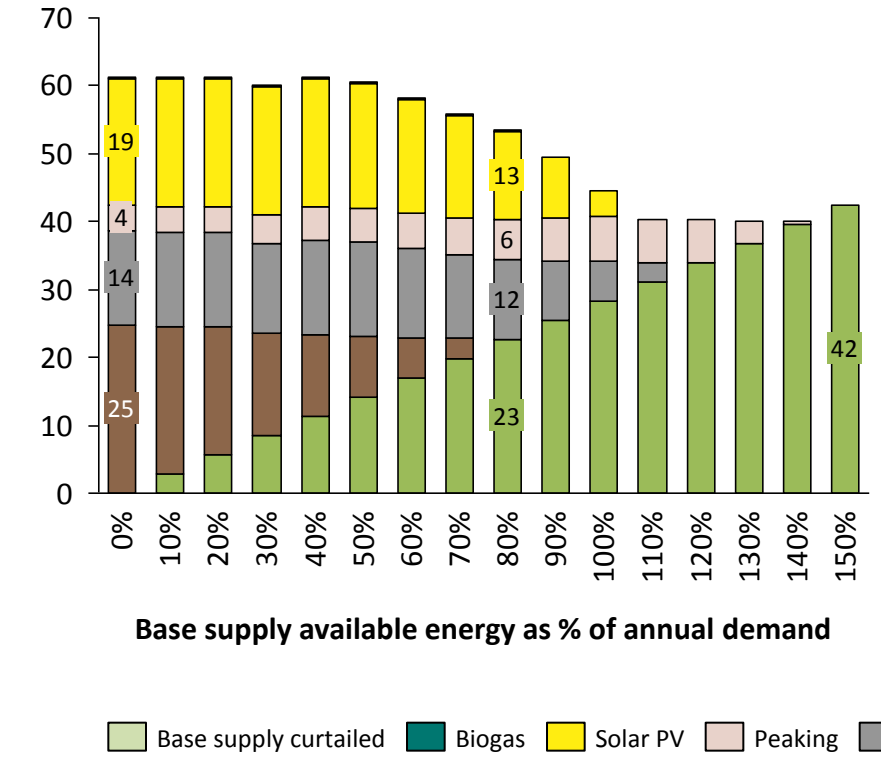
2011 wind profile (benchmark) | 2010 wind profile | 2013 wind profile | Cost of wind

2009 wind profile | 2012 wind profile | 2016 Actual wind

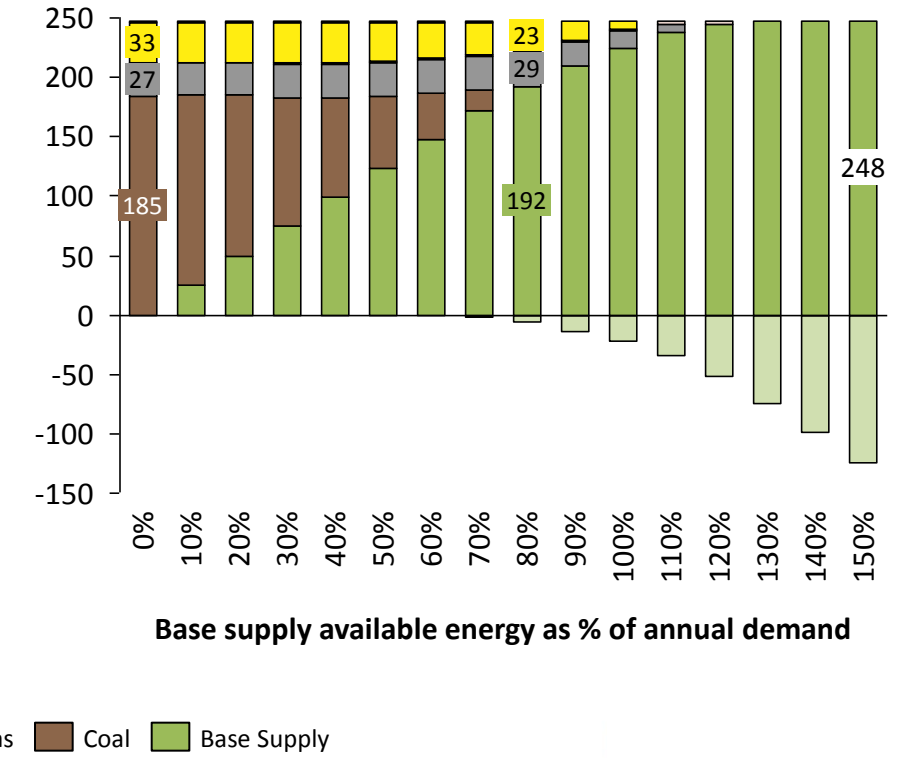
With same methodology but applied for a base-supplier and no wind to isolate the effect

Total capacity and energy of residual load for each penetration of base supply

Capacity built to supply demand



Energy Produced

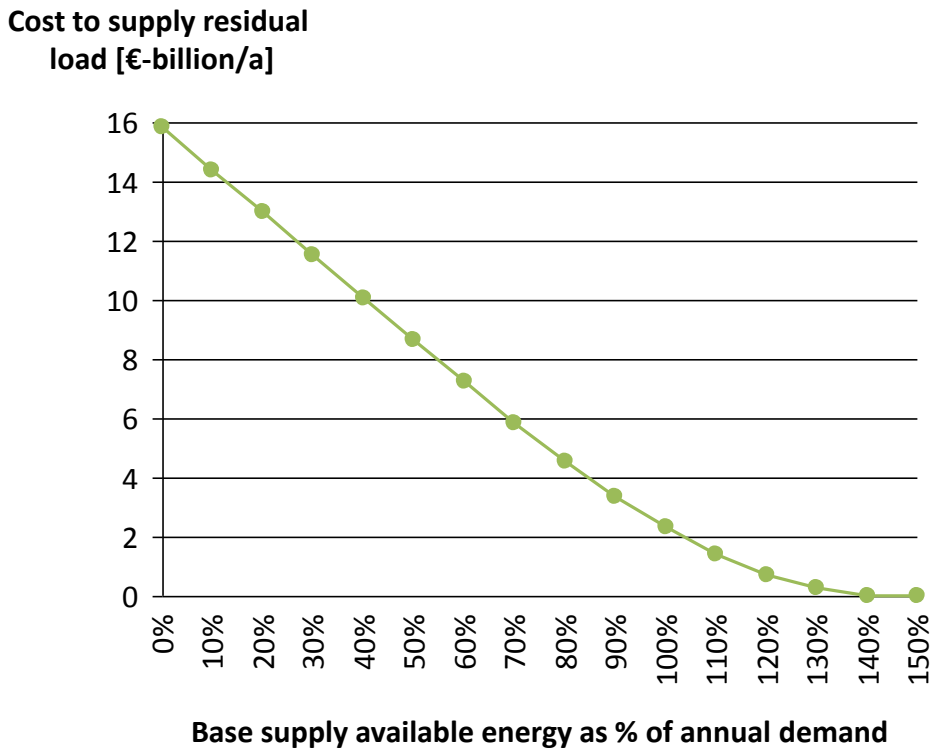


Base supply curtailed | Biogas | Solar PV | Peaking | Gas | Coal | Base Supply

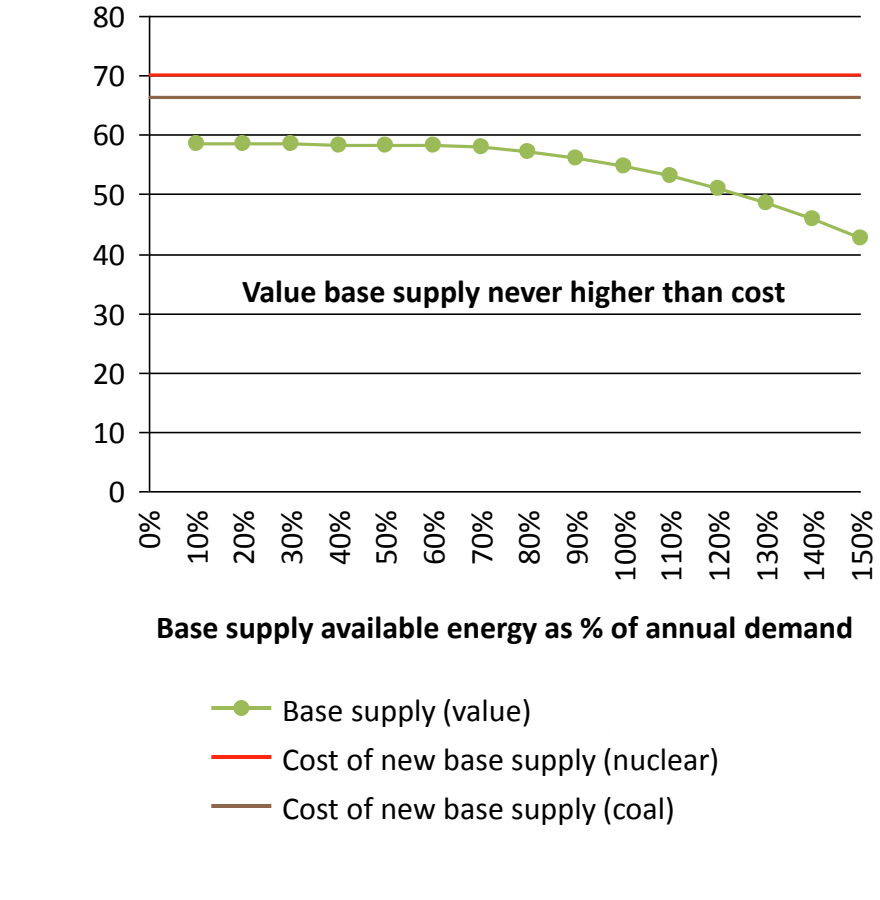
Average value for a base-supplier also declines but nowhere near as much as wind (as expected)

Average system value of base supply generator decreases as energy share of base supply increases

Cost to supply residual load



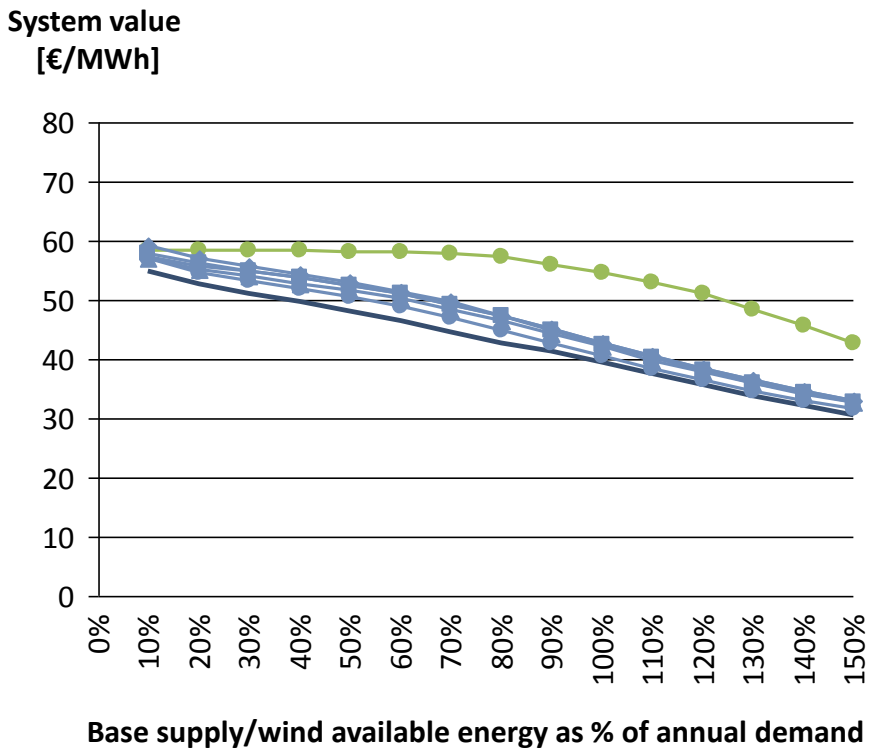
Average system value



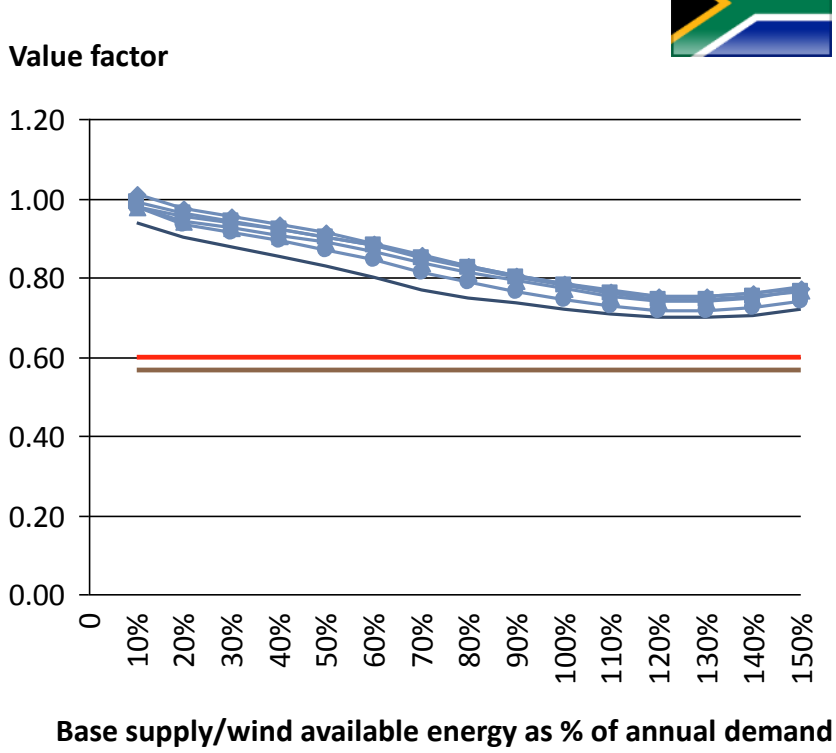
More importantly – what is the value of wind relative to a base-supplier and what are the actual relative costs of each?

Wind value relative to base supply

Average system value



Value factor

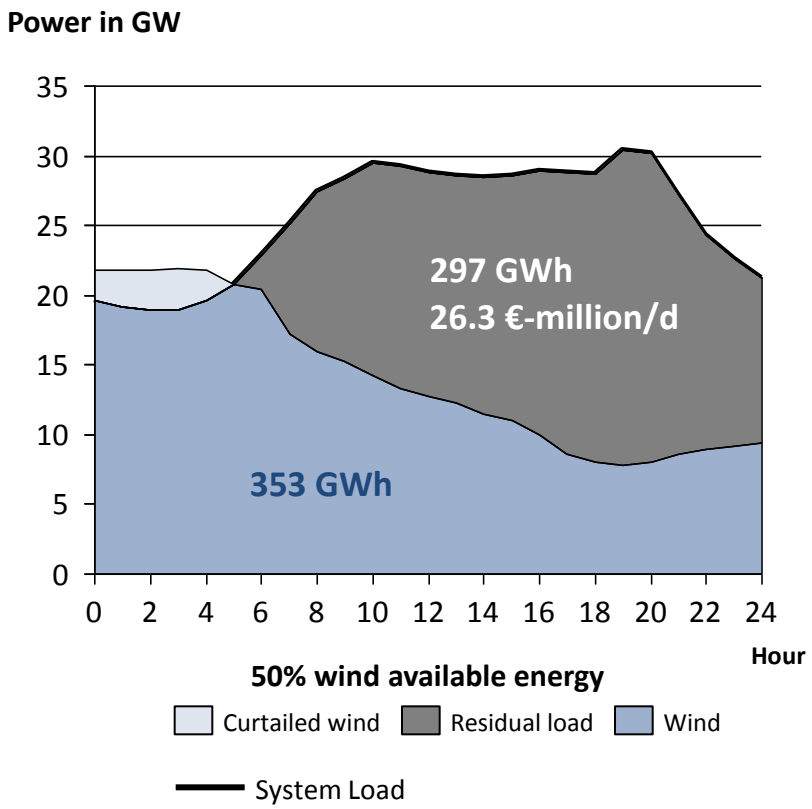


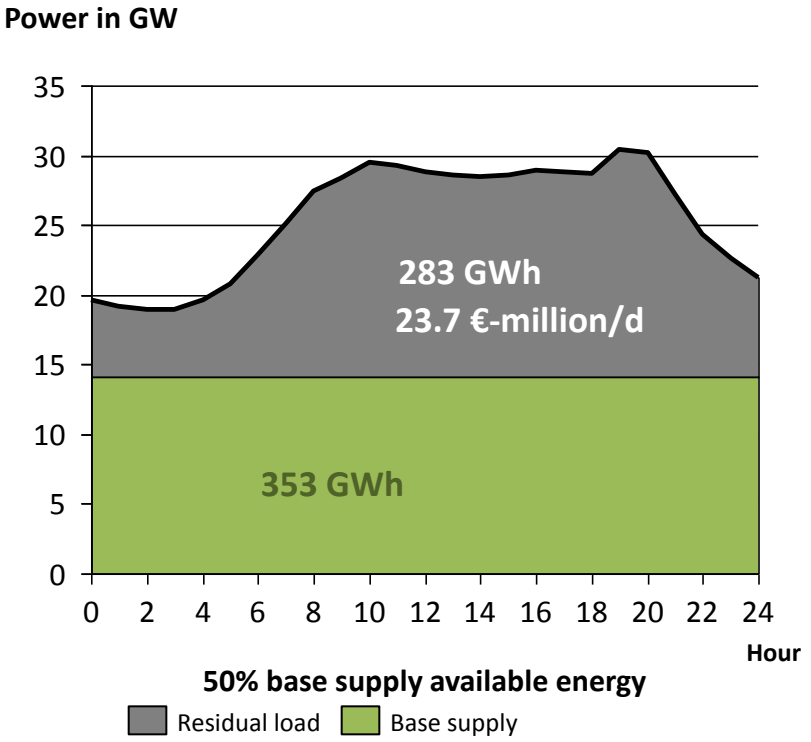
2011 wind profile
2010 wind profile
2013 wind profile
Cost factor (wind/nuclear)
2009 wind profile
2012 wind profile
2016 Actual wind
Cost factor (wind/coal)

Due to differences in profiles, wind value generally < base supply value at higher energy shares (as expected)

Example day: hourly generation for wind and base supply at 50% energy share

Residual load wind > Residual load base supply at higher energy shares as some wind is wasted





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As penetration ↑ - wind value decline not as extreme as expected and wind value-factor never below relative base-supply to wind cost-factor

System-planning approach to valuing power generators for a range of penetration levels (focus on wind)

- Value of any power generator can be considered - wind and base supply presented
- As expected – average and marginal value of wind declines with increasing penetration but:
- **Value of wind greater than cost for penetration levels of up to 60-70%**

Interesting outcomes:

- For a range of wind profiles - change in wind value is not too large
- Average and marginal wind value decline not as significant for all penetration levels (as seen in the literature)
- Value factor (relative to base-supply) never below cost factor of wind to base suppliers (coal/nuclear)

Going forward:

- Study based on 2017 costs. Future costs for batteries and solar PV plus uptake of electric vehicles change optimal capacity mix towards higher share of solar PV
- Apply methodology to other technologies (solar PV) and other jurisdictions
- How important is the wind resource and profile?
- Other aspects to enable richer findings and test whether fundamental findings change:
  - Cost of balancing (effect of forecast errors)
  - Relative grid-related costs

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Thank you