ENVIRONMENTAL IMPACTS OF THE INTEGRATION OF PHOTOVOLTAICS INTO THE SWISS LOW VOLTAGE ELECTRICITY GRID

LIFE CYCLE ASSESSMENT OF PRODUCTION, DISTRIBUTION AND STORAGE OF SOLAR POWER

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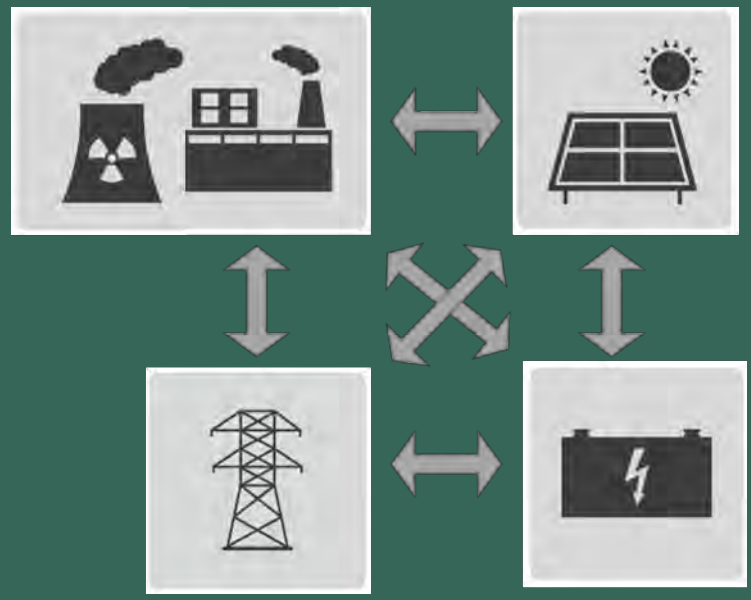

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CONTENT

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- Greenhouse Gas Emission
- Further Impact Assessments
- Conclusion

INTRODUCTION

- Swiss Energy Strategy 2050
- Promoting renewable energies
- Photovoltaic electricity in the production mix
  2015 today <1%
  2050 goal 20%
- Consequence: grid problems

GOAL

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- Environmental impacts of the integration of the photovoltaic potential on rooftops into the Swiss low voltage grid
- If PV power rises above 50%, this can cause overload or overvoltage of grids
- Technical Solutions:
  - restrictive allocation
  - expansion of the electricity grid
  - lithium-ion battery
  - demand side management (DSM)

INVESTIGATION AREA

- A medium size low voltage electricity grid
  - PV potential: 6 MWpeak photovoltaic plant on rooftops (max. lead peak 5.3MW)
  - 44km: low voltage electricity grid
  - 950 buildings
  - 1’900 customers
  - 19 GWh energy consumption incl. losses (industry making up 25%)

ELECTRICITY PRODUCTION / CONSUMPTION

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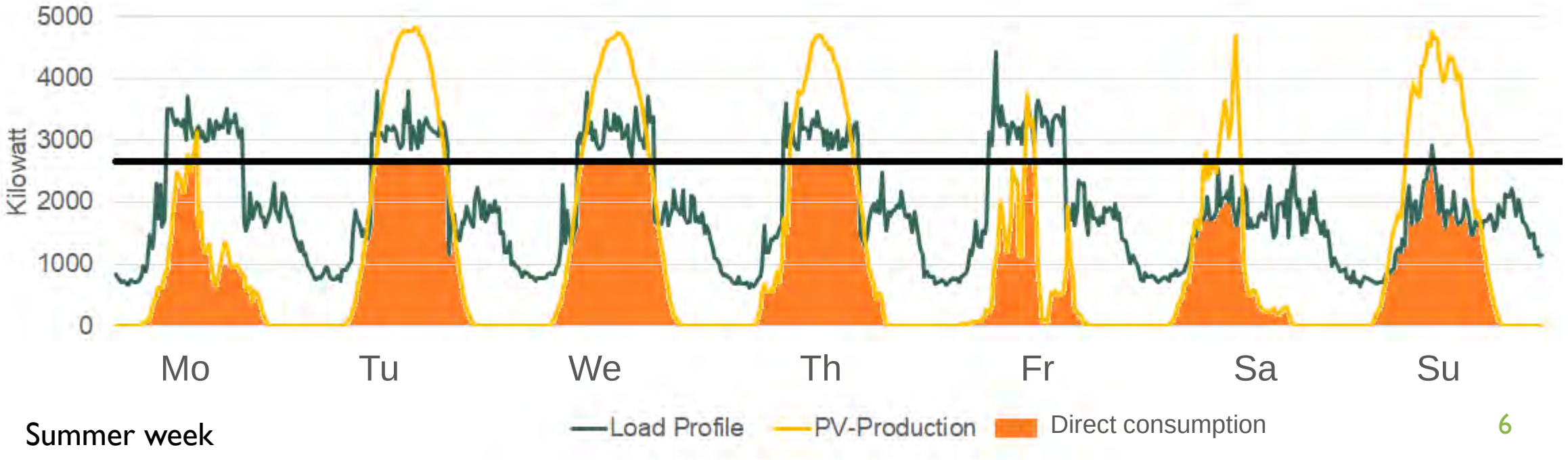
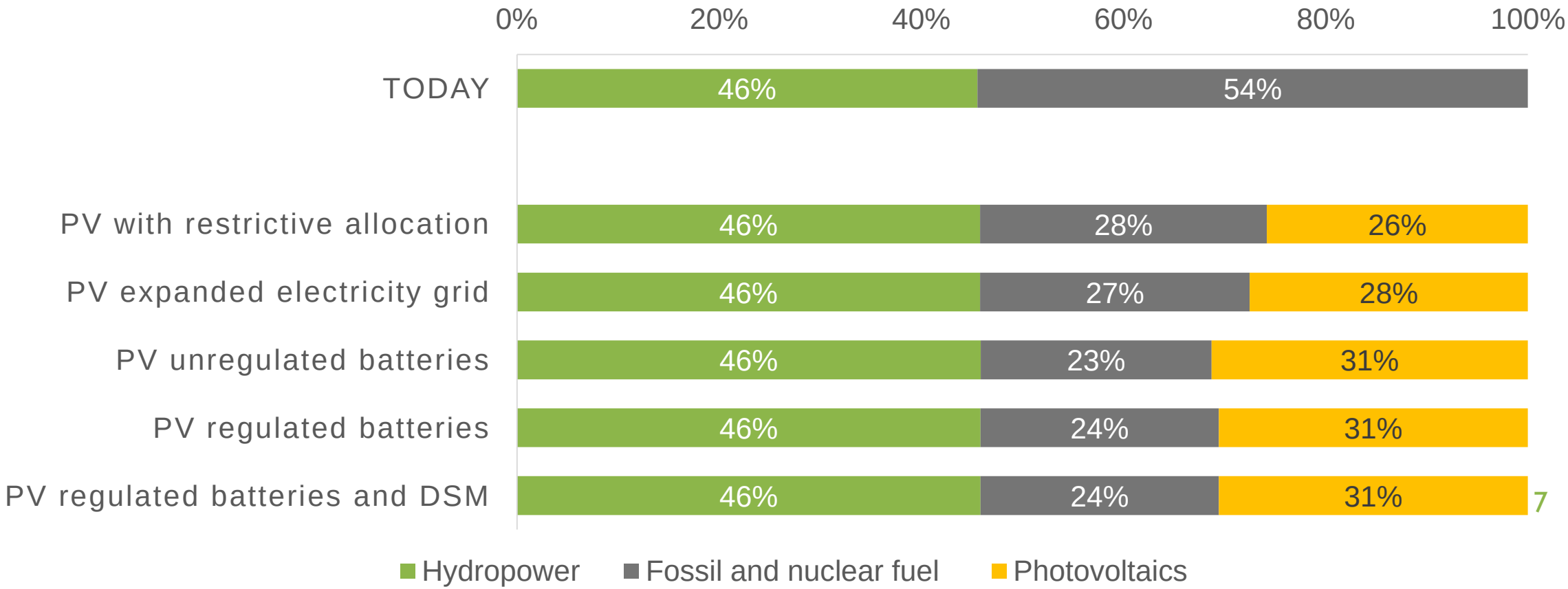
- PV-Production – Load = Direct consumption -> at least 75%/year
- If performance rises over the 50%-line, action is required
  (switch off PV-plants, battery, export in higher network level, DSM)



Summer week

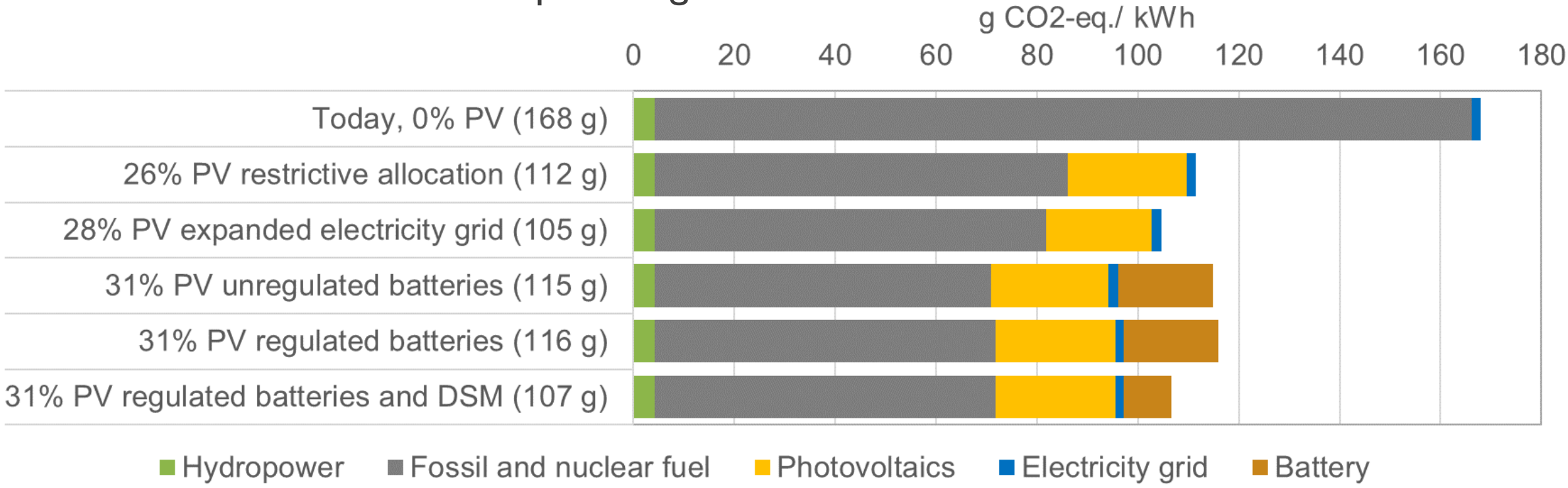
ELECTRICITY CONSUMPTION

- Technical solution influences the electricity consumption mix



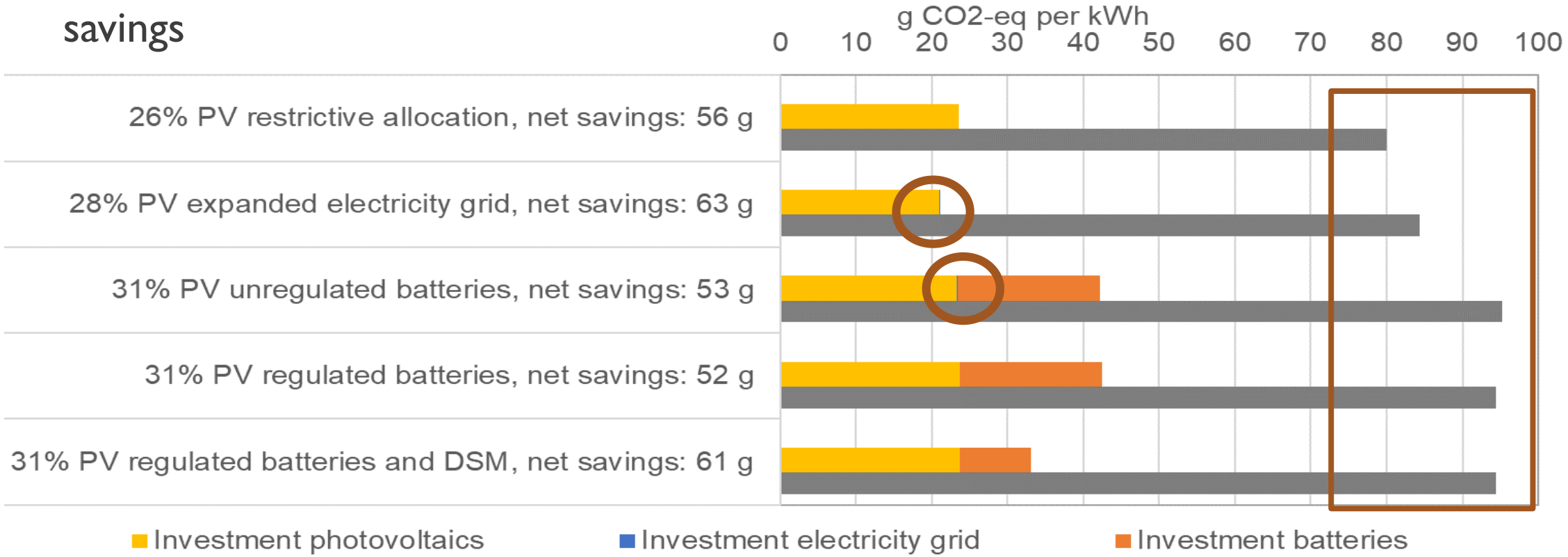
GREENHOUSE GAS EMISSIONS

- For all scenarios the GHG emissions decrease significantly with PV-plants in comparison to todays electricity mix
- Lowest emissions: PV with expanded grid



GREENHOUSE GAS SAVINGS

- PV with grid expansion causes comparably little emissions
- PV with (unregulated or regulated) battery increases the fossil and nuclear fuel savings



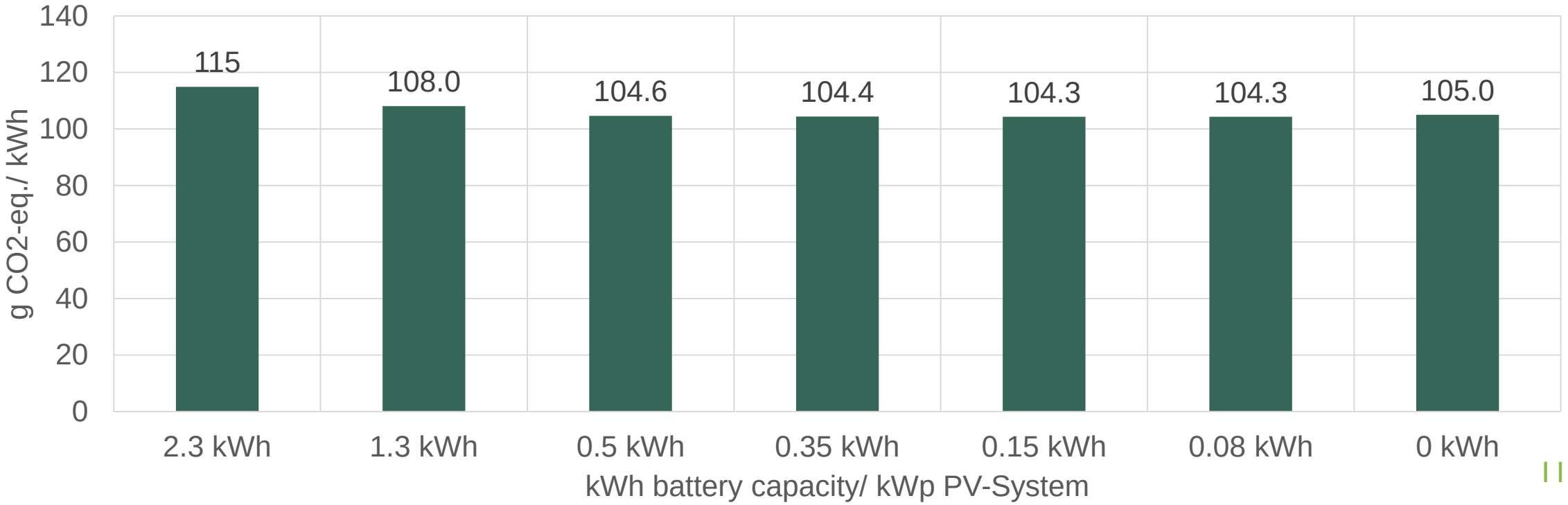
FURTHER IMPACT ASSESSMENTS

- Decrease of environmental impact for all technical alternatives according to most indicators compared to todays electricity mix
- Only particulate matter & freshwater eutrophication is higher
  -> due to PV-module and battery production in Asia with 80% fossil energy

/kWh	Cumulative Energy Demand (CED)	Ozone depletion	Human toxicity, cancer effects	Particulate matter	Freshwater eutrophication
	[MJ]	[kg CFC-11eq]	[CTUh]	[kg PM2.5eq]	[CTUe]
Today	10.0	5.1E-08	1.9E-08	3.5E-05	2.5
26% PV without improvements	6.4	2.8E-08	1.4E-08	4.8E-05	4.1
28% PV expanded electricity grid	6.1	2.6E-08	1.3E-08	4.5E-05	3.9
31% PV unregulated batteries	5.8	2.3E-08	1.4E-08	6.9E-05	4.6
31% PV regulated batteries	5.9	2.4E-08	1.4E-08	6.8E-05	4.4
31% PV regulated batteries and DSM	5.8	2.4E-08	1.3E-08	5.7E-05	4.2

ECOLOGICAL MAXIMUM WITH BATTERIES

- The battery size influences the green house emissions only minimal



CONCLUSION

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- Trade-off: Freshwater ecotoxicity and particulate matter increase in all scenarios, all other indicators decrease

- The ecological maximum for the examined low-voltage grid
  - ✚ Maximum Photovoltaic Expansion
  - ✚ Expansion of the Electricity Grid
  - ✚ 0 – 2 kWh net battery capacity per kWp of PV power (regulated or unregulated)

THANK YOU FOR YOUR ATTENTION!

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