Financing Concentrating Solar Power – Subsidy or Investment?

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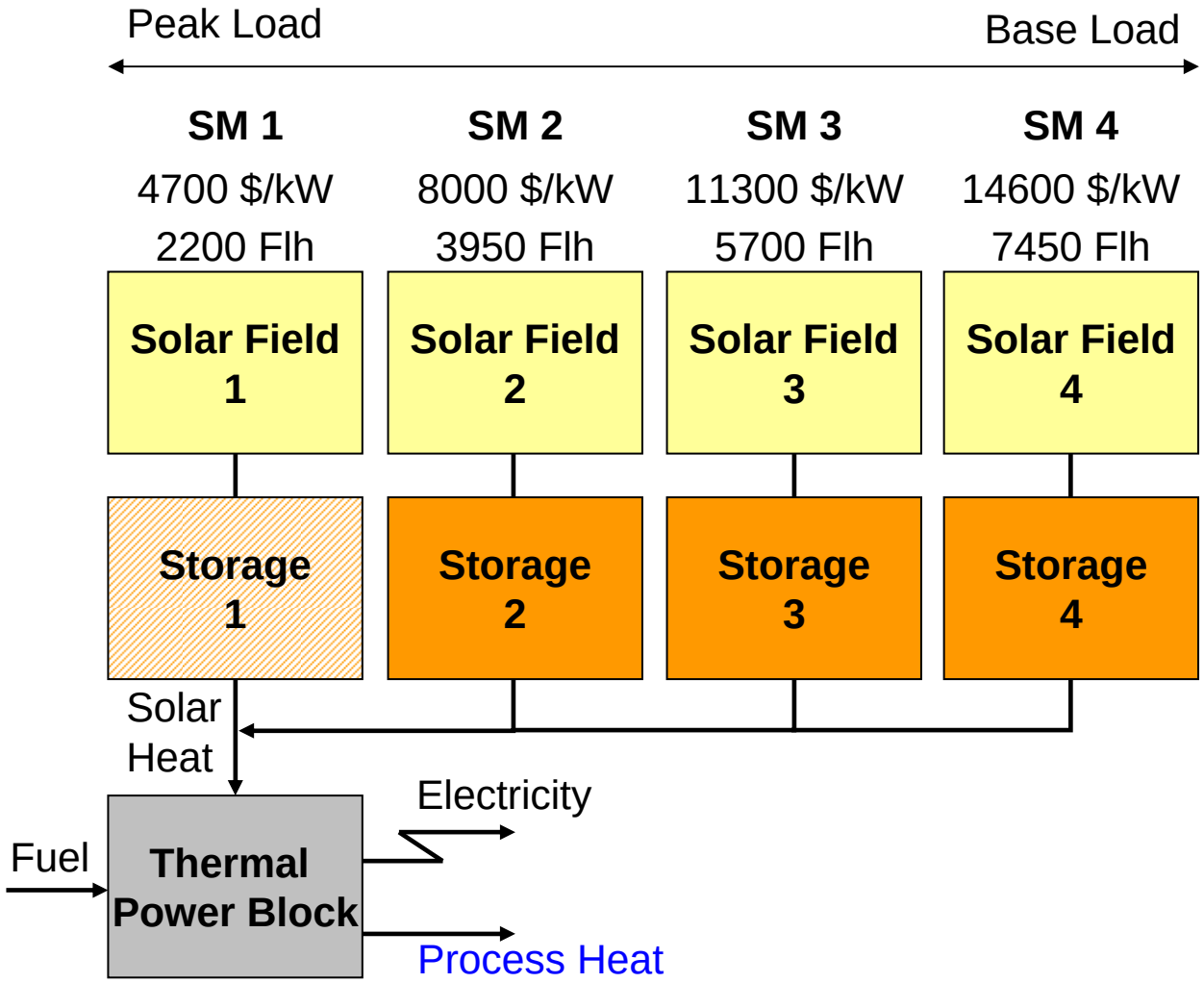
Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

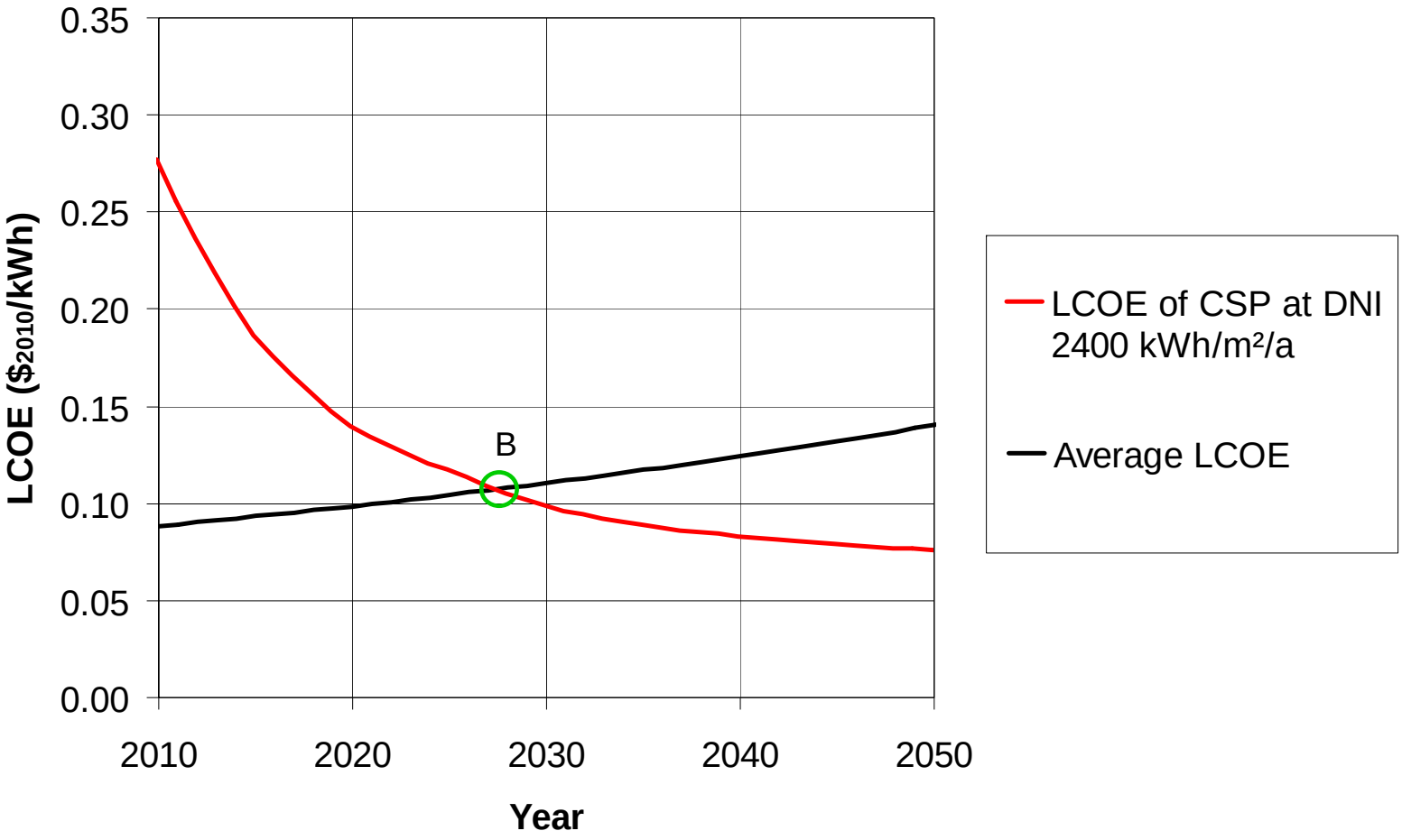
Principle of a Concentrating Solar Power Plant



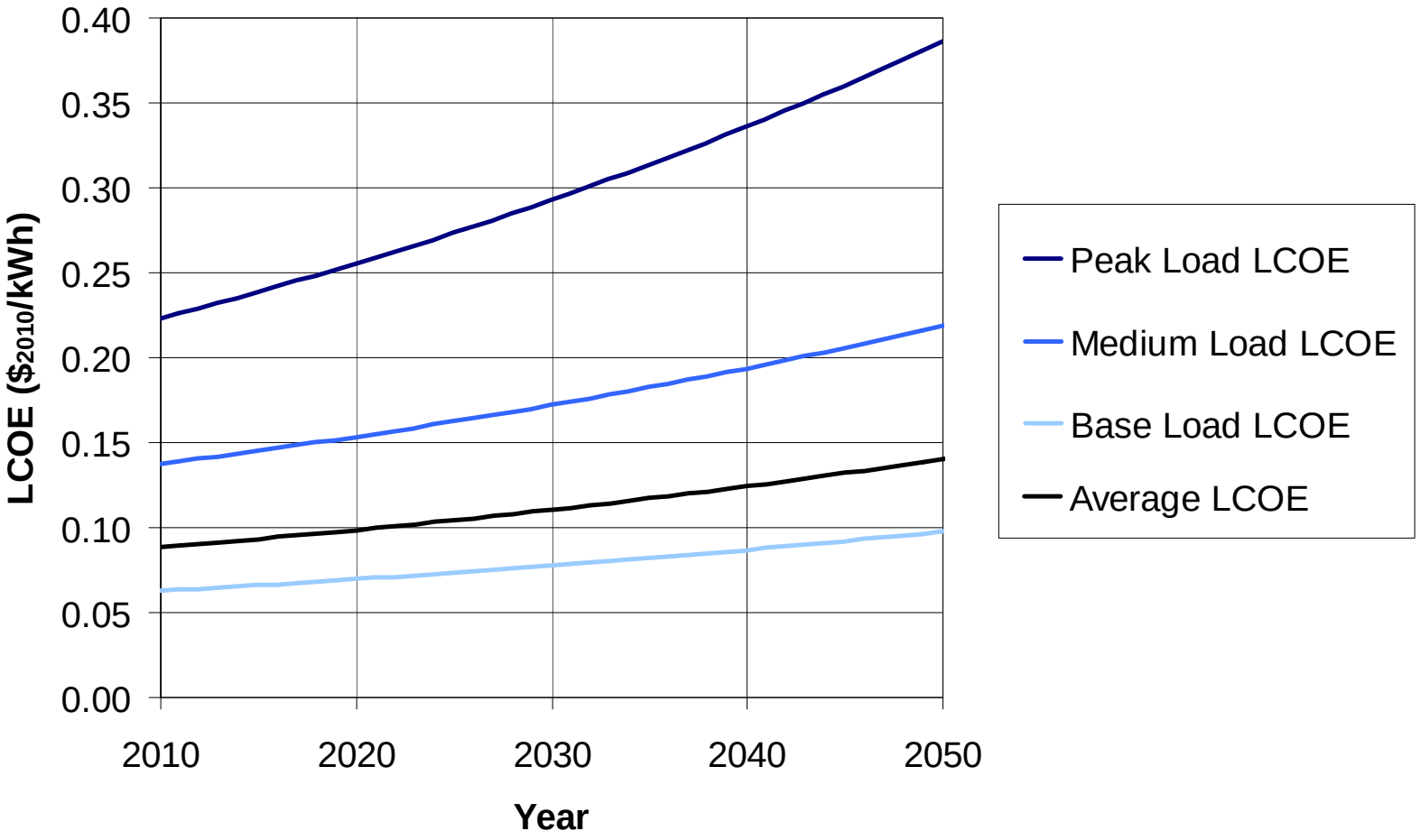
Qualities of CSP Plants:

- Operating as peak, medium or base load power plant
- Firm capacity
- Power on demand
- Spinning reserve
- Combined generation of process heat for industry, cooling, desalination, etc.

Main Barrier for Market Introduction in MENA

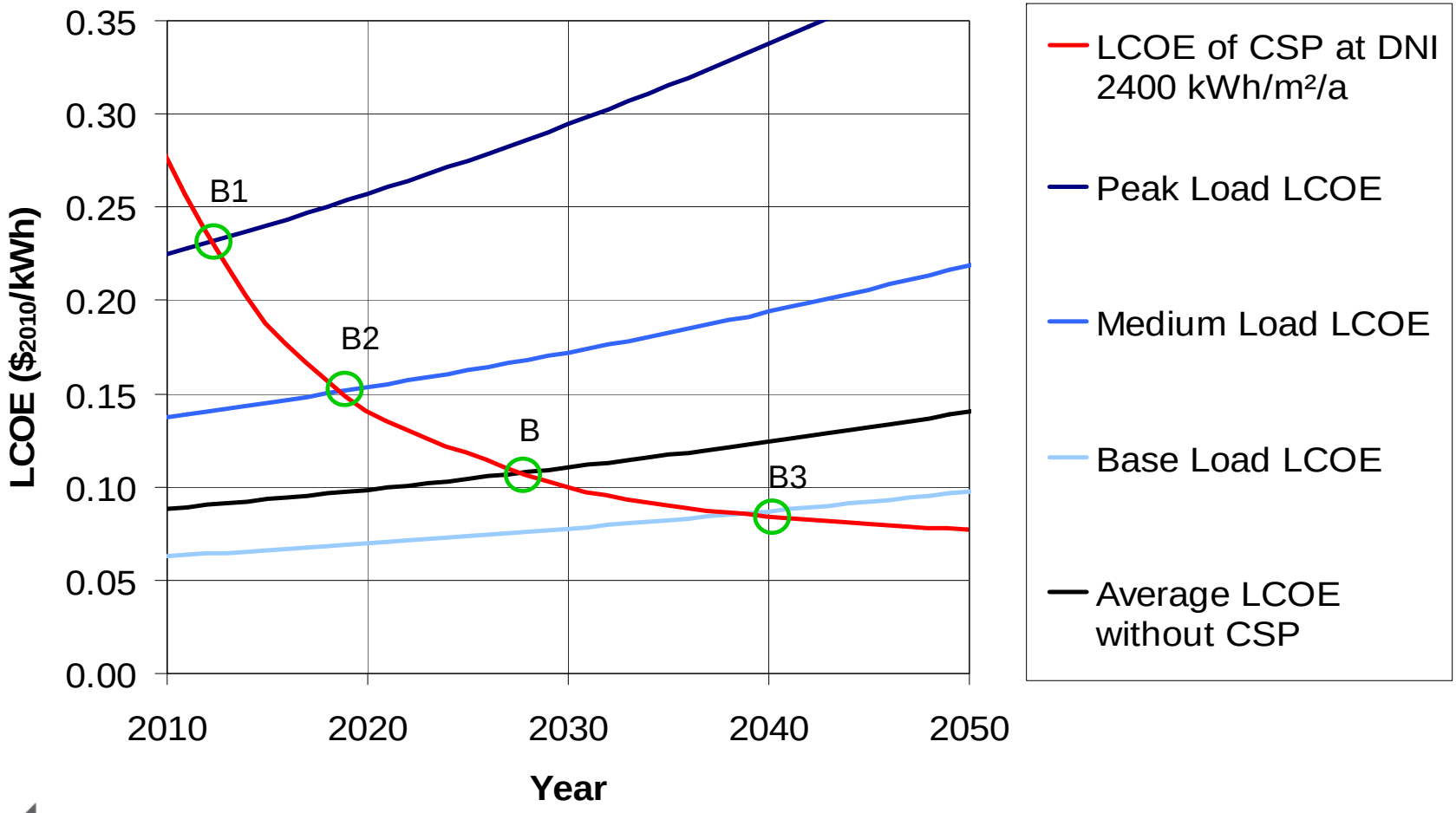


The Real Cost of Electricity (Model Case)



A Strategy for CSP Finance

- Break even with different load segments



A Strategy for CSP Finance

- **Goal:**
  1. Trigger considerable investments in CSP in MENA in the near future
  2. Market introduction of CSP with as low economic burden as possible
- **Approach:**
  1. Providing security by long-term international insured power purchase agreements (iPPA)
     → Easiest way to bring down electricity costs due to reduced interest rates (capital costs ~ 80 % of electricity costs)
  2. Profit from technical qualities of CSP plants
     → Step-by-step integration of CSP starting at the most expensive load segment (peak load)

Recommendations for Policy and CSP Finance

1. Calculate real full cost per kWh of each load segment and its possible future development
2. Calculate the required tariffs for CSP investments and its future development
3. Compare the cost of new conventional peak, medium and base load power plants with required CSP tariffs and identify cost break-even points
4. Identify quantitative requirements for additional capacity and its primary function within the peak, medium or base load segment

Recommendations for Policy and CSP Finance

5. Call for tender according to capacity planning and offering appropriate long-term PPA together with inflation and currency adjustment

6. Request bids for guaranteed quality for longevity of CSP plants and reasonable national share of manufacturing

7. Try to achieve governmental and in addition international guarantees for the PPA (iPPA) to reduce investment risk

8. Provide transparent information on the calculation of the tariffs and publish the long-term perspective of tariff reduction

➔ Carefully calculated iPPA can open business cases for CSP in MENA without additional economical burden

Thank You!

Contact Information

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Literature

- Franz Trieb, Hans Müller-Steinhagen, Jürgen Kern:
  Financing concentrating solar power in the Middle East and North Africa - Subsidy or investment?, Energy Policy 39 (2011) 307–317.

Parameters for a model case electricity supply structure:

Base Load Capacity	MW	4000
Base Load Annual Electricity	GWh/a	30000
Base Load Fuel Cost (Coal + NG + HFO)	$/MWh	15.0
Medium Load Capacity	MW	2500
Medium Load Annual Electricity	GWh/a	10000
Medium Load Fuel Cost (Coal + Fuel #2)	$/MWh	35.0
Peak Load Capacity	MW	1000
Peak Load Annual Electricity	GWh/a	2000
Peak Load Fuel Cost (Diesel + Fuel #2)	$/MWh	60.0
Cost Escalation of Fossil Fuels	%/a	1.5%
Specific Power Block Investment (B+M)	$/kW	1200
Specific Power Block Investment (Peak)	$/kW	400
Project Rate of Return	% of Inv./a	10.0%
O&M Rate	% of Inv./a	2.5%
Fuel Efficiency Base & Medium Load	%	35.0%
Fuel Efficiency Peak Load	%	30.0%

- Model parameters for the required revenues of CSP:

Reference LCOE of CSP in 2010	$/kWh	0.280
Reference Direct Normal Irradiance	kWh/m²/y	2400
CSP Progress Ratio	%	88.0%
Project Rate of Return	%	10.0%
O&M Rate	%	2.5%
Exchange Rate	$/€	1.19

- CSP feed-in tariff in Spain is used as reference value (27 €/MWh)
- Feed-in tariff has proven to trigger considerable investment in CSP
- Average DNI in Southern Spain: 2090 kWh/m²/y

Main Barriers/Challenges of CSP Finance

Main Barriers/Challenges for Market Introduction of CSP in MENA

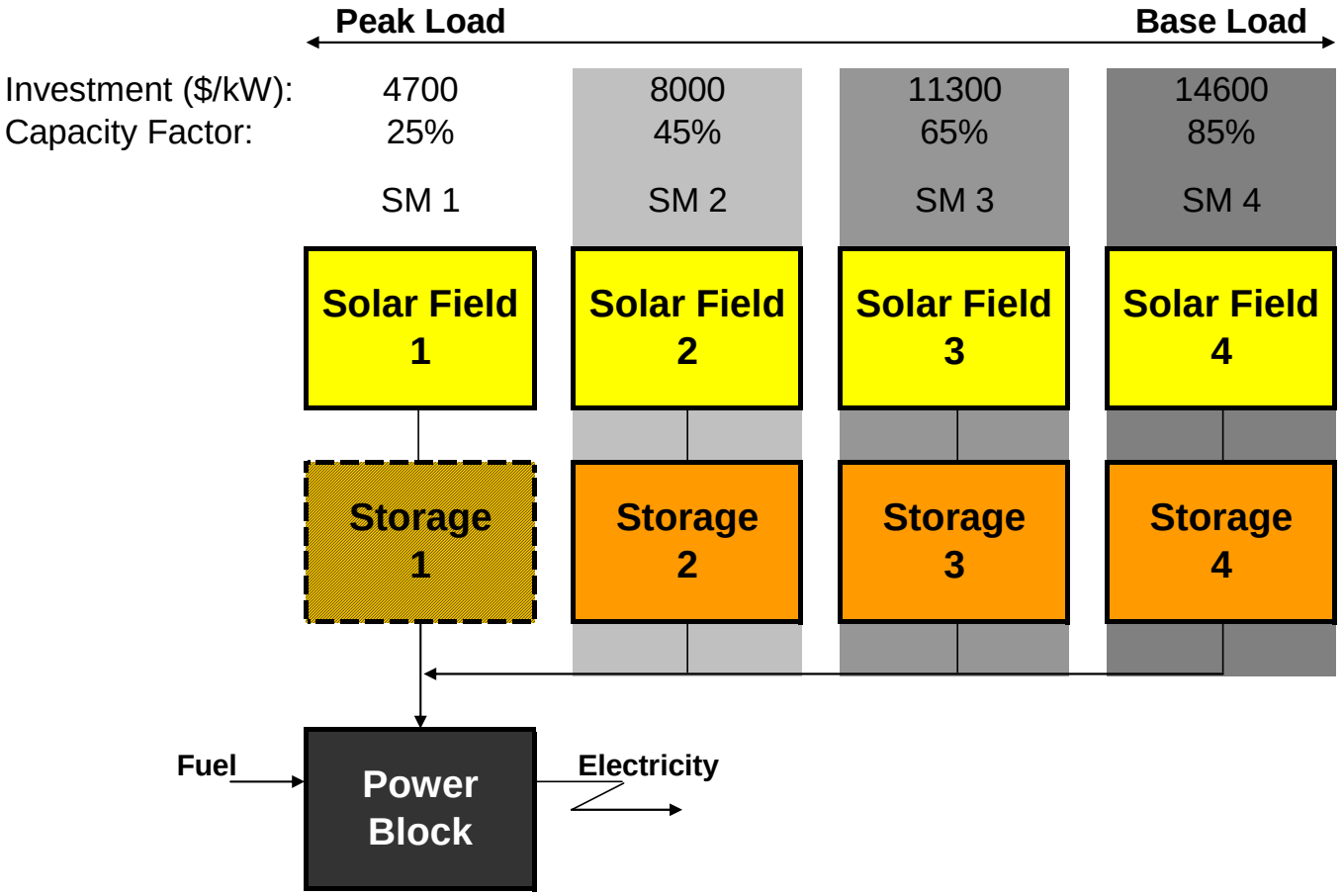
1. Very **high electricity costs** of CSP compared to present average market prices
2. Long-term investment (20-40 years) not only for the power plants but also for their „fuels“ → **High initial investment**
3. **Unknown future savings** due to volatile and unpredictable conventional fuel prices
4. **Known long-term cost** but **unknown long-term revenues** if electricity is sold at spot markets

➔ Lack of security for private and public investors

➔ Technical qualities of CSP plants are not taken into consideration

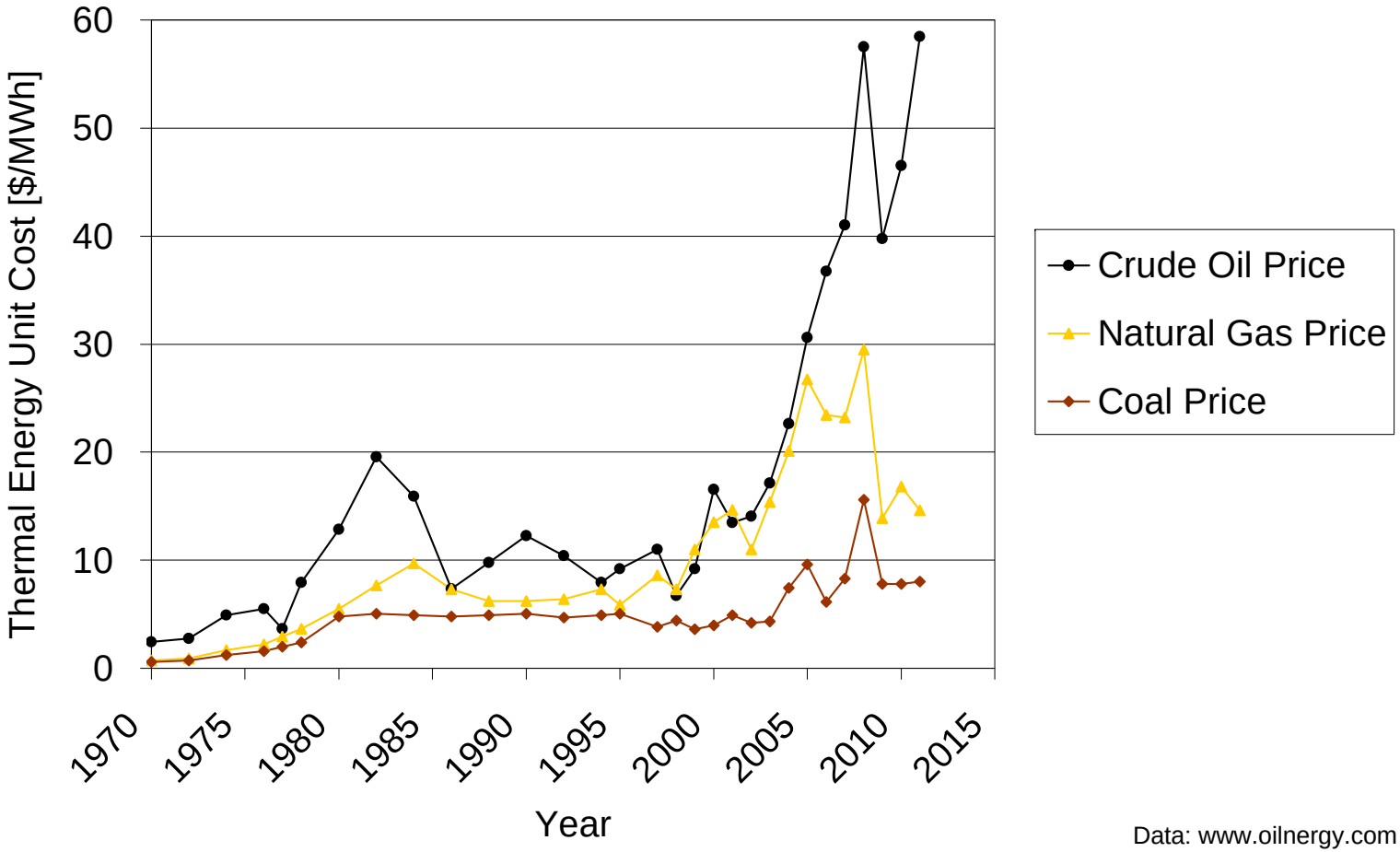
Challenges of CSP Finance:

Challenge 1: High initial investment



Challenges of CSP Finance:

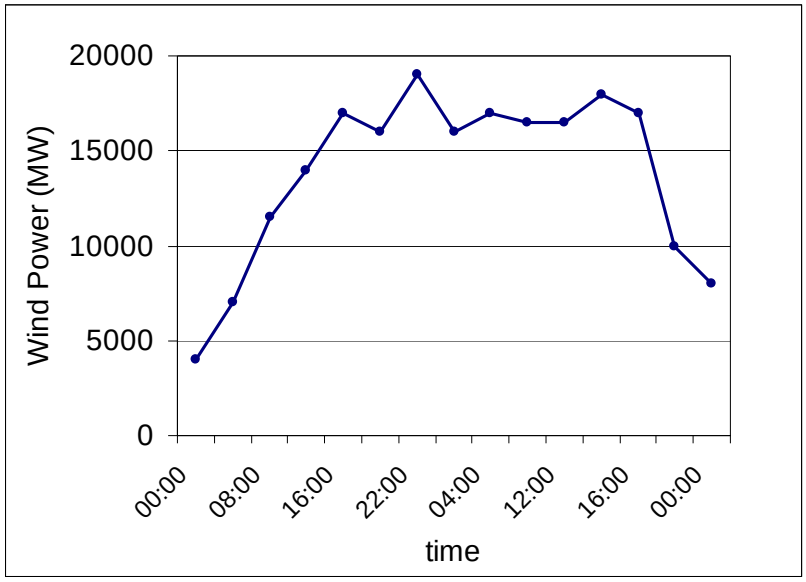
Challenge 2: Known immediate costs but unknown future savings

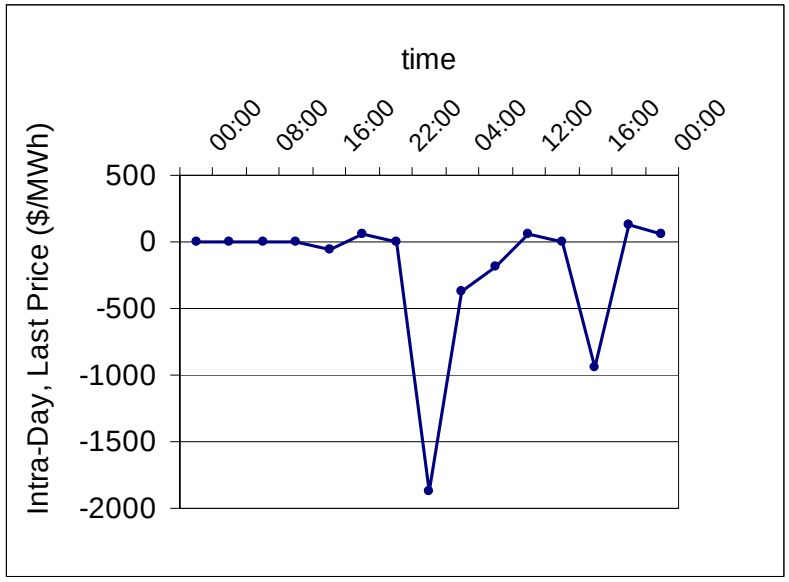


Data: www.oilnergy.com

Challenge of CSP Finance:

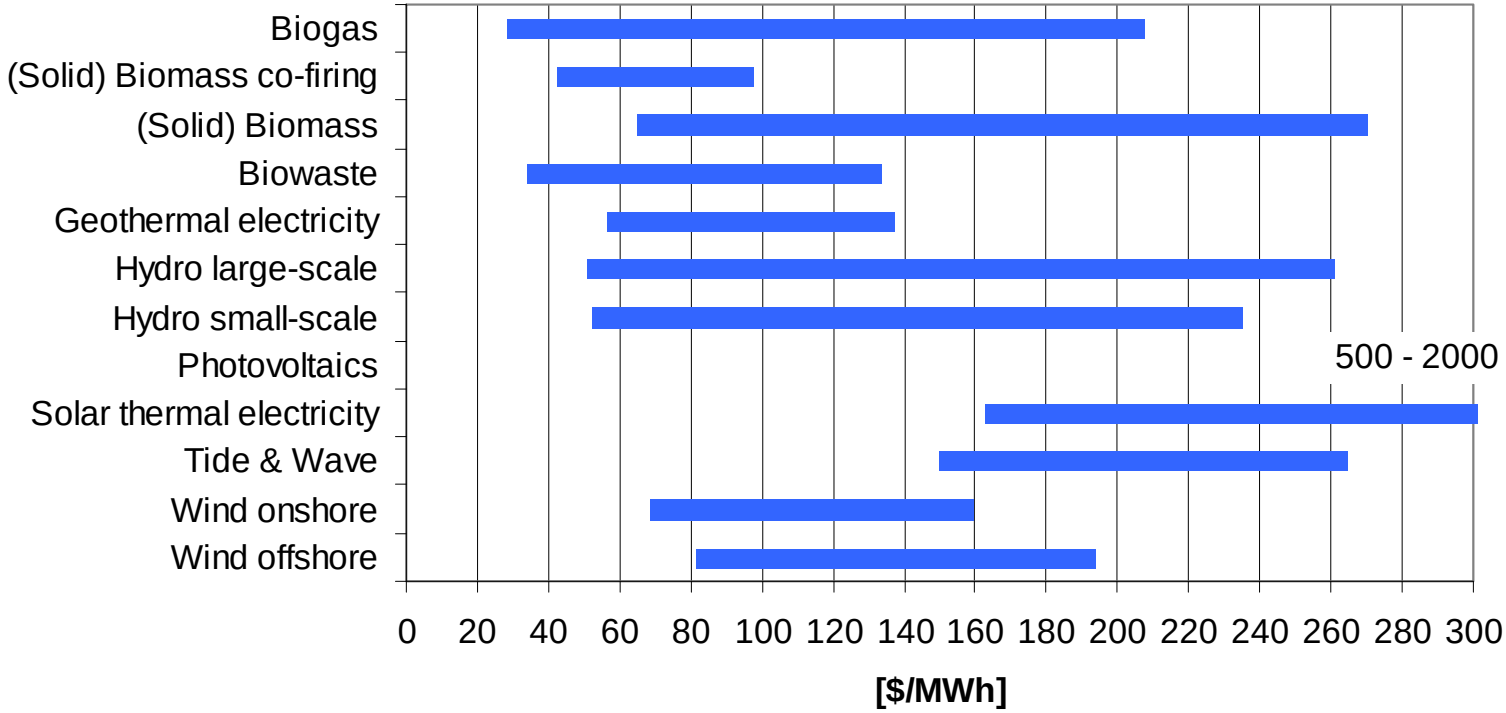
Challenge 3: Fix costs but non-fix revenues





Challenge of CSP Finance:

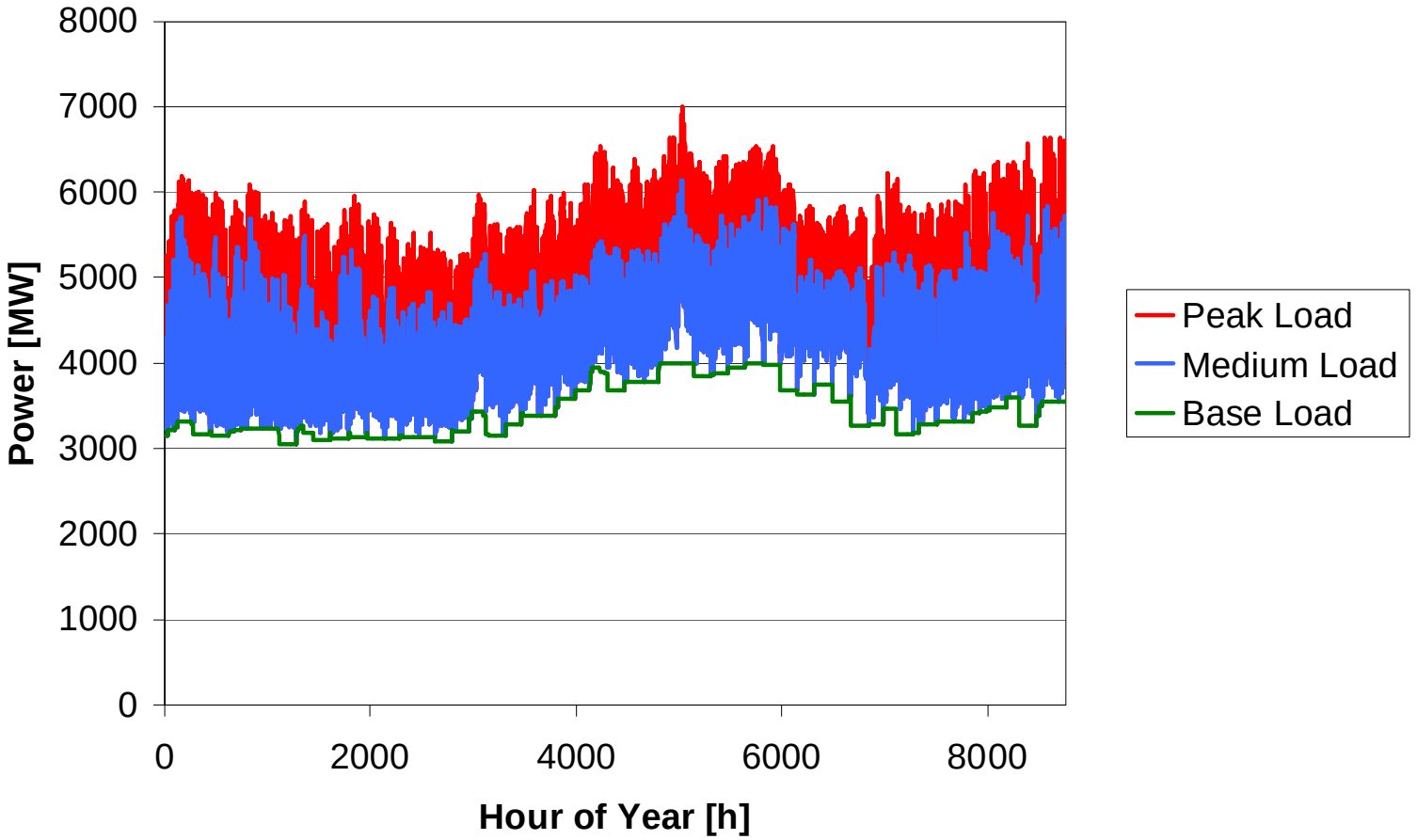
Challenge 4: Initial cost levels above market price



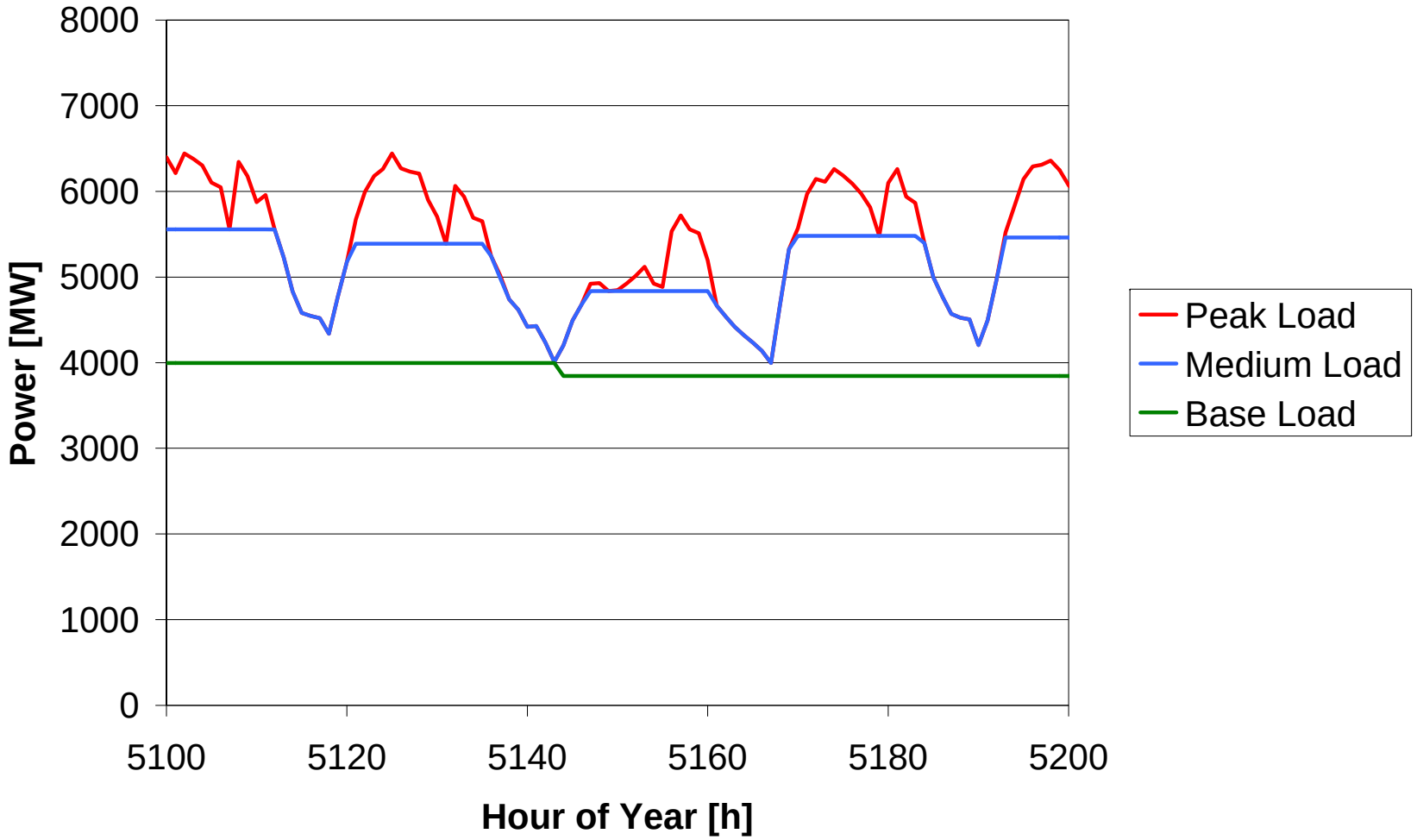
Source: Ragwitz 2009

Calculation of Annual Solar Share in the Initial Phase

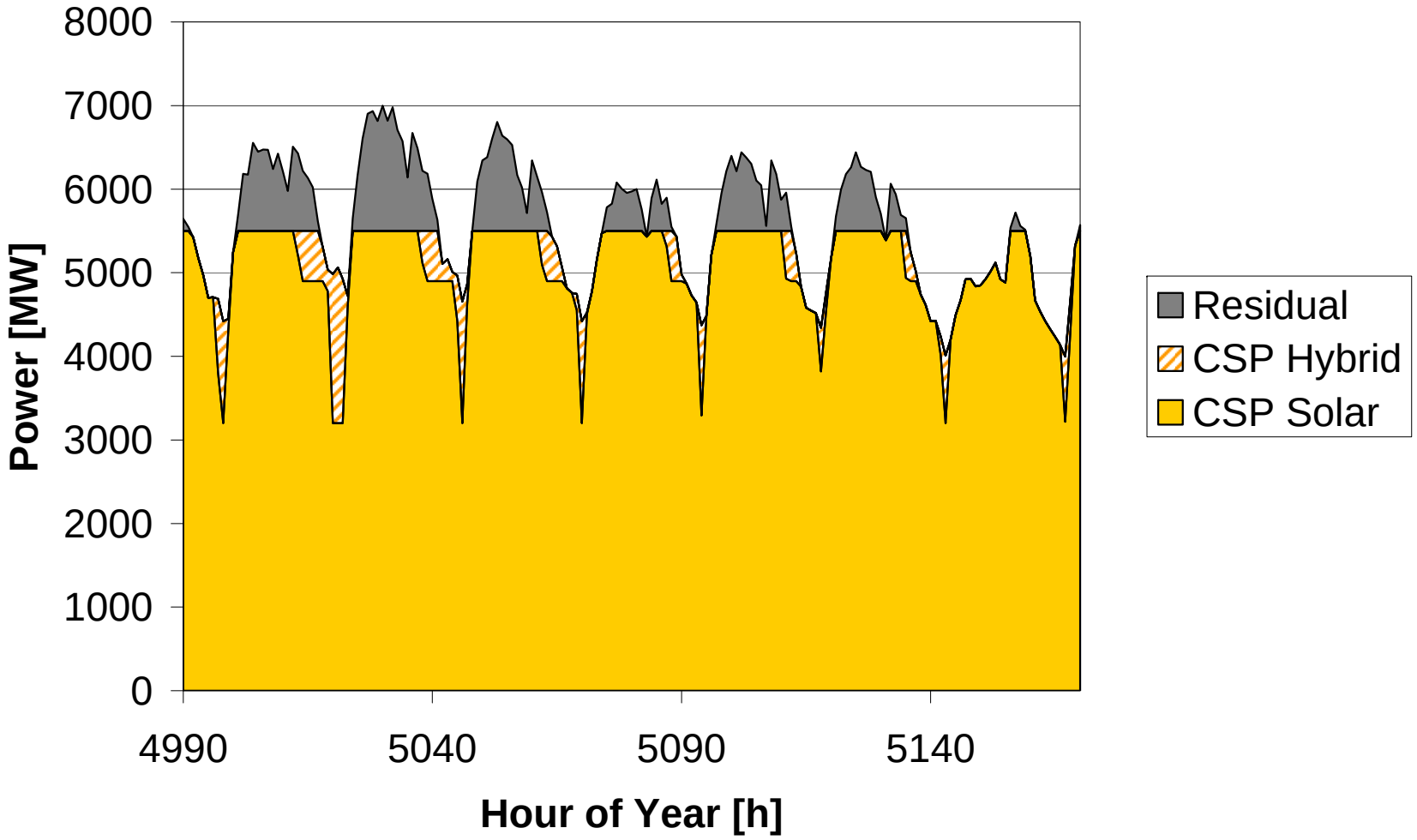
1st Step: The Load Curve is divided into Peak, Medium and Base Load



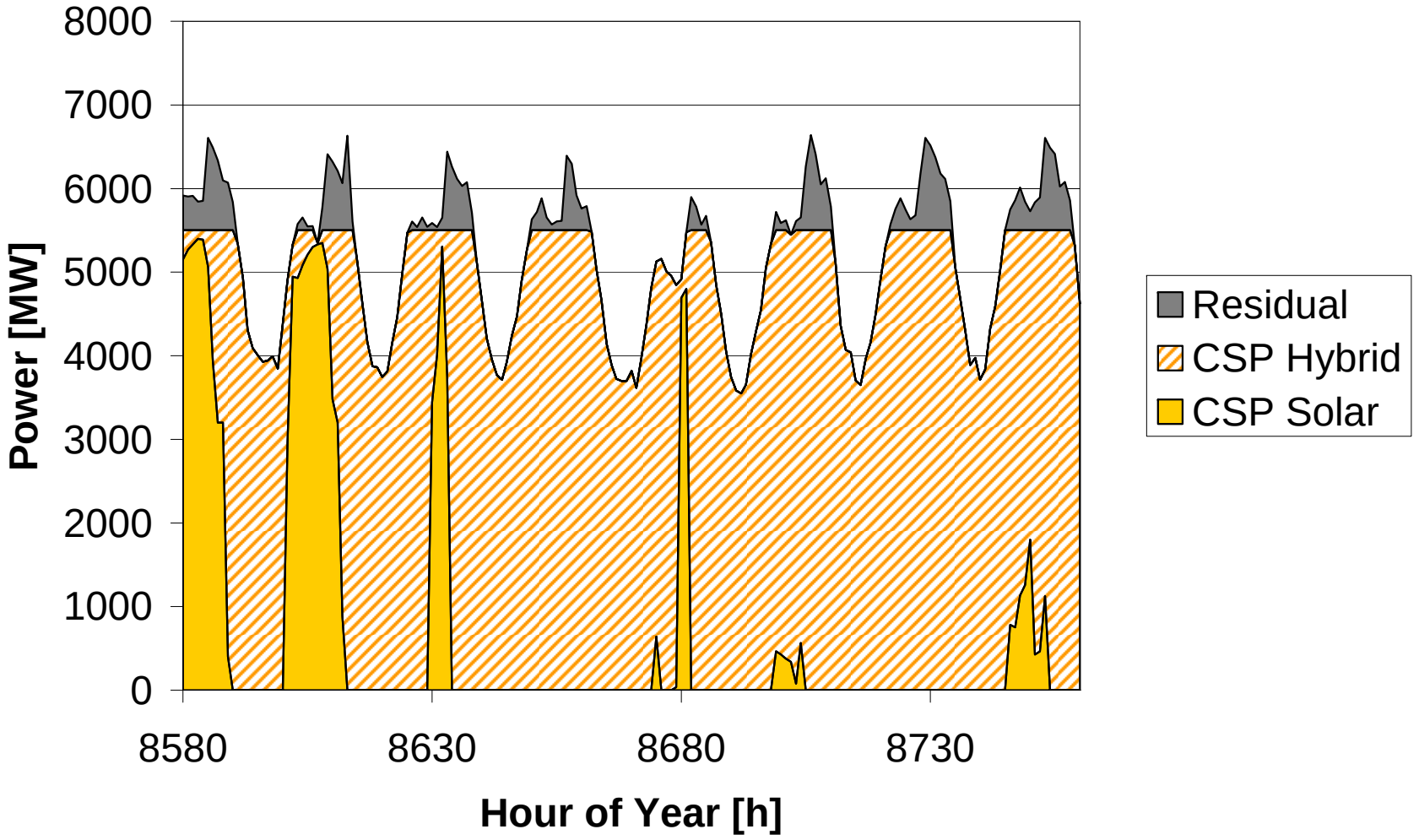
In higher time resolution it looks like this for a summer week



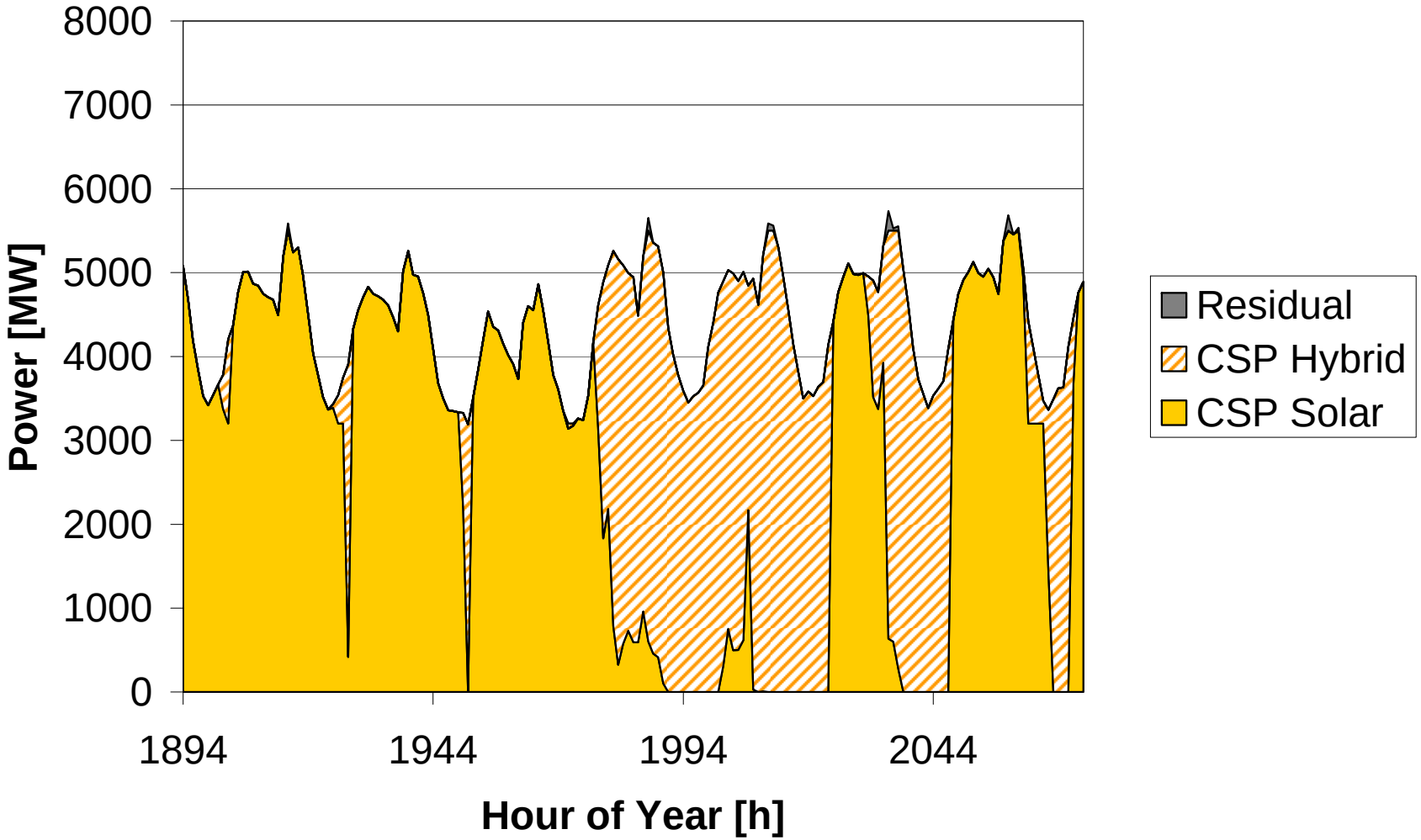
Demand and Supply in Summer Peak Load Week



Demand and Supply in Winter Peak Load Week

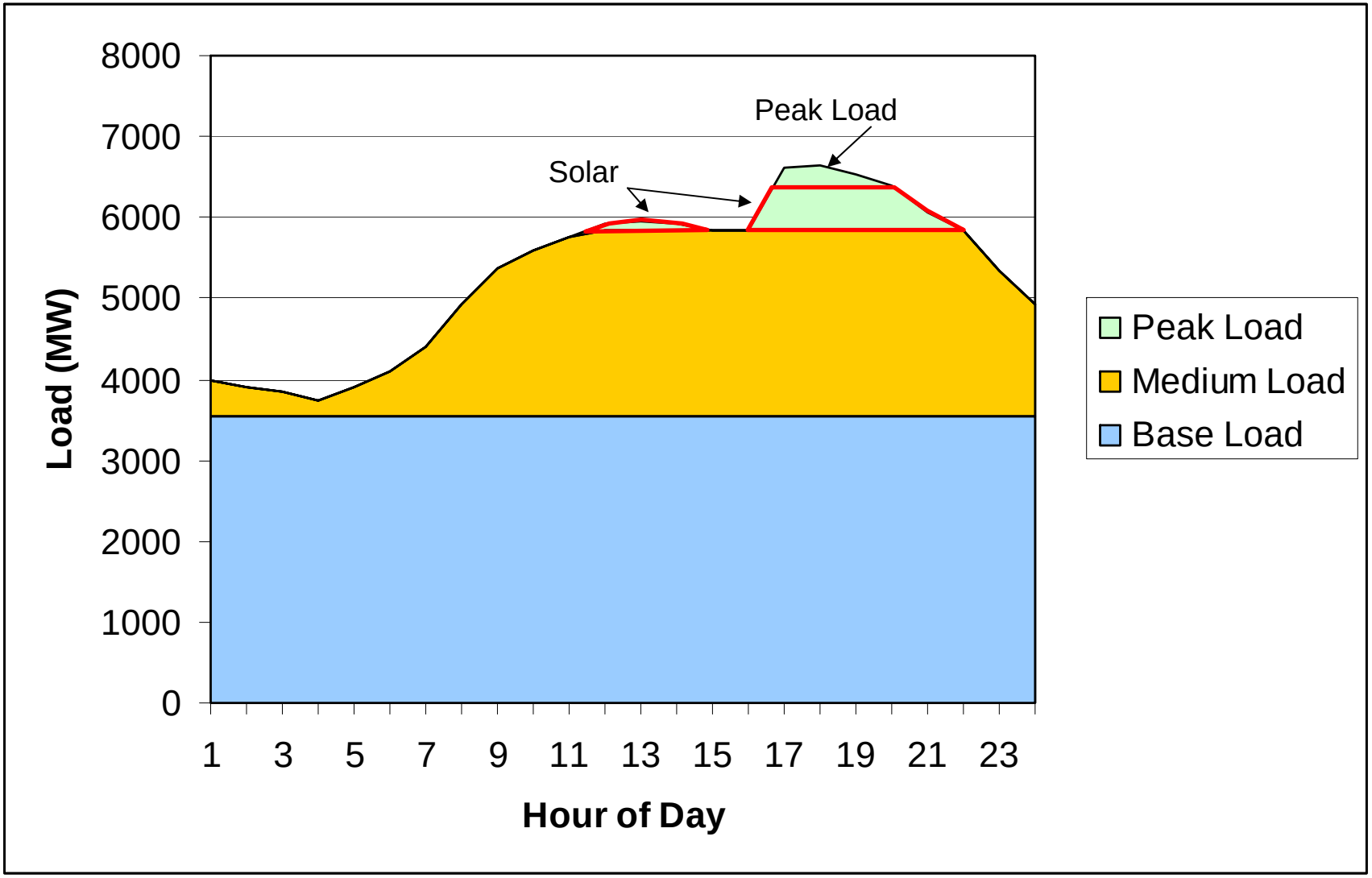


Demand and Supply in Spring Week

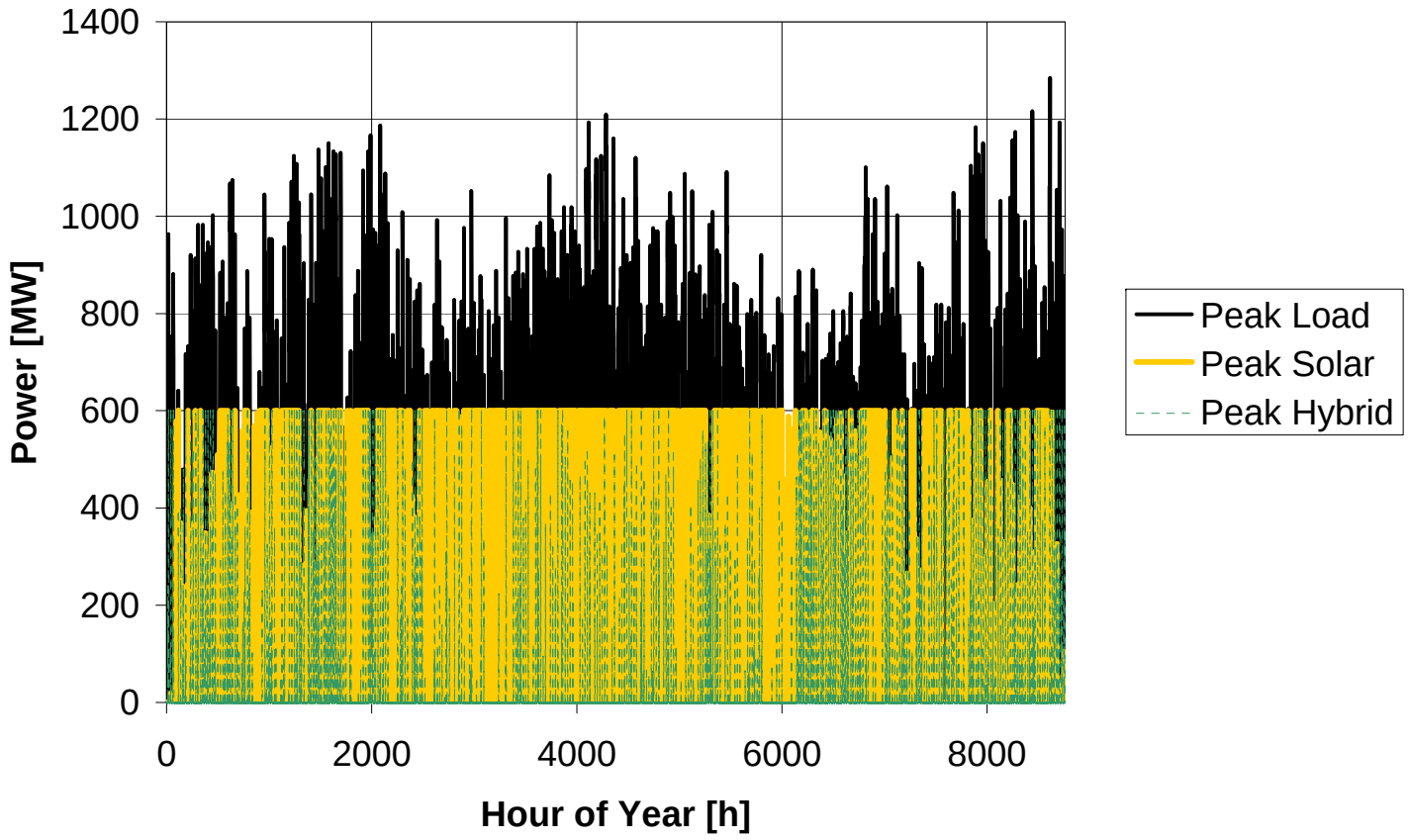


Calculation of Annual Solar Share Summary

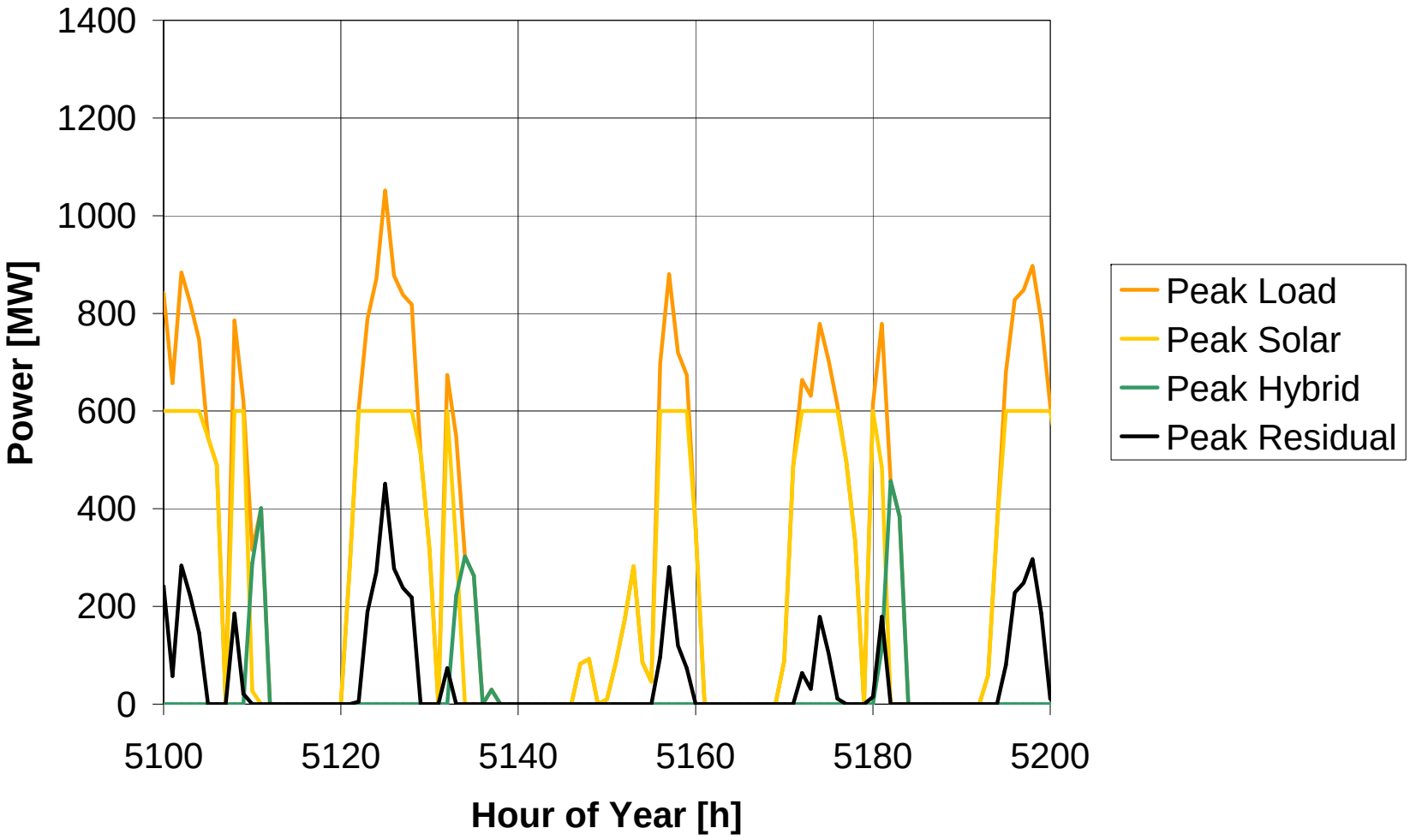
Load Segment	Peak Load	Medium Load	Base Load	Total
Installed Capacity (MW)	1285	2455	4000	7740
Electricity Production (GWh/a)	1925	10004	30095	42024
CSP Capacity (MW)	600	1700	3200	5500
CSP Solar Multiple	1	2	3.5	--
CSP Storage (h)	6	8	18	--
CSP Solar Share (GWh/a)	1159	6574	21313	29046
CSP Fuel Share (GWh/a)	537	3124	6560	10221
Residual Capacity (MW)	685	755	800	2240
Residual Electricity (GWh/a)	230	306	2222	2758
Solar Share	60%	66%	71%	69%


8000
7000
6000
5000
4000
3000
2000
1000
0
Load (MW)
Peak Load
Solar
1
3
5
7
9
11
13
15
17
19
21
23
Hour of Day
Peak Load
Medium Load
Base Load

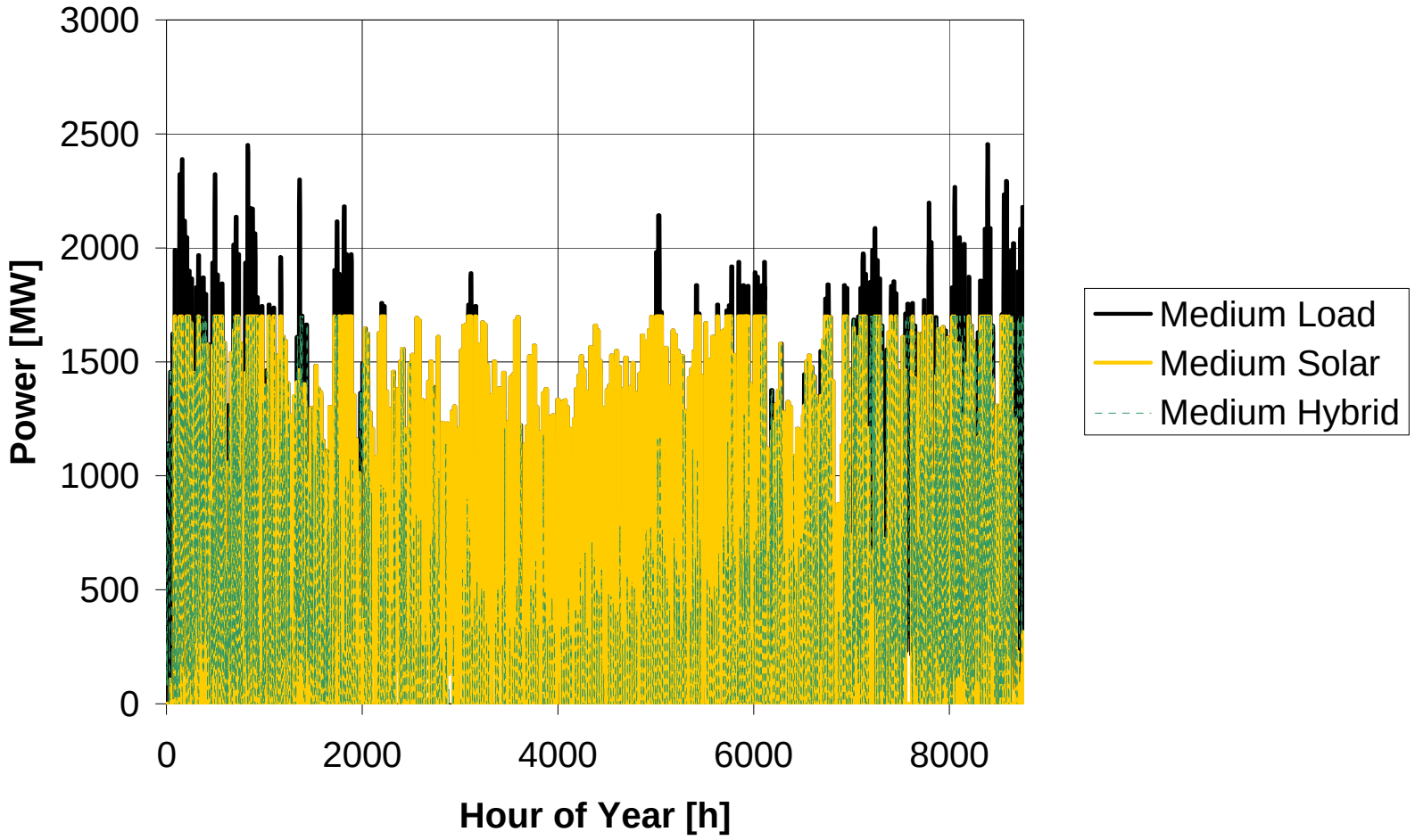
2nd Step: The peak segment is separated and then, the lower part is covered by CSP (solar or hybrid), while the upper part (residual capacity) is covered by conventional peaking plants



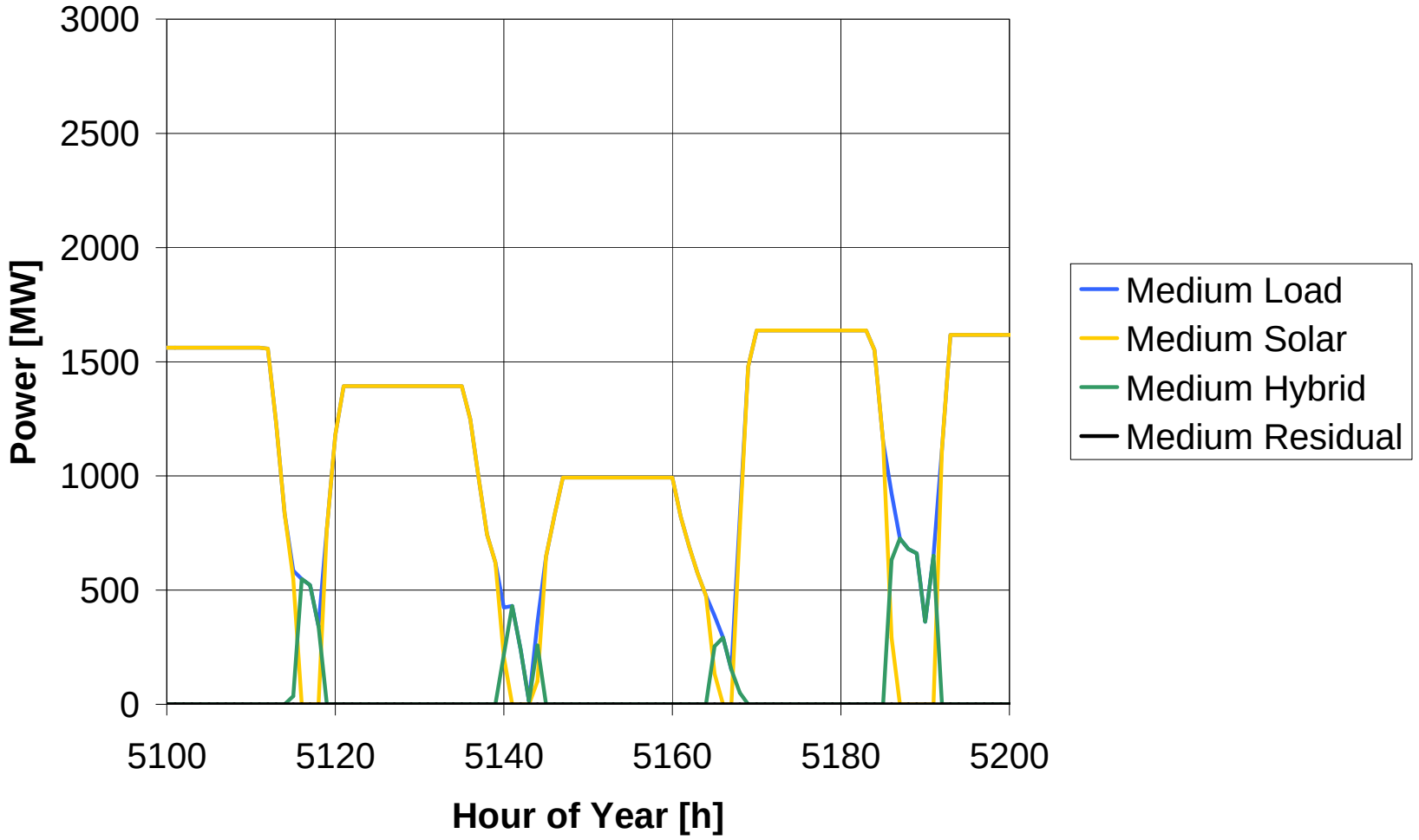
In higher time resolution it looks like this for a summer week



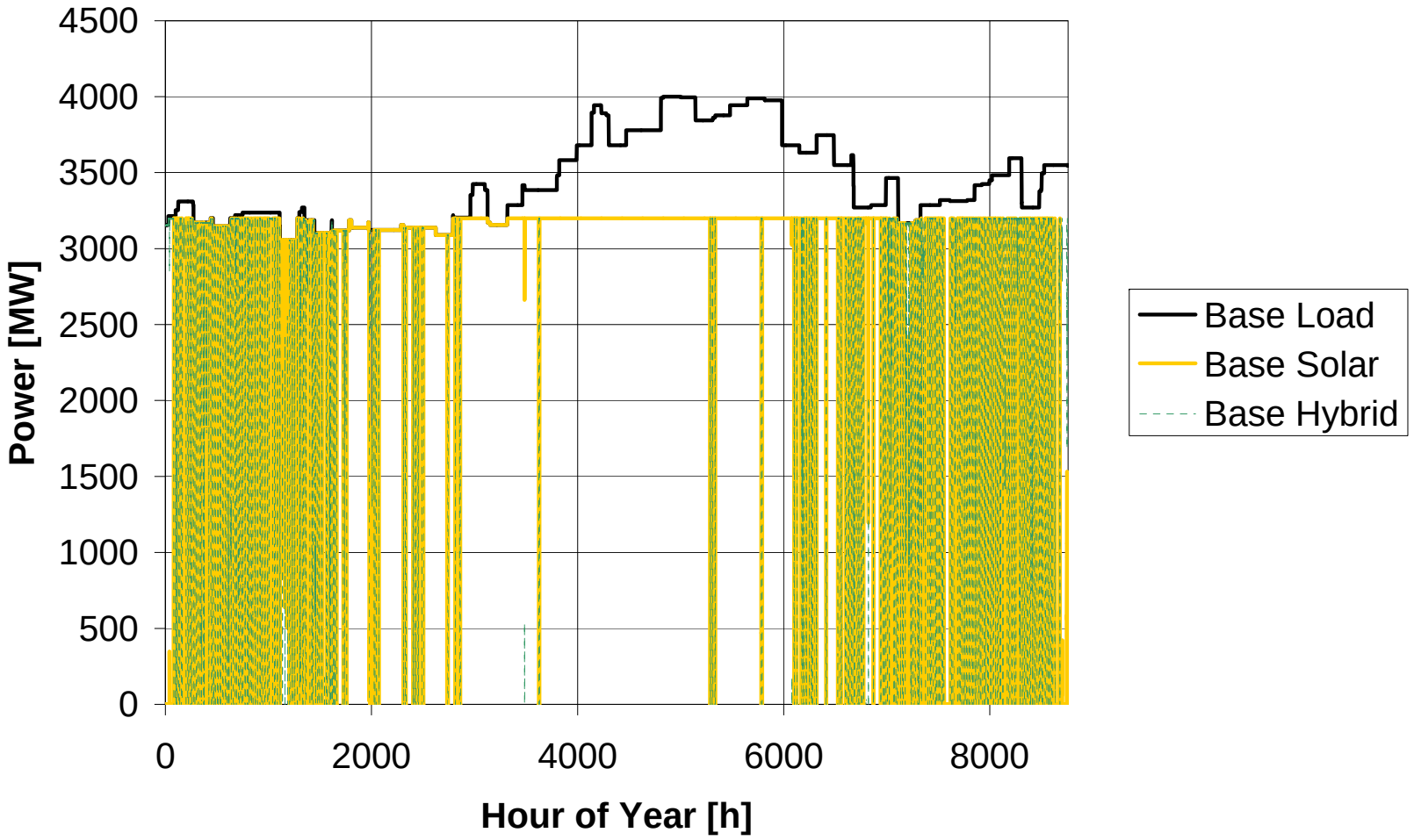
3rd Step: Medium Load is separated and the lower part covered by CSP



In higher time resolution it looks like this for a summer week



4th Step: Base Load is separated and the lower part covered by CSP



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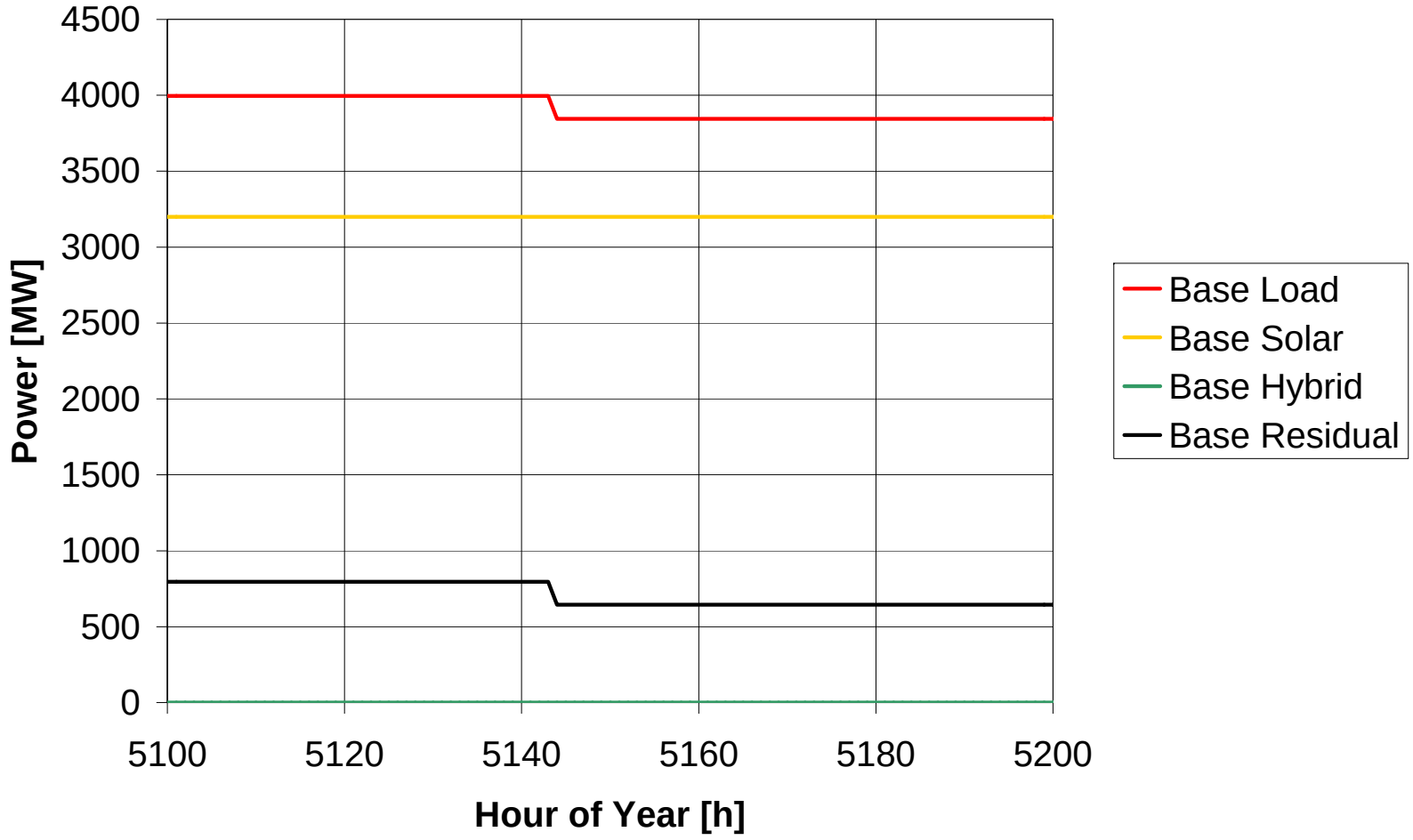
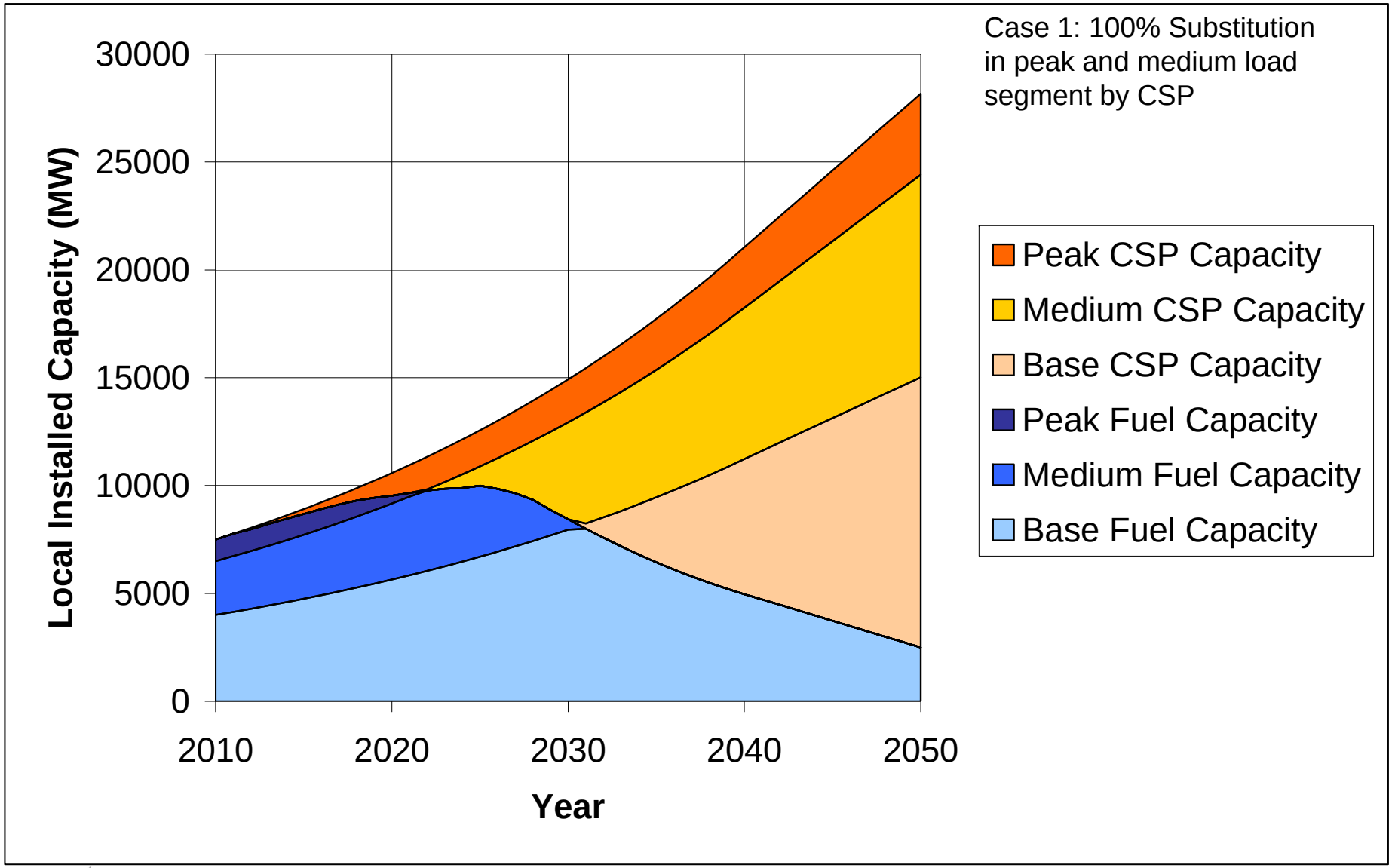
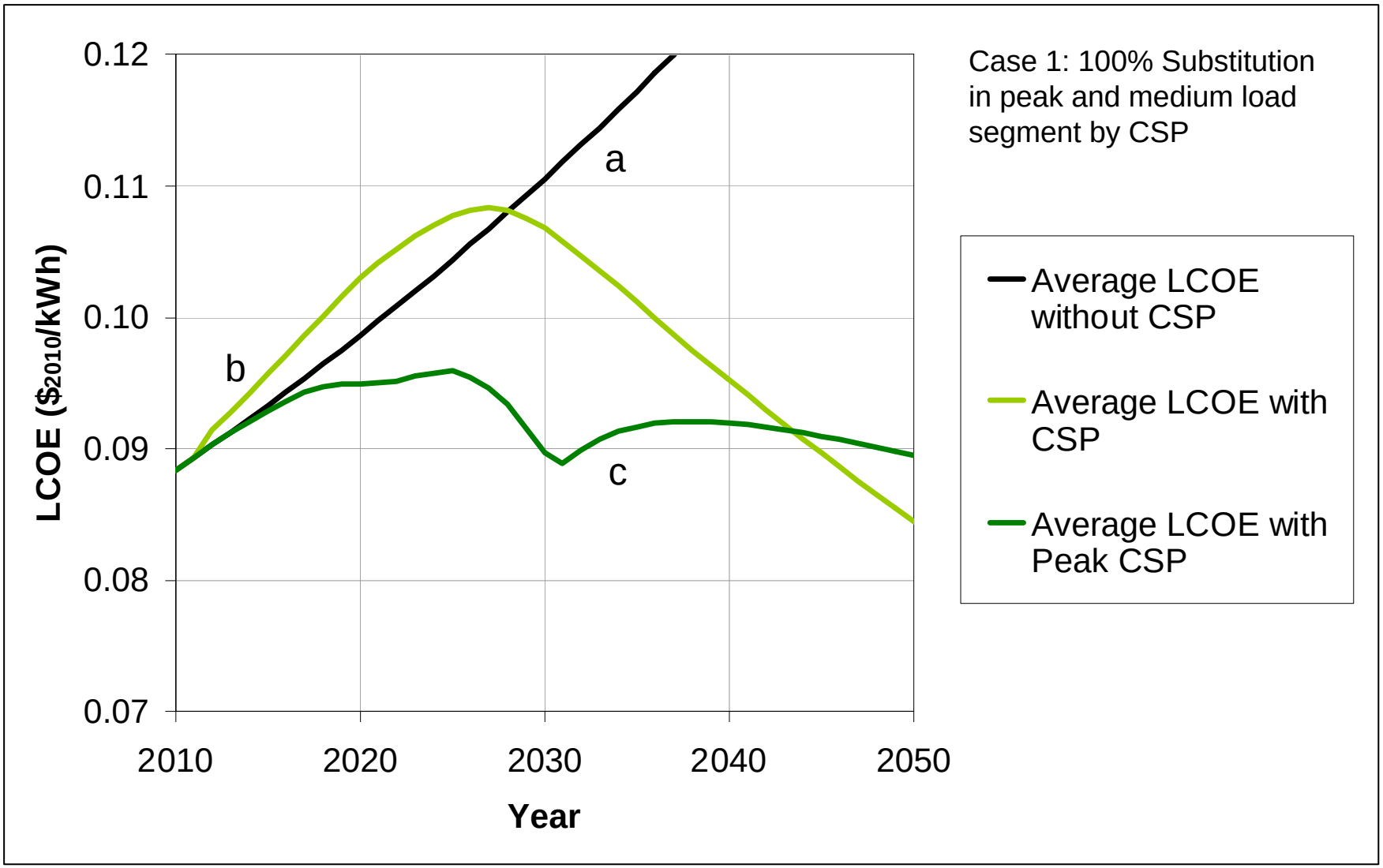
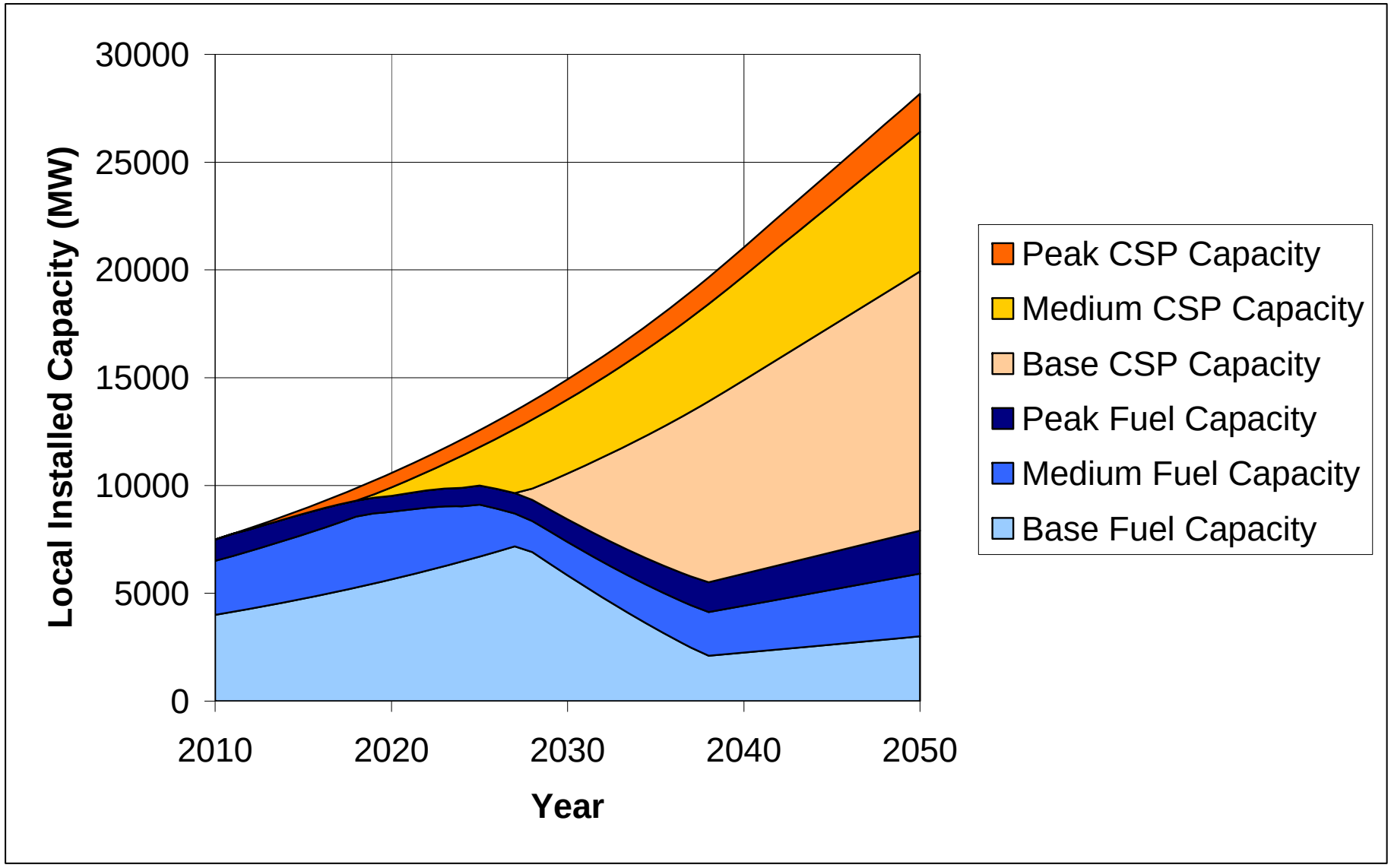
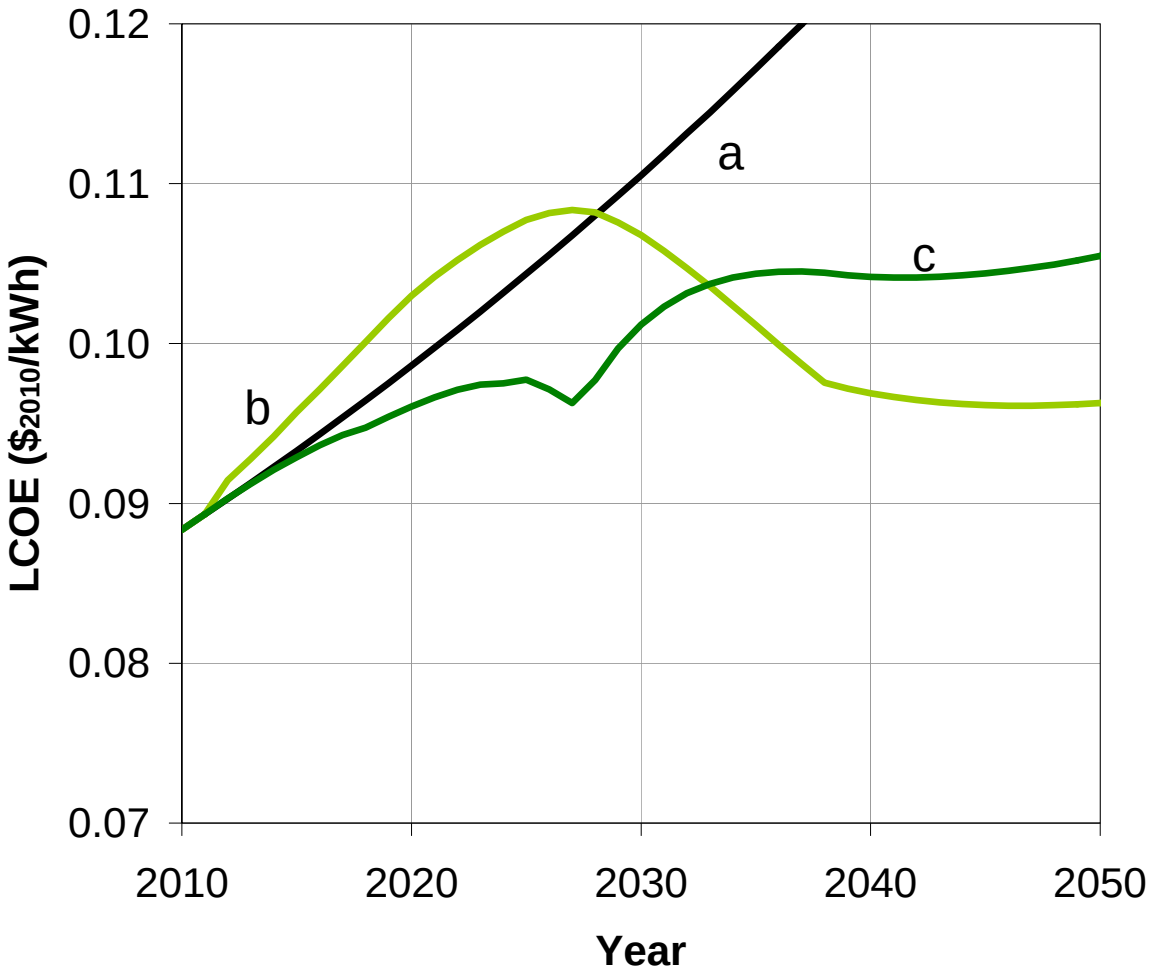



Case 1: 100% Substitution in peak and medium load segment by CSP
Local Installed Capacity (MW)
30000
25000
20000
15000
10000
5000
0
2010
2020
2030
2040
2050
Year
Peak CSP Capacity
Medium CSP Capacity
Base CSP Capacity
Peak Fuel Capacity
Medium Fuel Capacity
Base Fuel Capacity


0.12
0.11
0.10
0.09
0.08
0.07
LCOE ($2010/kWh)
2010
2020
2030
2040
2050
Year
a
b
c
Case 1: 100% Substitution in peak and medium load segment by CSP
Average LCOE without CSP
Average LCOE with CSP
Average LCOE with Peak CSP

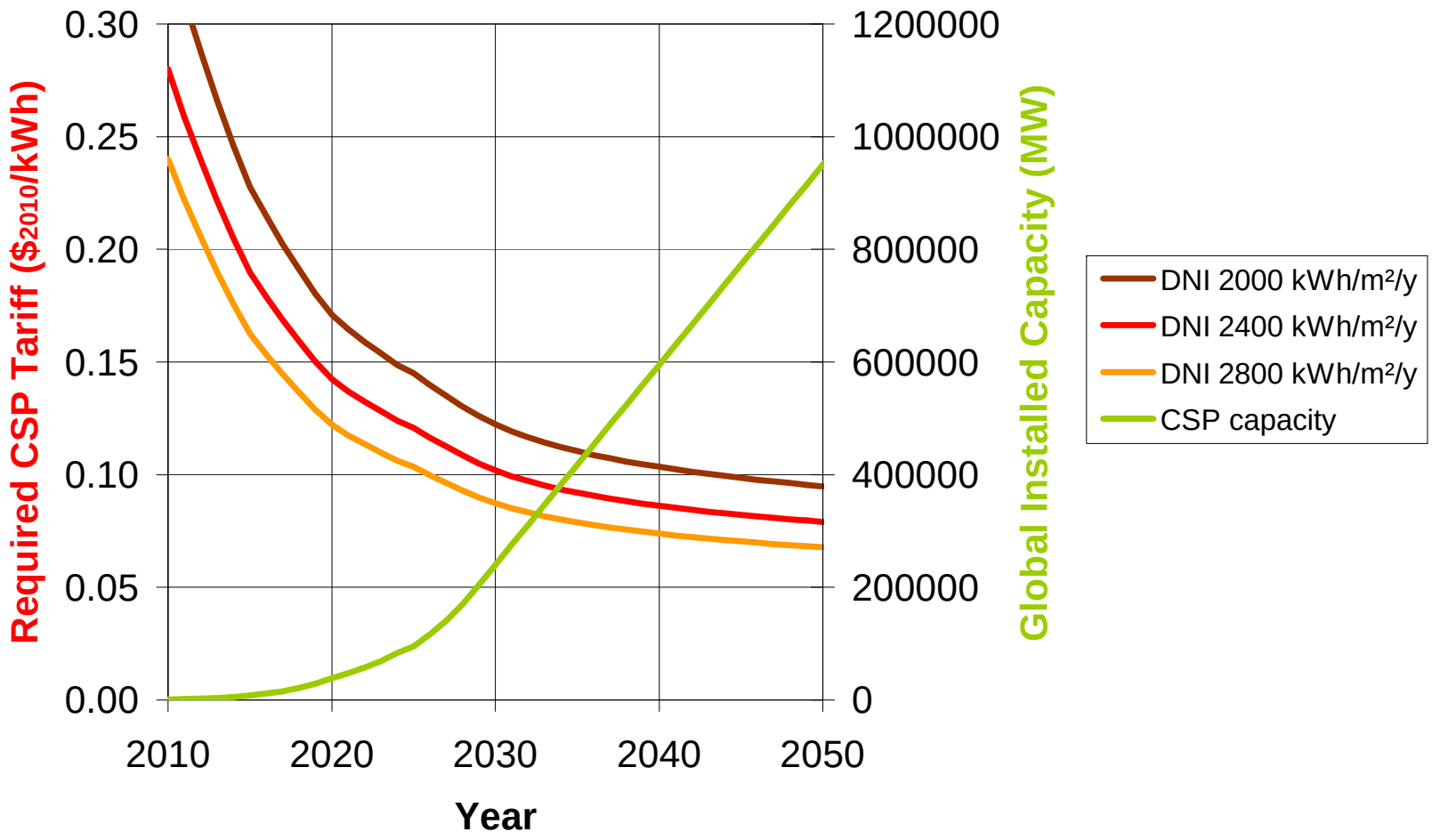

30000
25000
20000
15000
10000
5000
0
Local Installed Capacity (MW)
2010
2020
2030
2040
2050
Year
Peak CSP Capacity
Medium CSP Capacity
Base CSP Capacity
Peak Fuel Capacity
Medium Fuel Capacity
Base Fuel Capacity



Case 2: Partial Substitution of Fuel by CSP

- Average LCOE without CSP
- Average LCOE with CSP
- Average LCOE with Peak CSP

Decreasing Cost of Concentrating Solar Power



Future Work by DLR within the topic:

- Including other renewable energies into the presented approach
- Using General Algebraic Modelling Software for calculation of optimal capacity adding plans for renewable energies in MENA
- Developing country specific case-studies
- For more information please visit:
  http://www.dlr.de/tt/csp-finance