Exploring long-term strategies for the German Energy Transition - A Review of Multi-Sector Energy Scenarios - Supplementary Material

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1. Own calculations: Environmental heat in buildings an electricity demand for heat pumps

Most studies that document the heat demand by energy carrier in the building sector explicitly include the demand for environmental heat in (electric) heat pumps. However, this is not the case for [1] and [2, 3]. In these cases, the demand for environmental heat in the building sector was estimated as follows:

1. [2, 3] document the electricity demand for electric heat pumps. We recalculated the amount of environmental heat used in these heat pumps with the assumptions that the average (annual) coefficient of performance (COP) is 4, and heat pumps are not used to provide process heat.
2. [1] only document the electricity demand in the building sector, and the number of electric heat pump systems in Germany. We estimated the electricity demand for applications other than heat pumps from a linear correlation between total electricity demand in buildings and the number of heat pump systems. This calculation also yields the electricity demand of heat pumps. We than proceeded as described for [2, 3].

In those cases where the electricity demand for heat pumps was not documented, but the environmental heat used by electric heat pumps was, we recalculated the electricity demand in heat pumps assuming an average annual COP of 4.

2. Results for scenarios with a CO_2 emission reduction between 80% and 90%

In this section, we present similar results as in the main study, but for scenarios with a CO_2 emission reduction between 80% and 90%. The corresponding studies and scenarios are summarized in Table 1.

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Table 1: Overview of the ambitious scenarios analyzed in this study (80-90% greenhouse gas reduction)

research institution(s)	funding agency	year	scenario name	scenario abbreviation	reference
DLR, FhG IWES, IfNE	BMU	2012	A	BMU12-A	[4]
			B	BMU12-B	
			C	BMU12-C	
Prognos, ewi, GWS	BMWi	2014	ZIEL	BMWi14-ZIEL	[5]
Öko-Institut, FhG ISI, H.-J. Ziesing	BMUB	2015	Klimaschutzszenario 80	BMUB15-KSSz80	[6]
FhG IWES, ifeu	BMWi	2015	IntEEStrom	IWES/IFEU15-IntEEStrom	[7]
FhG ISE		2015	80/gering/klassisch/nicht beschl.	ISE15-80-g-k-nb	[8]
			80/gering/CH4/nicht beschl.	ISE15-80-g-CH4-nb	
			80/gering/H2/nicht beschl.	ISE15-80-g-H2-nb	
			80/gering/elektr./nicht beschl.	ISE15-80-g-el-nb	
			80/gering/Mix/nicht beschl.	ISE15-80-g-mix-nb	
			80/ambit./Mix/nicht beschl.	ISE15-80-amb-mix-nb	
			80/ambit./Mix/beschl.	ISE15-80-amb-mix-b	
			85/ambit./Mix/beschl.	ISE15-85-amb-mix-b	
FhG ISI, ifeu Consentec	BMWi	2017	Basisszenario	BMWi17-Basis	[9]
			geringerer Ausbau der Übertragungsnetze	BMWi17-gNetz	
			altern. reg. EE-Verteilung	BMWi17-altEE	
			restriktionsarm	BMWi17-restarm	
BCG, Prognos	BDI	2018	80%-THG-Minderung	BDI18-80	[10]
GWS, Prognos, DIW FhG ISI, DLR	BMWi	2018	Energiewende-Szenario	BMWi18-EW	[11]
ewi Energy Research and Scenarios gGmbH	dena	2018	Elektrifizierungs-Szenario 80%	dena18-EL80	[1]
			Technologie-Mix-Szenario 80%	dena18-TM80	
J. Nitsch		2019	Klima-19-PLAN	NIT19-PLAN	[12]
FZJ		2019	80%	FZJ19-80	[2, 3]

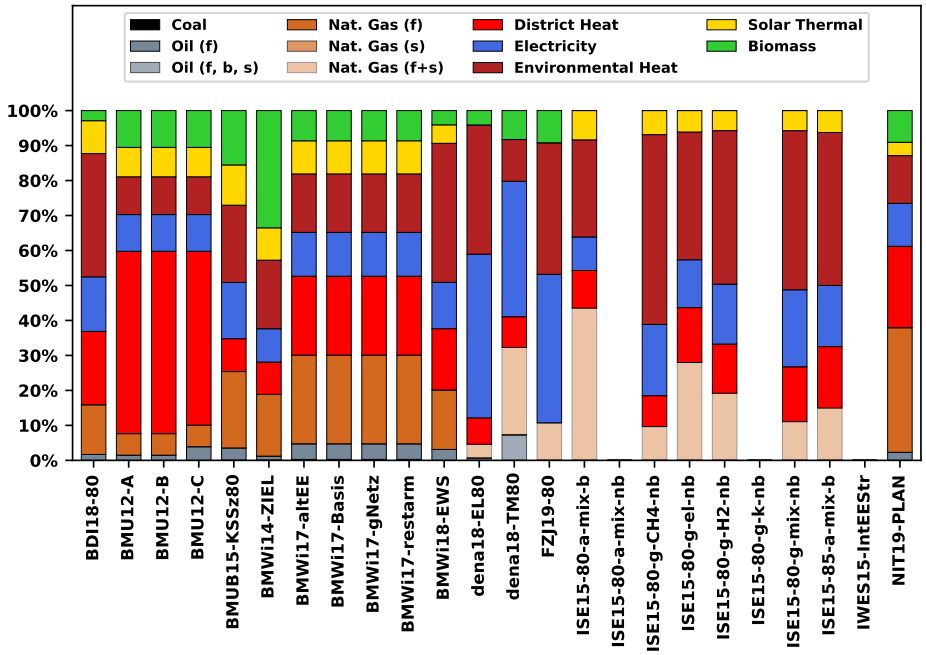

Figure 1: Fuel Shares in final energy demand in buildings in 2050 in the 80% scenarios. Letters f, b and s indicate fossil, biogenic or synthetic origin.

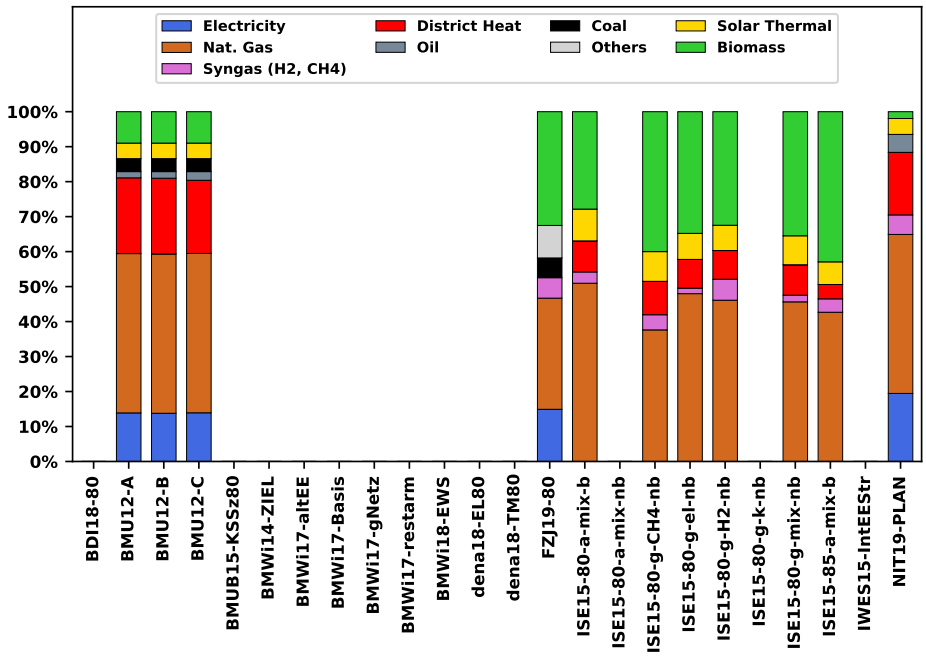

Figure 2: Fuel shares in final energy demand for process heat in 2050 in the 80% scenarios. "s" indicates synthetic origin.

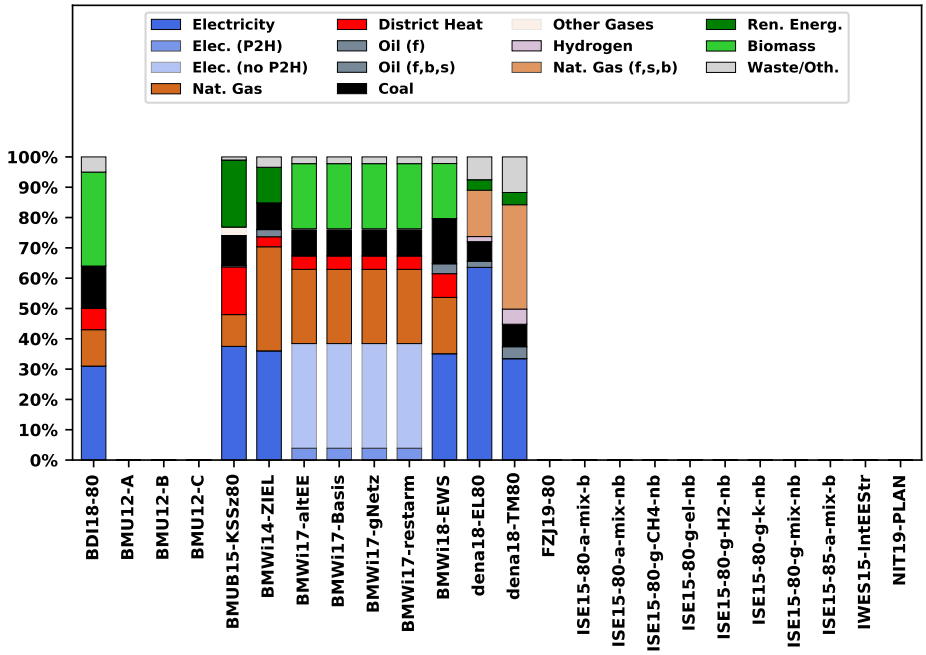

Figure 3: Fuel shares in final energy demand in the industry sector in 2050 in the 80% scenarios. Letters f, b and s indicate fossil, biogenic or synthetic origin.

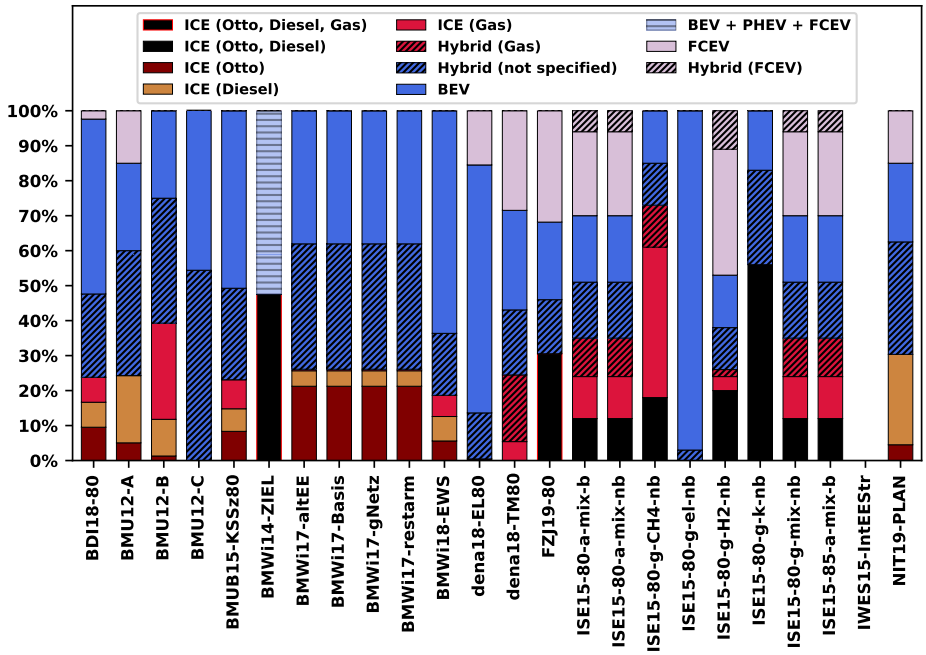

Figure 4: Shares in power train technologies for passenger cars in 2050 in the 80% scenarios. Letters O, D and G denote Otto, Diesel, and Gas motors, respectively.

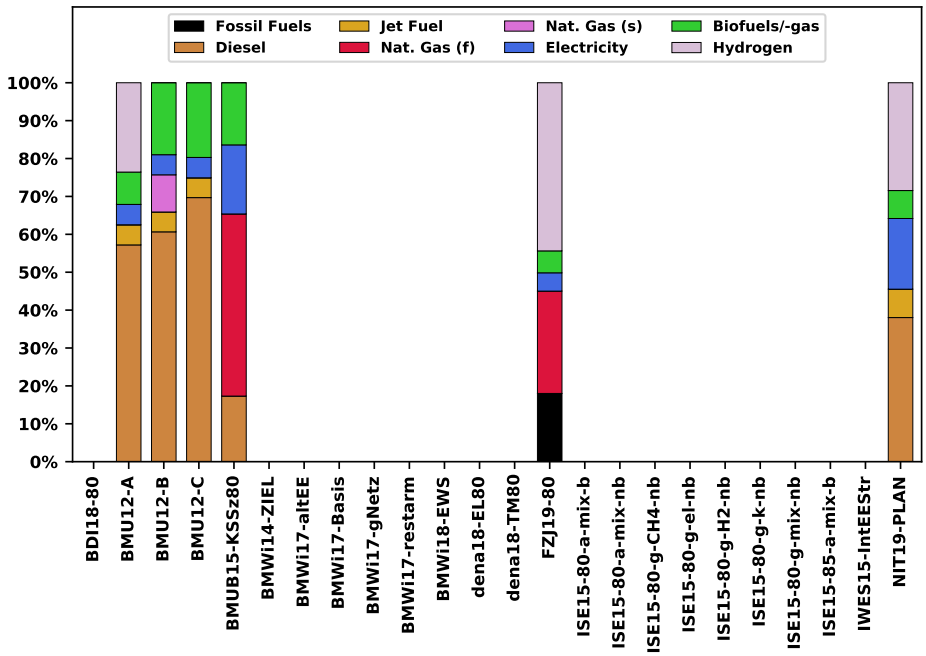

Figure 5: Fuel shares in freight transport in 2050 in the 80% scenarios. Letters f and s denote fossil and synthetic origin.

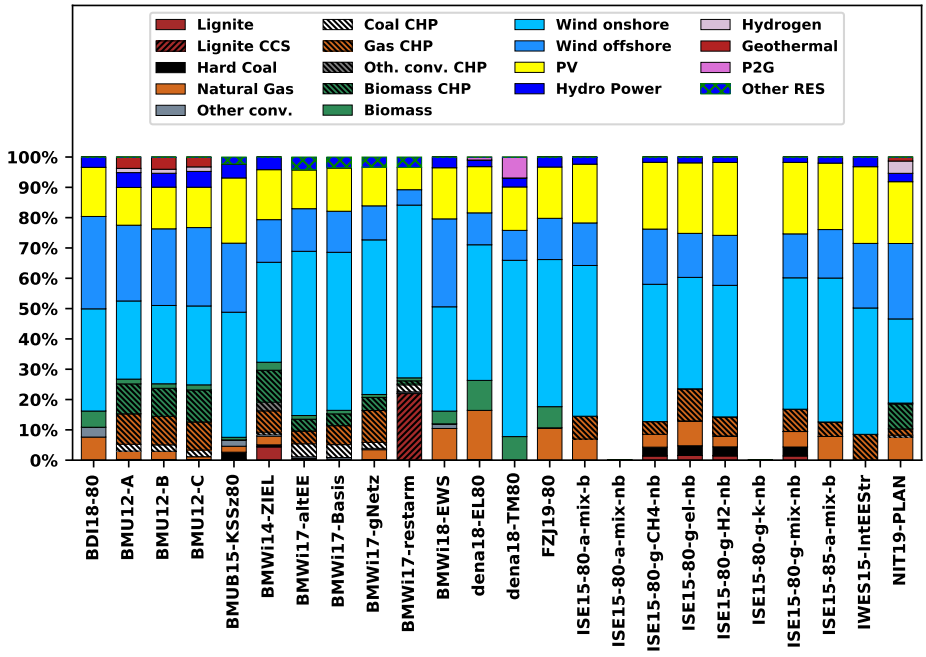

Figure 6: Technology shares in power generation in 2050 in the 80% scenarios.

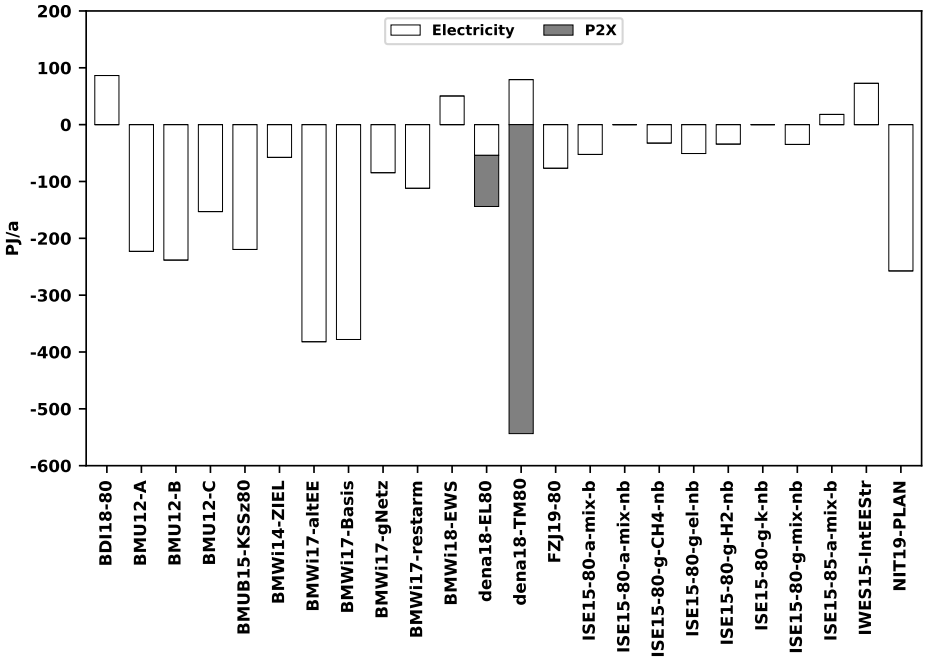

Figure 7: Power and P2X imports (negative values) and exports (positive values) in 2050 in the 80% scenarios.

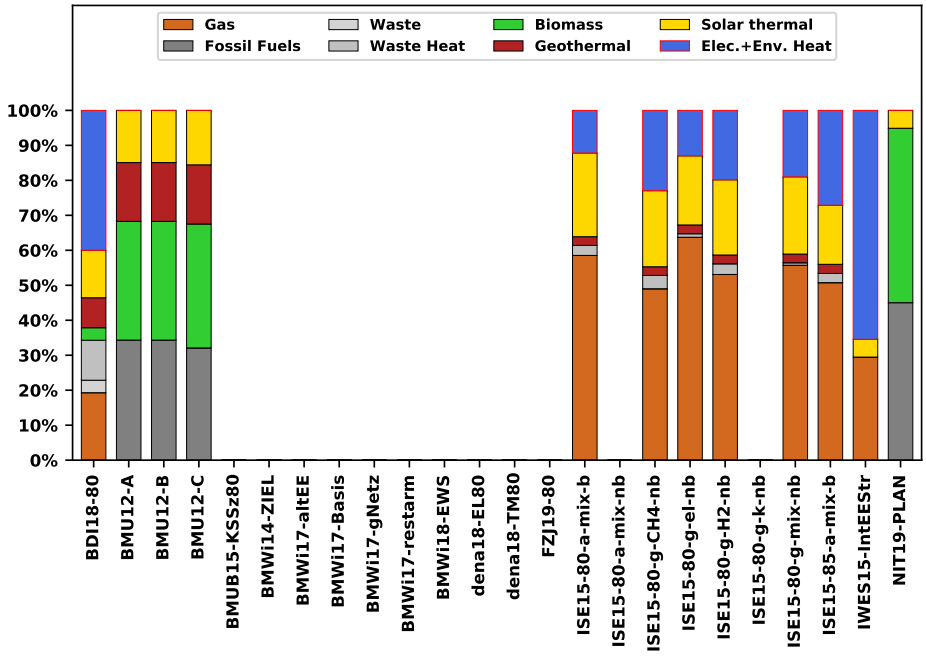

Figure 8: Fuel shares in district heat generation in 2050 in the 80% scenarios.

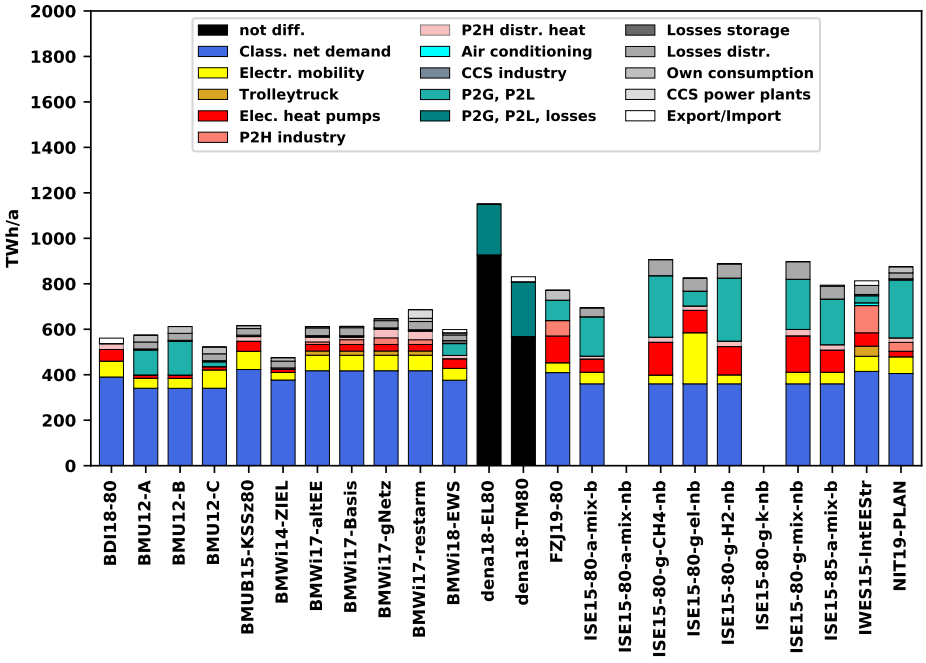

Figure 9: Power demand in 2050 in the 80% scenarios.

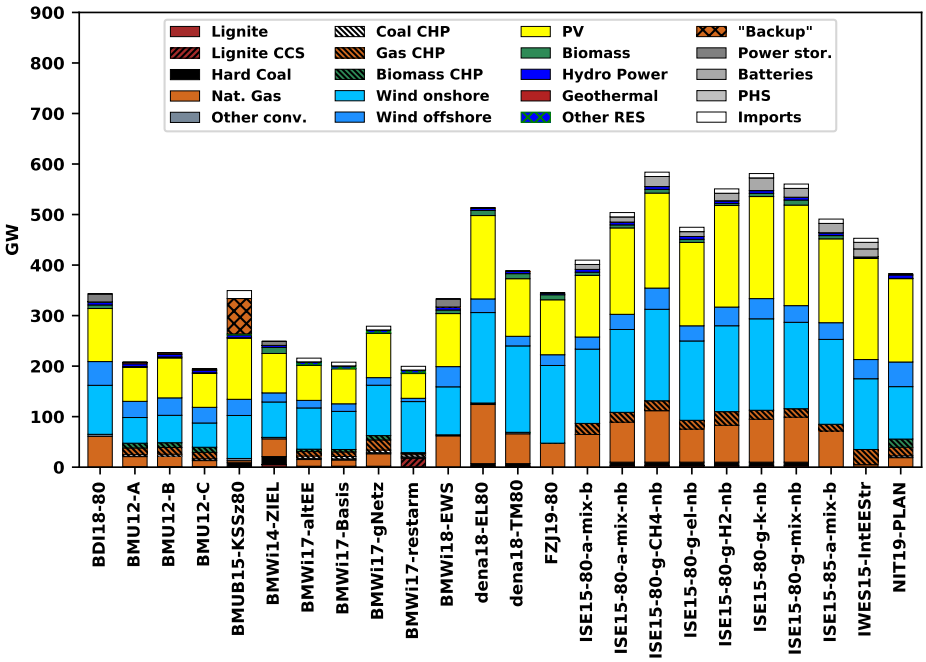

Figure 10: Installed capacities for power generation (and storage) in 2050 in the 80% scenarios.

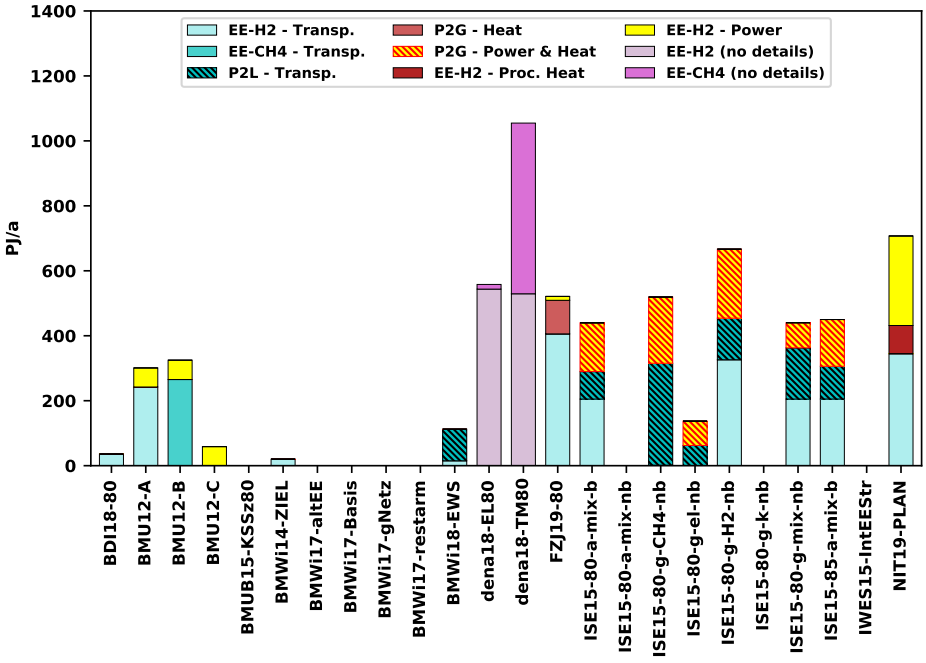

Figure 11: Consumption of P2G (H_2, CH_4) and P2L in 2050 in the 80% scenarios.

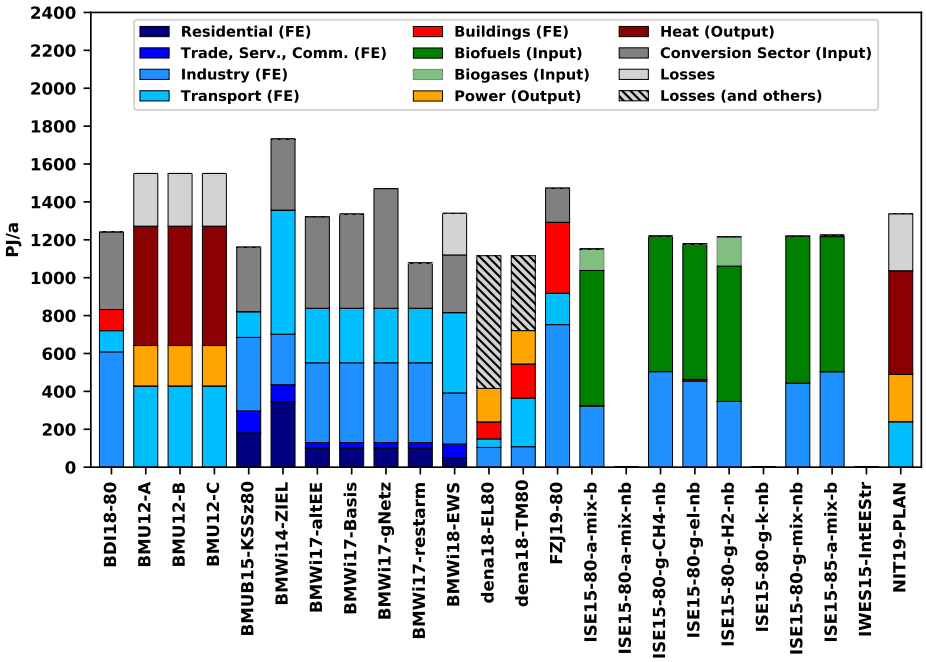

Figure 12: Biomass consumption for energy purposes in 2050 in the 80% scenarios.

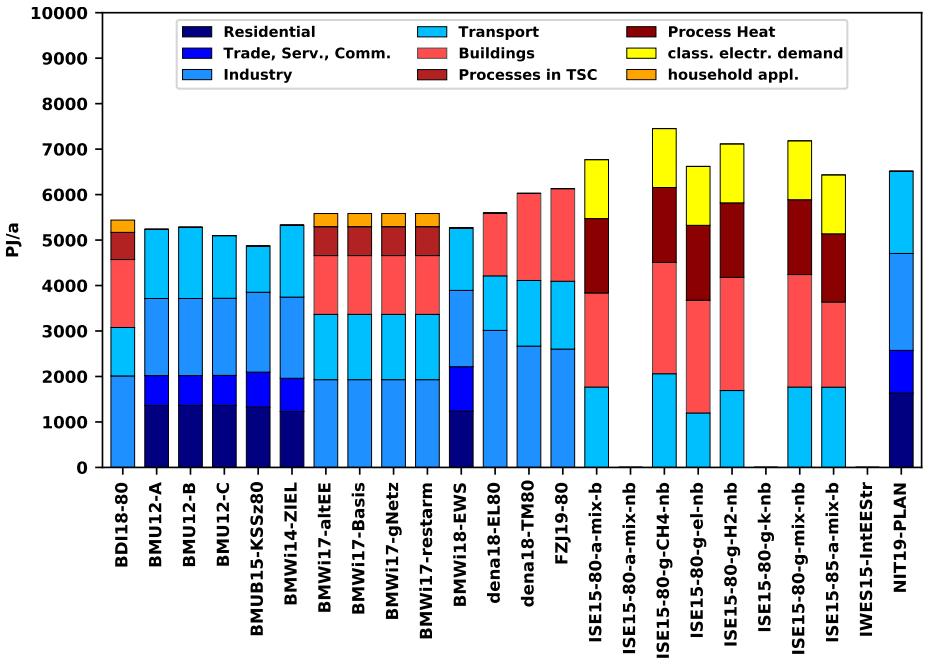

Figure 13: Final energy demand in 2050 in the 80% scenarios.

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