

Electrification of domestic hot water: does it lead to a more sustainable future?

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Agenda

Energy Future

Renewable Electricity

Renewable Gas

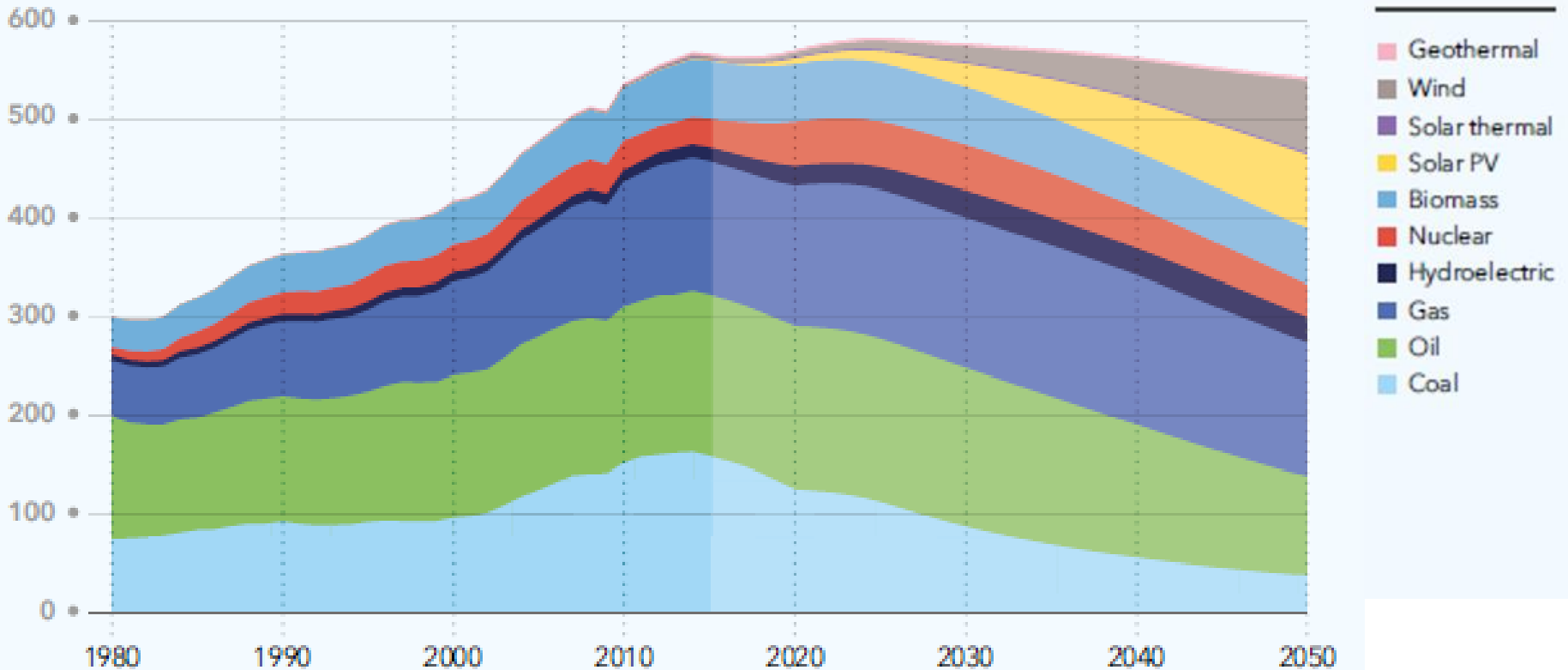
Demand Response

Conclusions

Energy future

FIGURE 7. FORECAST WORLD PRIMARY ENERGY SUPPLY BY SOURCE

Units: EJ/yr



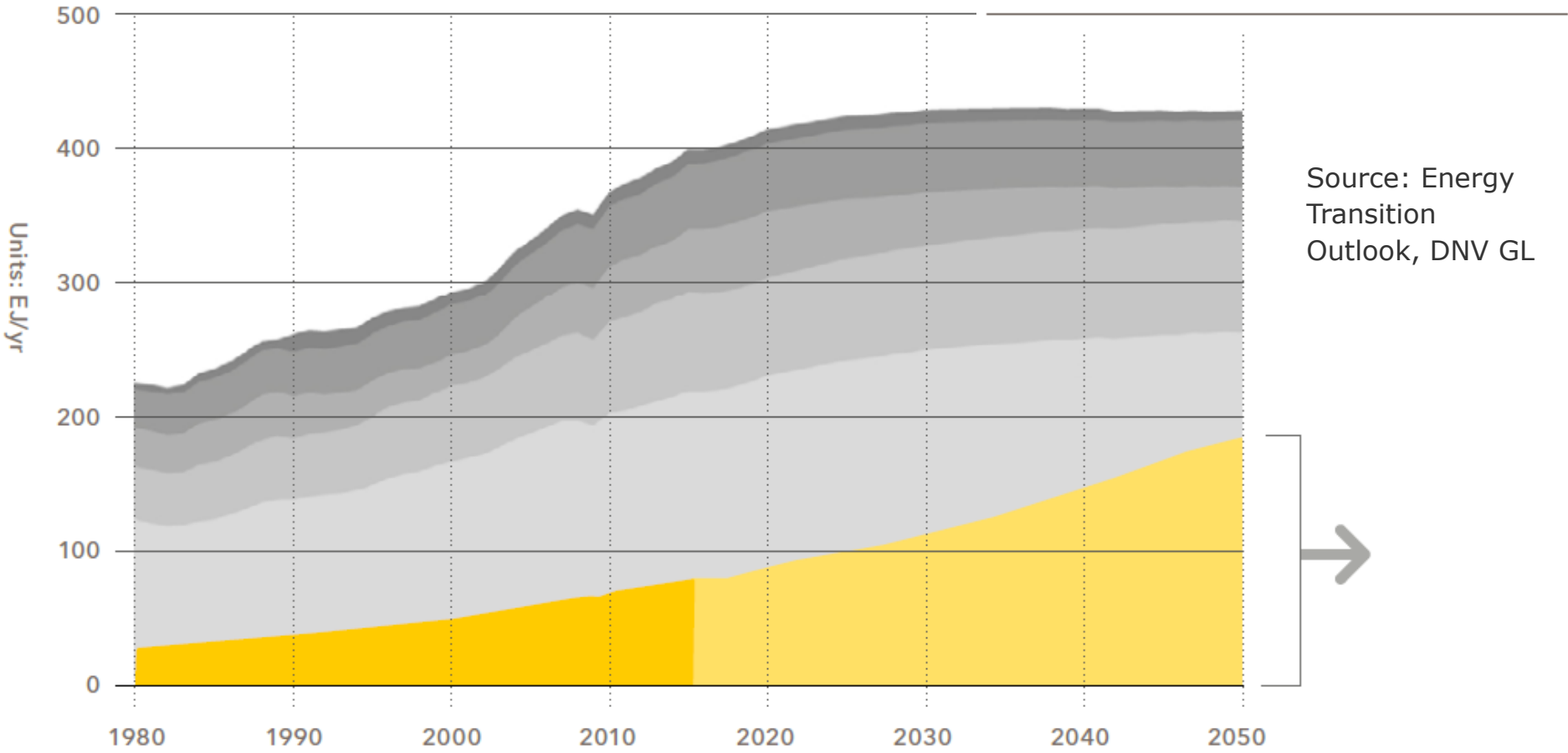
Source: Energy Transition Outlook, DNV GL (<https://eto.dnvgl.com/2017#Energy-Transition-Outlook>)

Renewable electricity

WORLD FINAL ENERGY DEMAND

ENERGY CARRIER

- Direct heat
- Biomass
- Coal
- Natural gas
- Oil
- Electricity

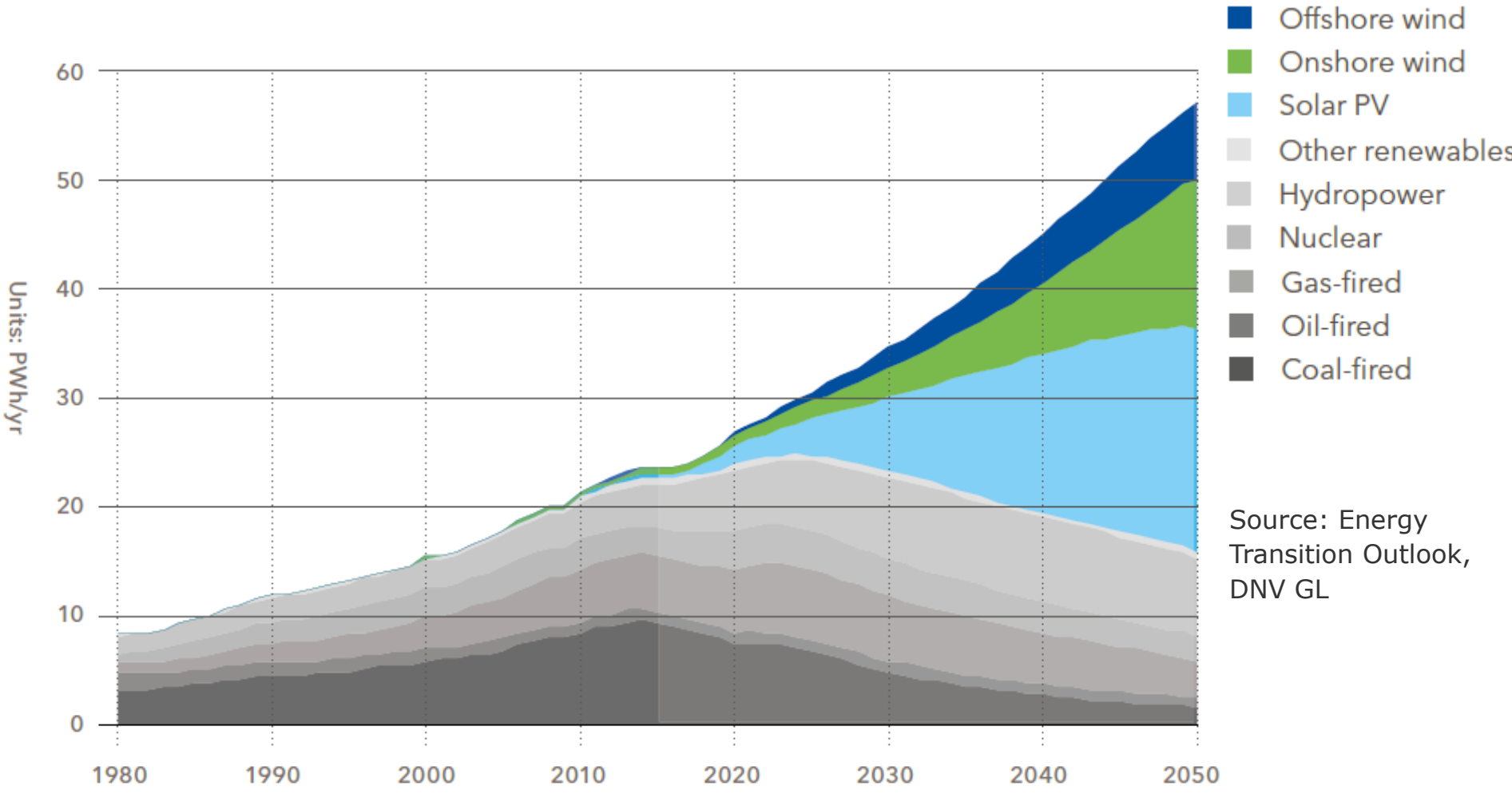


Source: Energy Transition Outlook, DNV GL



Renewable electricity

WORLD ELECTRICITY GENERATION



Source: Energy Transition Outlook, DNV GL

Renewable electricity

Generation (thousand megawatthours)	2010 USA Value	2010 Percent of USA Total	2016 Percent of USA Total
Total Electricity Net Generation	4,125,060	100	100
Total Renewable Net Generation	427,376	10.4	14.9
Geothermal	15,219	0.4	0.4
Hydro Conventional	260,203	6.3	6.5
Solar	1,212	*	0.9
Wind	94,652	2.3	5.6
Wood/Wood Waste	37,172	0.9	0.9
MSW/Landfill Gas	16,304	0.4	0.4
Other Biomass	2,613	0.1	0.2

Data from U.S. Energy Information Administration: Independent Studies and Analysis, www.eia.gov

Renewable electricity

- California versus Pennsylvania
- 2010 State level data from EIA

Generation (thousand megawatthours)	CA Value	Percent of CA State Total	PA Value	Percent of PA State Total
Total Electricity Net Generation	204,126	100	229,752	100
Total Renewable Net Generation	58,881	28.8	6,577	2.9
Geothermal	12,600	6.2	-	-
Hydro Conventional	33,431	16.4	2,332	1
Solar	769	0.4	8	*
Wind	6,079	3	1,854	0.8
Wood/Wood Waste	3,551	1.7	675	0.3
MSW/Landfill Gas	1,812	0.9	1,706	0.7
Other Biomass	639	0.3	3	*

Data from U.S. Energy Information Administration: Independent Studies and Analysis, www.eia.gov

Renewable gas

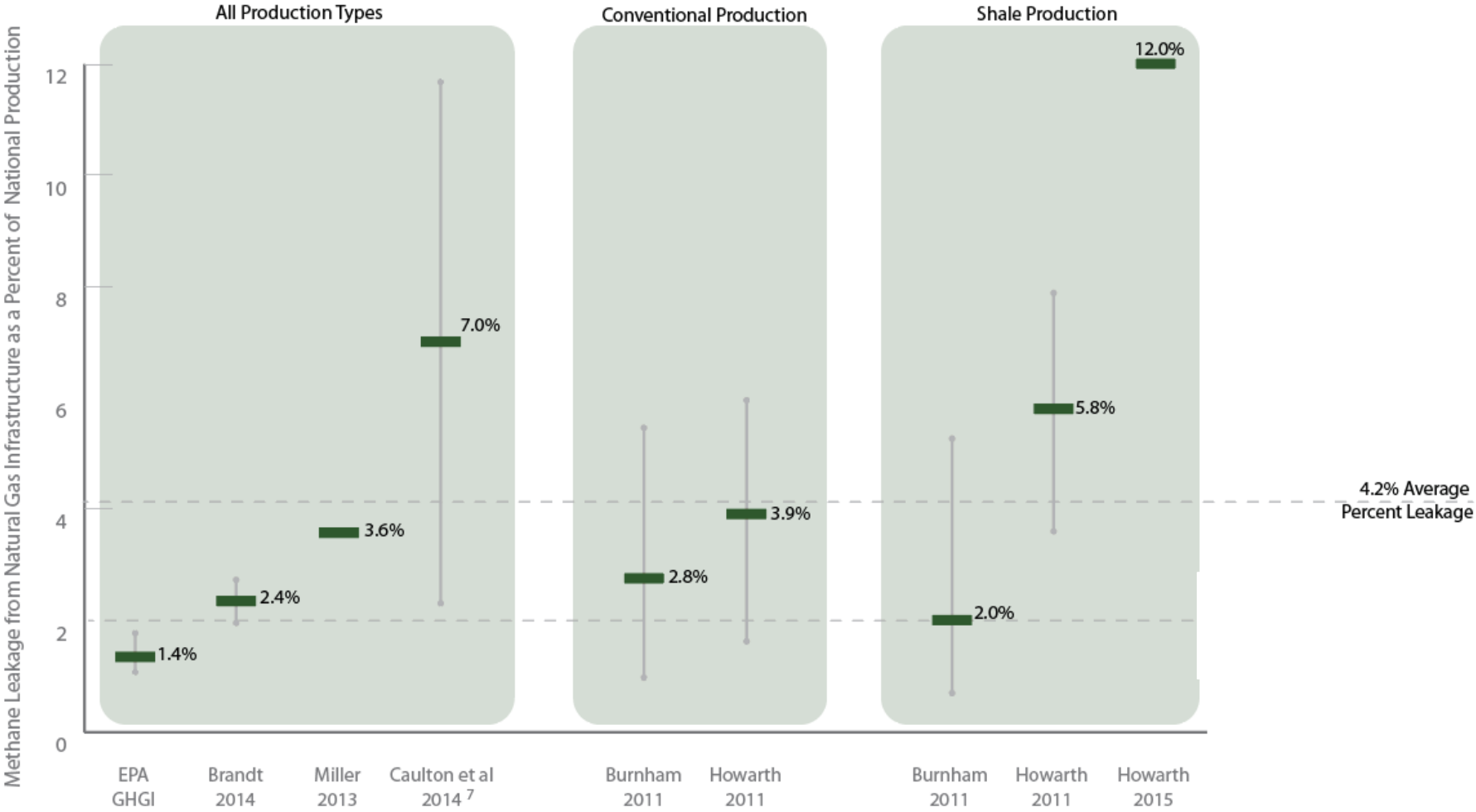
- What is the potential for biomethane compared to current natural gas use?
- 0.42 Trillion cubic feet “low-hanging fruit” *and* 10x higher if lignocellulosic biomass is included

U.S. natural gas consumption by major end uses, 2016, EIA		
End use	Amount (Tcf)	Share of total
Electric power generation	9.98	36%
Industrial	7.72	28%
Residential	4.35	16%
Commercial	3.11	11%
Lease and plant fuel consumption	1.59	6%
Pipeline and distribution	0.7	3%
Vehicle fuel	0.04	0.20%
Total	27.49	100%

Data from U.S. Energy Information Administration: Independent Studies and Analysis, www.eia.gov

Renewable gas

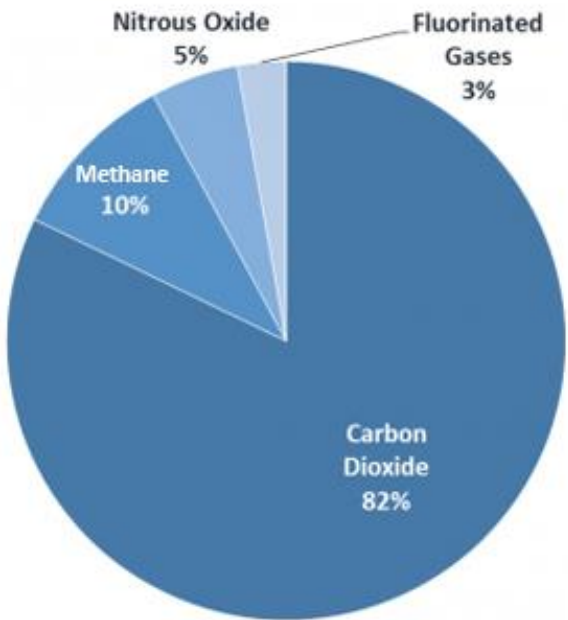
Figure 20: Percent Leakage from the Natural Gas System



Source: Naomi Wentworth, Natural Gas: Our Underestimated Climate Change Catalyst, draft 2017

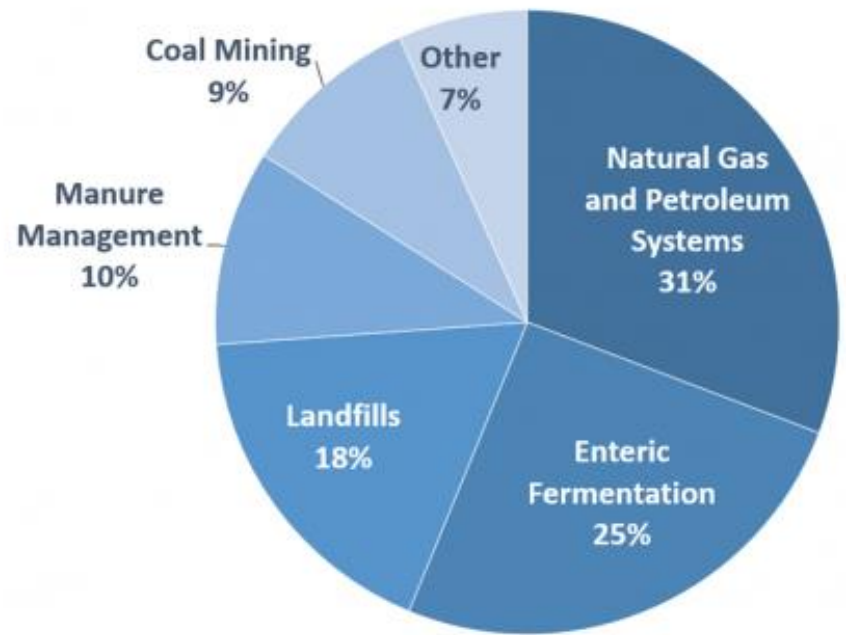
Renewable gas

U.S. Greenhouse Gas Emissions in 2015



U.S. Environmental Protection Agency (2017). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015*.

2015 U.S. Methane Emissions, By Source



U.S. Environmental Protection Agency (2017). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015*.

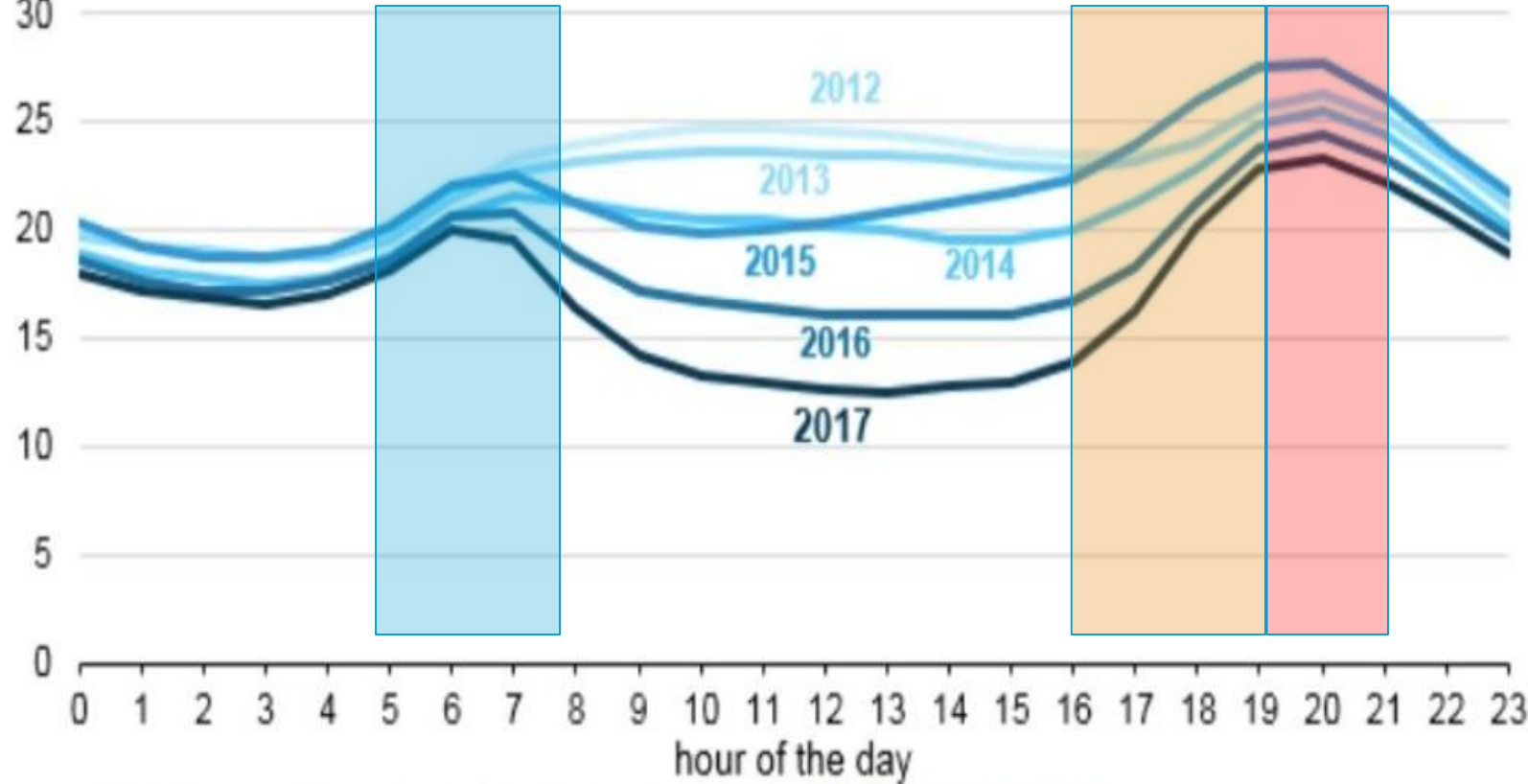
Renewable gas

Should we generate electricity with biogas *or* purify it to methane and inject into natural gas distribution network?

	Generate Electricity	Inject in Pipeline
Produce end-use fuel	0.70	0.96
Transmission	0.95	0.97
Overall end use - weighted	0.91	0.69
heating	1.00	0.80
water heating (EF)	0.95	0.60
cooking	0.39	0.28
Overall efficiency	0.61	0.64

Demand response

California Independent System Operator (CAISO) average net electric load last week of March
gigawatts

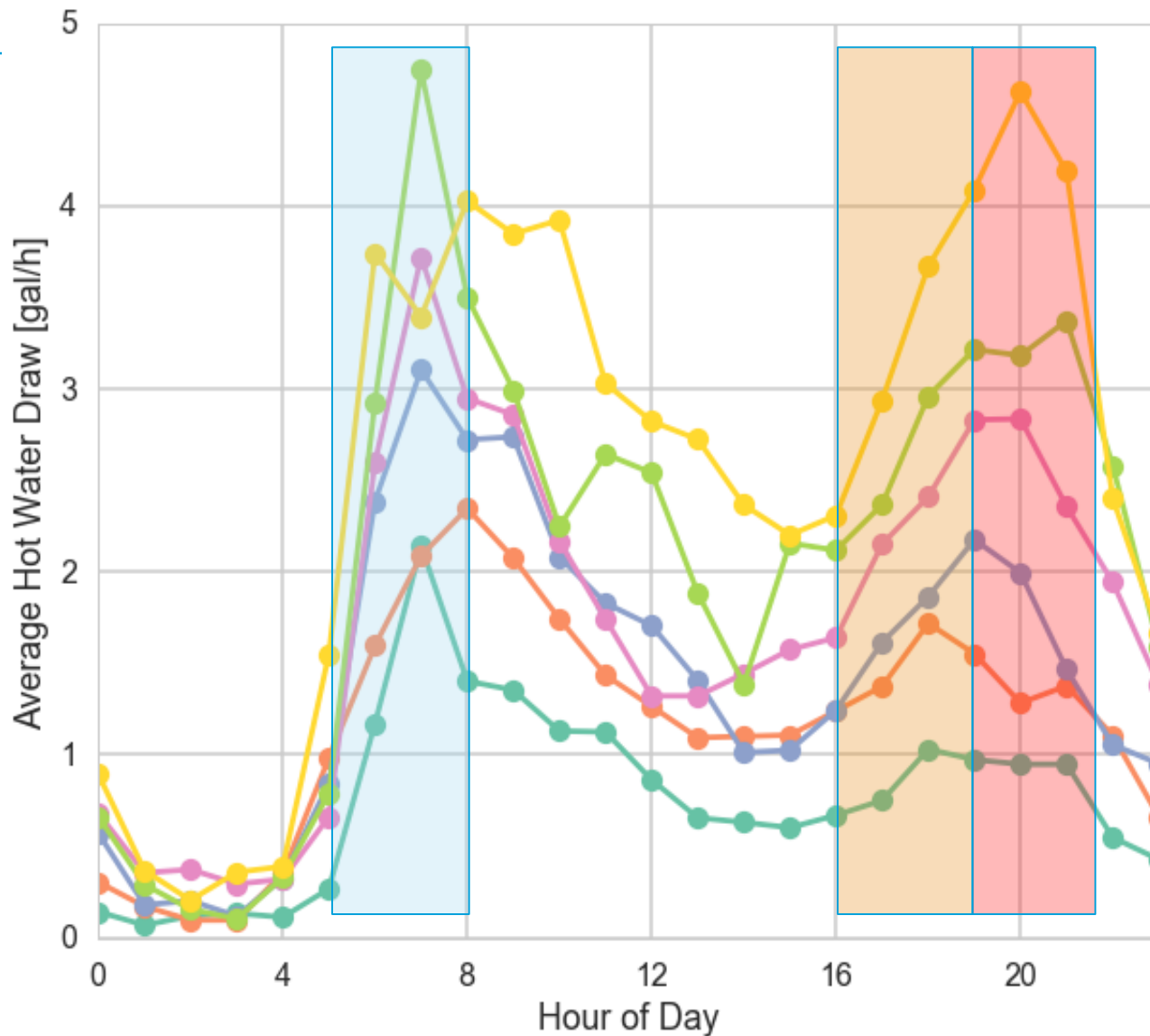


Source: U.S. Energy Information Administration

Average Daily Hot Water Draw Profile by Occupancy Level

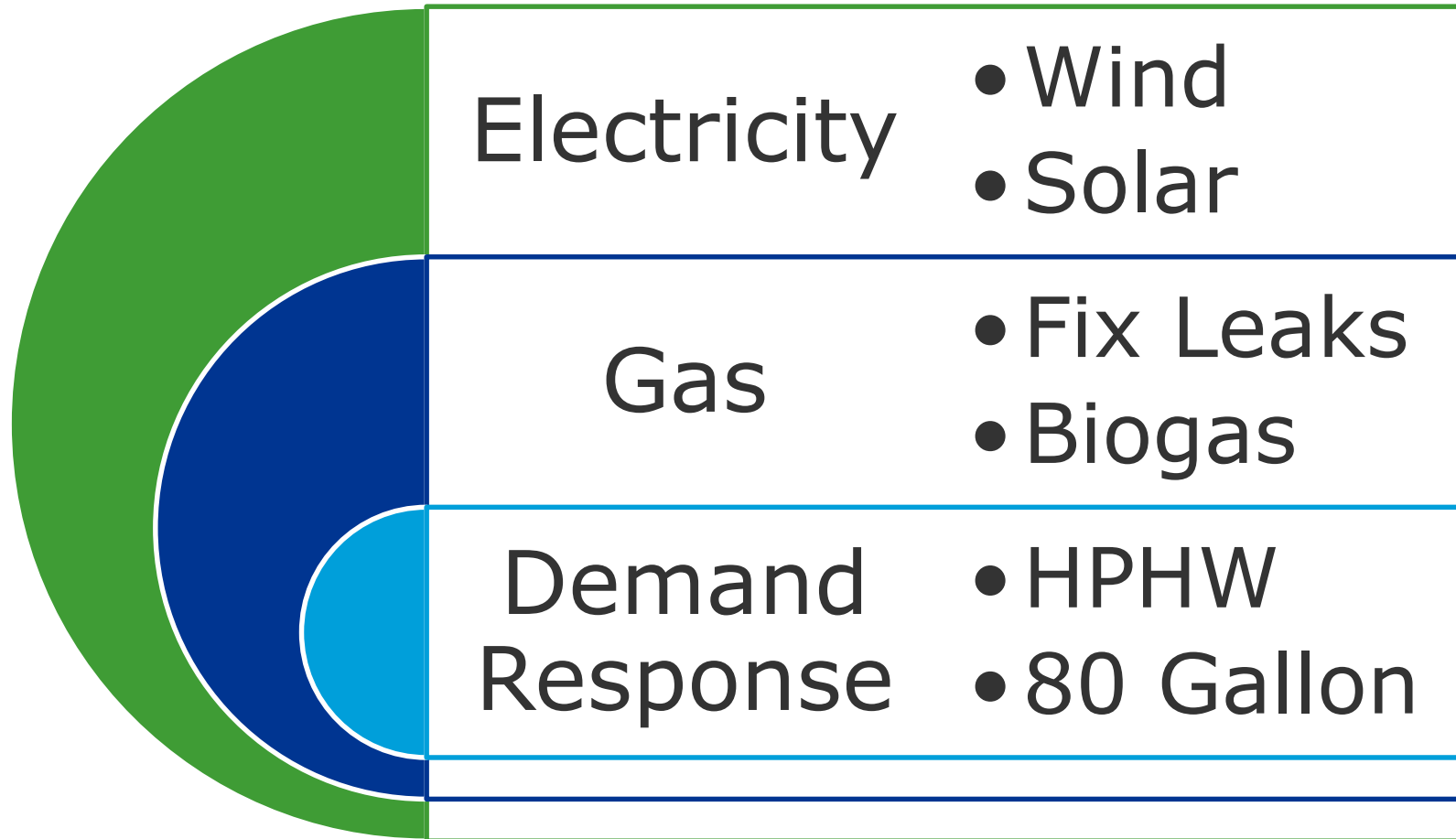
Demand response

- 1 person
- 2 people
- 3 people
- 4 people
- 5 people
- 6+ people



Source: Krusis N., B Wilcox, J. Lutz, C. Barnaby, "California Residential Domestic Hot Water Draw Profiles", Draft 2016

Conclusions



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Does it lead to a more sustainable future

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