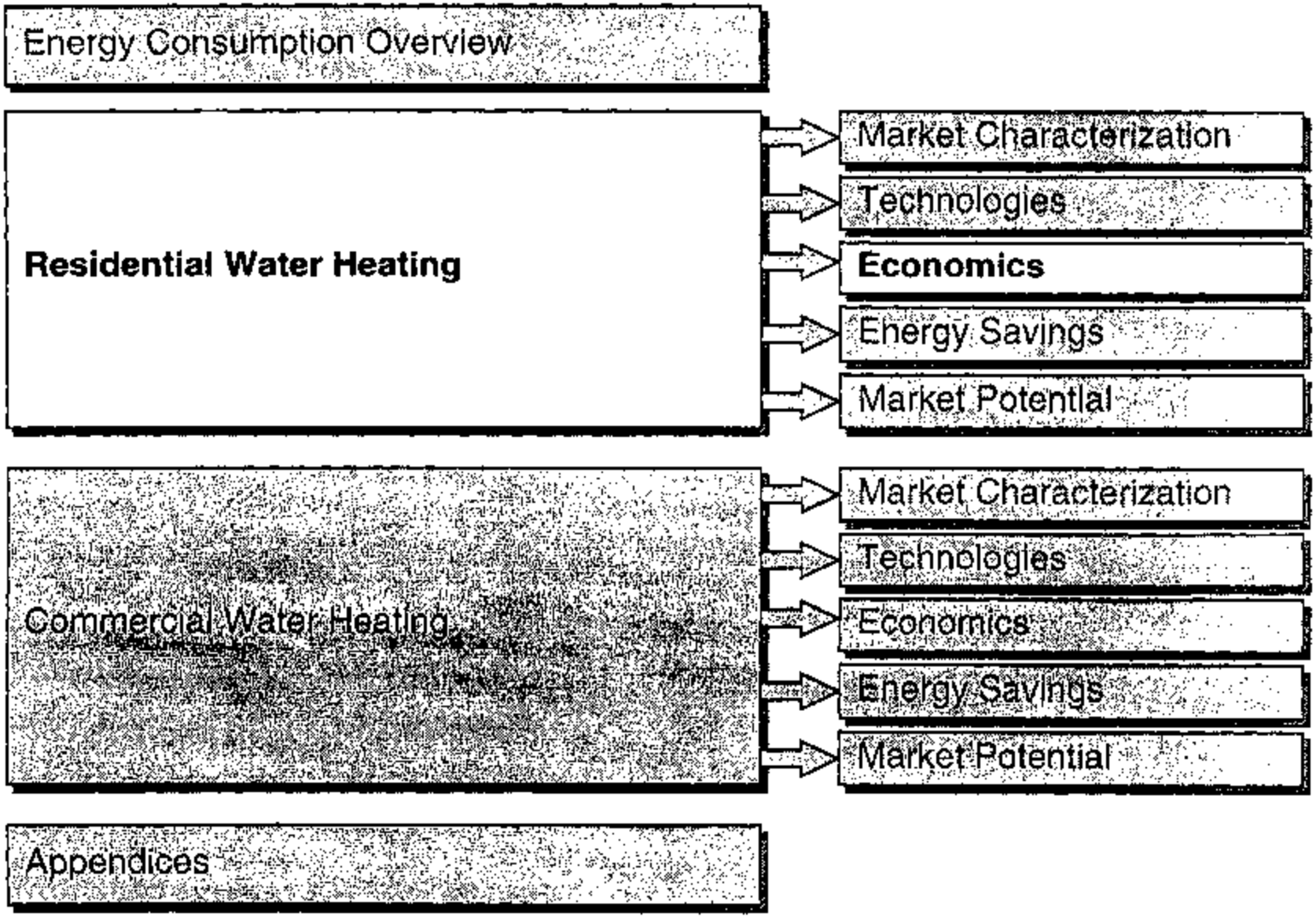

Energy Consumption Overview
Residential Water Heating
Market Characterization
Technologies
Economics
Energy Savings
Market Potential
Commercial Water Heating
Market Characterization
Technologies
Economics
Energy Savings
Market Potential
Appendices

Performance was simulated based on detailed weekly draw profiles[1] using EPRI's WATSIM model.

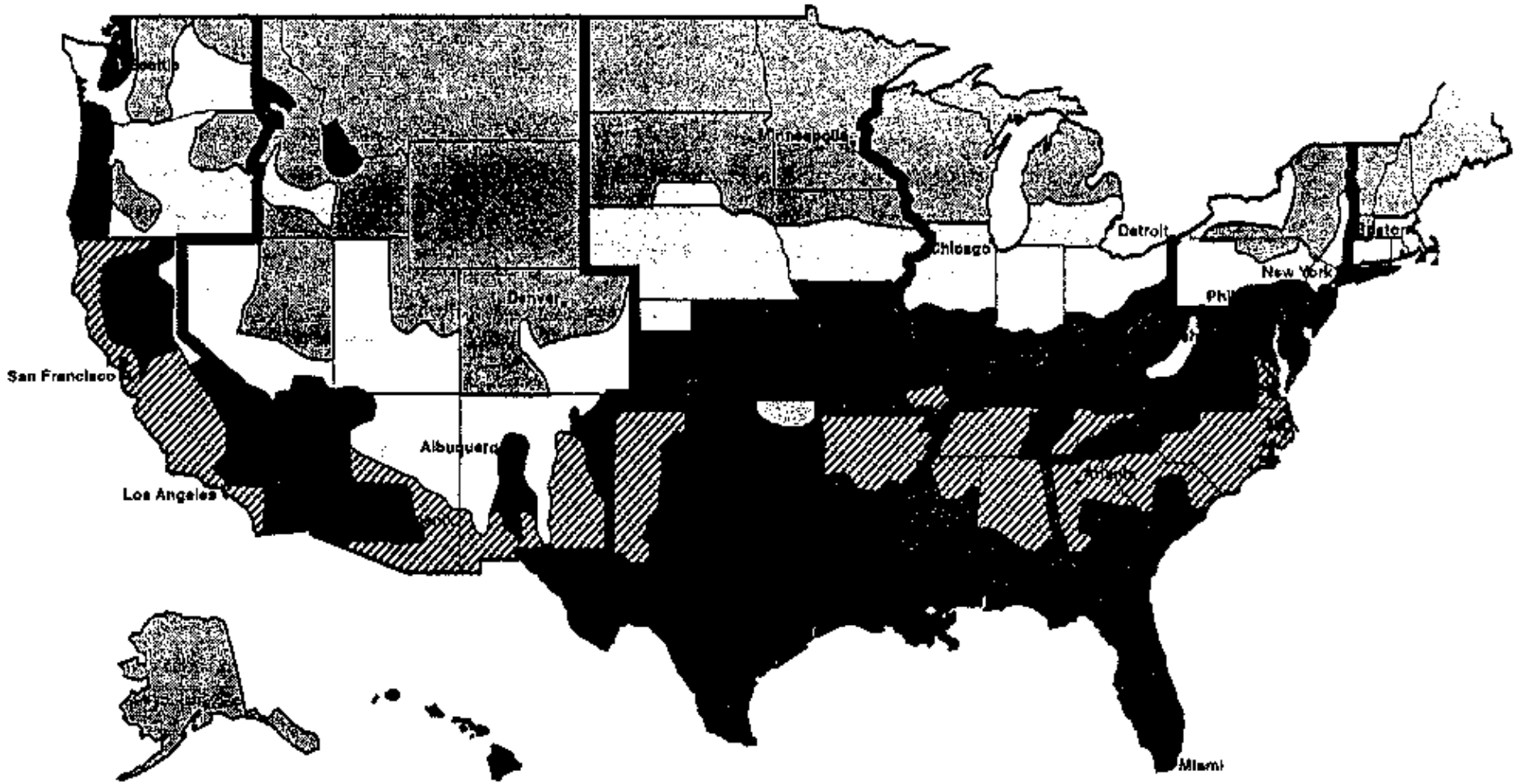
- Typical fall/spring entering water temperatures and daily water draws (assumed constant year round)

DOE Climate Zone	Representative City	Water Temperature (°F)	Medium/High Draw[2] (GPD)
1	Minneapolis	45.8	50/100
2	Detroit	49.9	45/90
3	NYC	57.6	40/80
4	Atlanta	62	35/70
5	New Orleans	64.9	32/64

- 120°F (set-point) water delivery temperature

1 Draw profiles developed from actual site measurements. See Appendix A for discussion of water draws.

2 Households having low water draws were assumed to be of less interest (due to economics).



Zone 1 is less than 2,000 CDD and greater than 7,000 HDD.

Zone 2 is less than 2,000 CDD and 5,500–7,000 HDD.

Zone 3 is less than 2,000 CDD and 4,000–5,499 HDD.

Zone 4 is less than 2,000 CDD and less than 4,000 HDD.

Zone 5 is 2,000 CDD or more and less than 4,000 HDD.

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The economic and energy-impact analysis matrix was selected to cover a broad range of products and applications.

Housing Type	Market Segment	Hot Water Draw[2]	Climate Region	New Electric Product	Displaced Water Heater	Marginal Utility Rates
Single Family	Replacement	High	National Average	High-Efficiency Resistance	Standard-Efficiency Natural Gas	Fixed
• Multifamily • Mobile home • Other	• New Construction	Medium • Low	DOE Zone 1 DOE Zone 2 DOE Zone 3 DOE Zone 4 DOE Zone 5	Point-of-use Resistance Resistance with Drain Water Heat Recovery Add-On HPWH Active Solar Thermal Multifunction, Full-Condensing Heat Pump Desuperheater • Other Distributed • Other HPWH • Other Solar • Other Integrated	Standard-Efficiency Electric Resistance • Various High-Efficiency (ex: Condensing Gas) • Various Integrated Products (ex. Combo Systems)	• Variable

Straight-forward installation costs[1] for electric resistance and gas water heaters are similar.

NAECA Electric Resistance				
Tank Size (Gallons)	EF[2]	Equipment Cost[3] ($)	Installation Cost[4] ($)	Total Installed Cost ($)
50	0.86	250	190	440
66	0.84	275	225	500
80	0.83	300	250	550

Natural Gas				
Tank Size (Gallons)	EF[5]	Equipment Cost[3] ($)	Installation Cost[4,6] ($)	Total Installed Cost ($)
40	0.544	230	190	420
50	0.525	250	190	440
66	0.495	260	225	485

1 Based on wholesaler distribution channel. Installed costs through retail outlet channels tend to be 5% to 10% lower. Costs for purchase and installation by end user may be much lower.

2 Energy Factor determined from WATSIM simulation of DOE test procedure to match as closely as practical actual NAECA standard.

3 Includes distributor and installer equipment markups. Safety-related equipment for gas-fired water heaters (e.g., CO detectors) are not included in the equipment costs.

4 For straight-forward installations, replacing similar technologies.

5 Actual NAECA standard Energy Factor.

6 Assumes that gas piping and exhaust-flue installation are not required. Installation costs would increase substantially with the addition of this equipment.

Source: Interviews with manufacturers, distributors, wholesalers, retail outets and contractors; survey of appliance manufacturers; ADL analysis.

Tank Size (Gallons)	High-Efficiency Resistance				Add-On HPWH[1]				
	EF[2]	Equipment Cost[3] ($)	Installation Cost[4] ($)	Total Installed Cost ($)[5]	EF[2]	Equipment Cost[3] ($)		Installation Costs[4] ($)		Total Installed Cost ($)[5]
						Tank[6]	Heat Pump	Tank[6]	Heat Pump	
50	.93	320	190	510	2.24	250	600[7]	190	260	1,300
66	.92	350	225	575	2.24	275	600[7]	225	260	1,360
80	.91	430	250	680	2.24	300	600[7]	250	260	1,410

1 Based on a design similar to the Crispaire WH-68X.

2 Energy Factor determined from WATSIM simulation of DOE test procedure.

3 Includes distributor and installer markups.

4 For straight-forward installations.

5 Based on current distribution-chain pricing.

6 Conventional resistance WH tank.

7 Estimated end-user cost through normal distribution channels (telephone interview between Ed Barbour, ADL, and David Shuford, Crispaire, August 1996.

Source: Interviews with manufacturers, distributors, wholesalers, retail outlets and contractors; survey of appliance manufacturers; ADL analysis.

Point-of-Use Unit Costs[1]			
Tank Size (Gallons)	Costs per Unit ($)		
	Equipment[2]	First-Unit Installation[3]	Subsequent-Unit Installation[2]
20	200	200	150

Point-of-Use Total Costs		
Water Draw	Units per Household	Total Installed Cost Per Household ($)
High	5	1,800
Low	3	1,100

1 Assumes use of compact water heaters (see description under "Technologies" Section). Based on wholesaler distribution channel. Installed costs through retail outlet channels tend to be 5% to 10% lower. Costs for purchase and installation by end user may be much lower.

2 Based on ADL analysis and Grainger 1995 equipment catalog.

3 Assumes straight-forward installation. Plumbing codes require drain line to be connected with an indirect waste outlet or the lowest level of the building which typically results in a higher installation cost, as compared with a larger, centrally-located electric resistance water heater.

City	Solar Thermal w/ Resistance						
	Tank Size (Gallons)	Collector Area (sq. ft)	Equipment Costs ($)			Installation and Markup($)[2]	Total Installed Cost ($)[3]
			Tank	Collector	Other Equipment[1]		
Atlanta	50	40	200	400	300	1,350	**2,250**
	65	40	220	400	300	1,380	**2,300**
Detroit	50	64	200	640	300	1,710	**2,850**
	80	64	240	640	300	1,770	**2,950**
Minneapolis	50	64	200	640	300	1,710	**2,850**
	80	64	240	640	300	1,770	**2,950**
New Orleans	50	40	200	400	300	1,350	**2,250**
	65	40	220	400	300	1,380	**2,300**
New York	50	80	200	800	300	1,950	**3,250**
	65	80	220	800	300	1,980	**3,300**

1 Includes heat exchanger, pump, valves, glycol, piping, and supports.

2 Includes 25% manufacturer profit, 25% distribution markup, and 60% dealer/ contractor markup.

3 Based on wholesaler distribution channel. Installed costs through retail outlet channels tend to be 5% to 10% lower. Costs for purchase and installation by end user may be much lower.

Drain Water Heat Recovery[1]					
Tank Size (Gallons)	Equipment Cost[1] ($)		Installation Costs[4] ($)		Total Installed Cost ($)[5]
	Tank[2]	Heat Recovery[3]	Tank[2]	Heat Recovery[3]	
50	250	300	190	100	840
66	275	300	225	100	900
80	300	300	250	100	950

1 Includes distributor and installer markups.

2 Conventional resistance WH.

3 Based on GFX Model 3F60-1/2 (offered by Vaughn Manufacturing).

4 For straight-forward installations.

5 Based on wholesaler distribution channel. Installed costs through retail outlet channels tend to be 5% to 10% lower.

Tank Size (Gallons)	Desuperheater				Multifunction, Full-Condensing HP[1]			
	Tank Equipment Costs[2,3] ($)	Tank Installation Costs[2] ($)	Premium for Air Cond. ($)	Total Installed Cost ($)[4]	Tank[3] Equipment Costs[2,3] ($)	Tank Installation Costs[3] ($)	Premium for Heat Pump($)[5]	Total Installed Cost ($)[4]
50	250	190	600	**1,040**	250	190	1,000	**1,440**
66	275	225	600	**1,100**	275	225	1,000	**1,500**
80	300	250	600	**1,150**	300	250	1,000	**1,550**

1 Assumes 100% of water heating is provided by heat pump. Thermal losses through piping to heat pump are neglected. Tank stand-by losses are included. Heat pump efficiency assumed to be the same as for a 10-SEER, 7.4 HSPF space-conditioning heat pump.

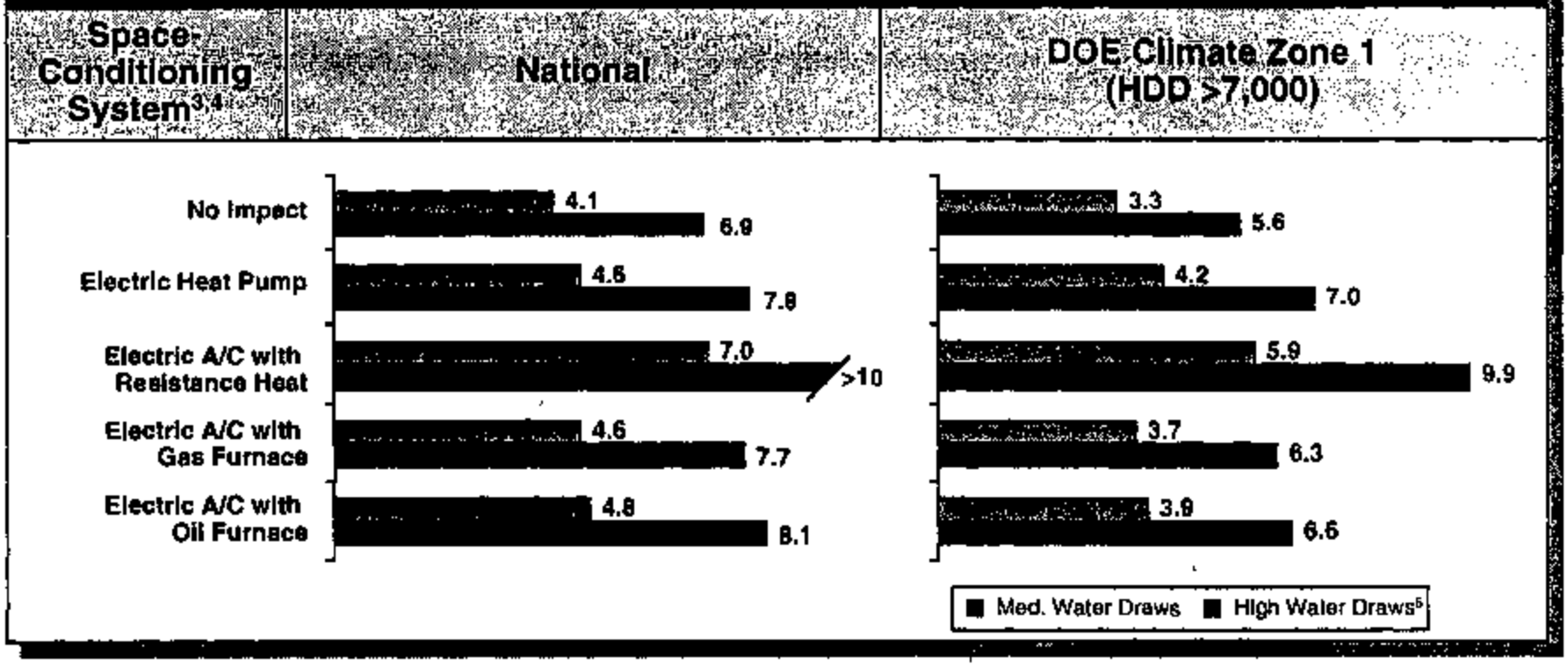
2 Includes distributor and installer markups.

3 Conventional resistance WH.

4 Includes 10-year tank and 5-year parts warranties.

5 Based on typical installed-cost premium estimate of $1,000 for a 3-ton, 10-SEER Nordyne Powermiser, relative to a comparable air-source heat pump. [Phone interview with Wayne Reedy, Nordyne; conducted by R. Zogg, ADL; 7-12-96]

Typical Payback Periods[1] (Years)
Add-On HPWH Displacing[2] NAECA Resistance Water Heater



1 Without incentives. Marginal rates of $0.06/kWh, $6.26/MMBtu, and $1.00/gal. fuel oil (assumes natural gas service is available at the household, and in the vicinity of the water heater). See Appendix D for calculations and additional electric rates.

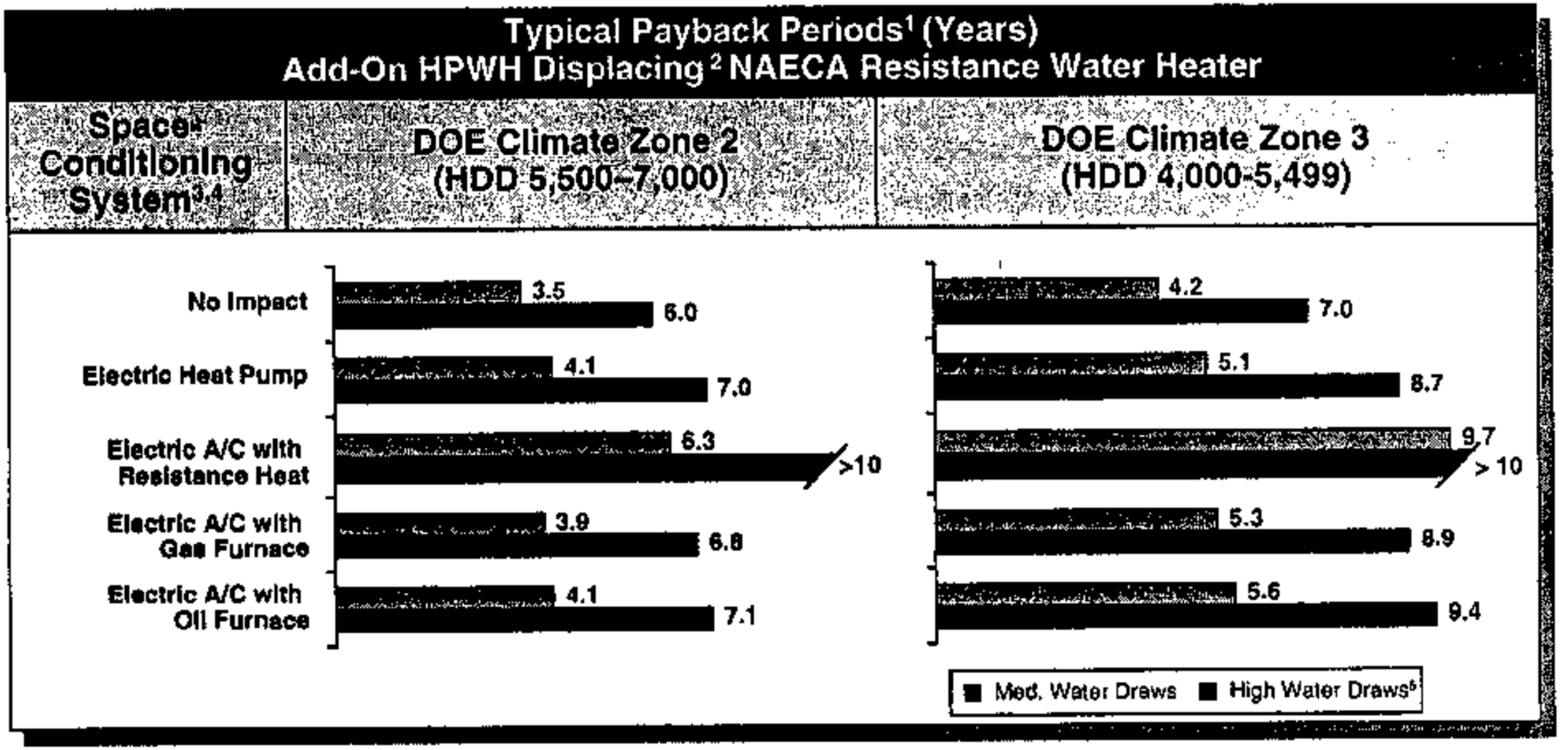
2 Not necessarily the product **replaced**. The product **displaced** is the product that would have been installed absent a joint industry/DOE program.

3 If the HPWH uses space-conditioned air as the heat source, it will impact space-conditioning loads. Hence, the overall energy use and cost will be dependent on the space-conditioning system. See Appendix D for space-conditioning impact calculations.

4 Assumed space-conditioning efficiencies: 10-SEER/7.4-HSPF electric Heat Pump; 10-SEER electric A/C; 80% AFUE Oil Furnace; 80% AFUE Gas Furnace.

5 See Appendix A for discussion of water draws.

Typical Payback Periods[1] (Years)
Add-On HPWH Displacing[2] NAECA Resistance Water Heater



1 Without incentives. Marginal rates of $0.06/kWh, $6.26/MMBtu, and $1.00/gal. fuel oil (assumes natural gas service is available at the household, and in the vicinity of the water heater). See Appendix D for calculations and additional electric rates.

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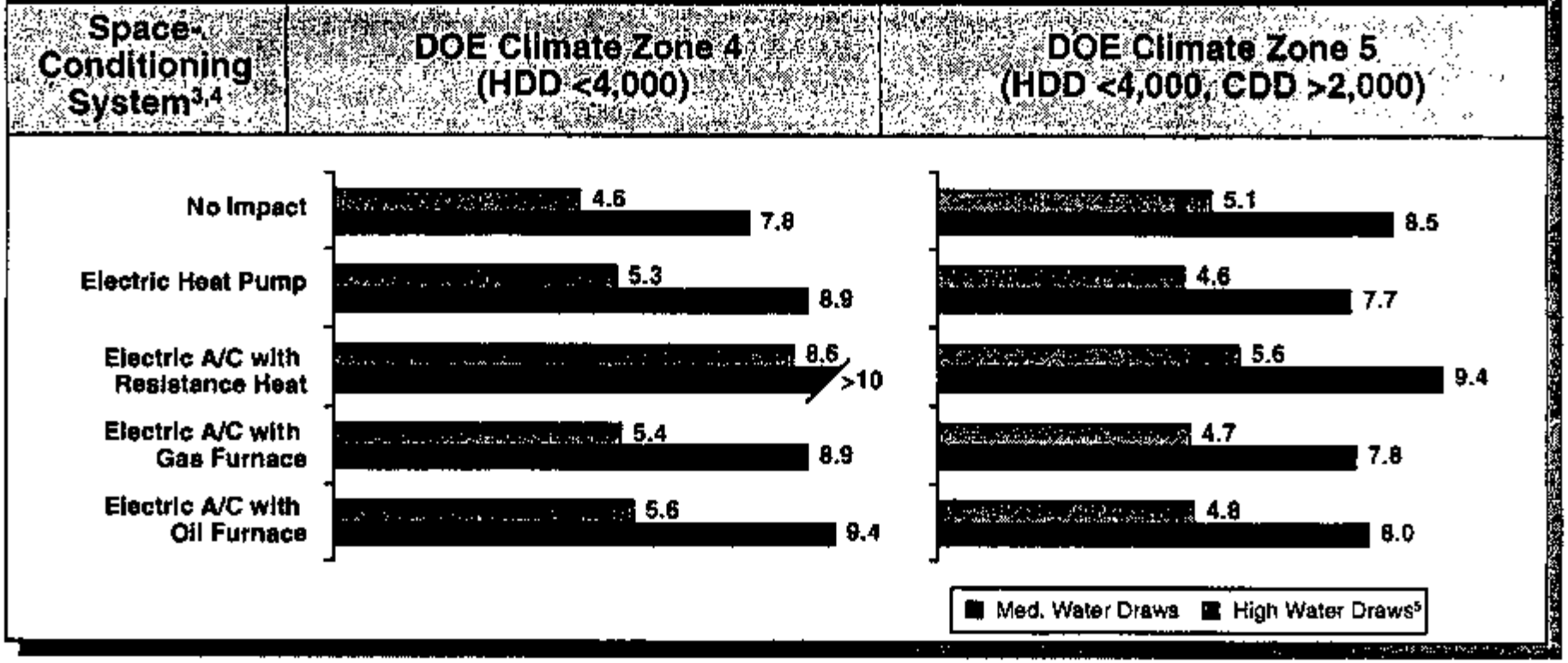
4 Assumed space-conditioning efficiencies: 10-SEER/7.4-HSPF electric Heat Pump; 10-SEER electric A/C; 60% AFUE Oil Furnace; 60% AFUE Gas Furnace.

5 See Appendix A for discussion of water draws.

Typical Payback Periods[1] (Years)
Add-On HPWH Displacing[2] NAECA Resistance Water Heater



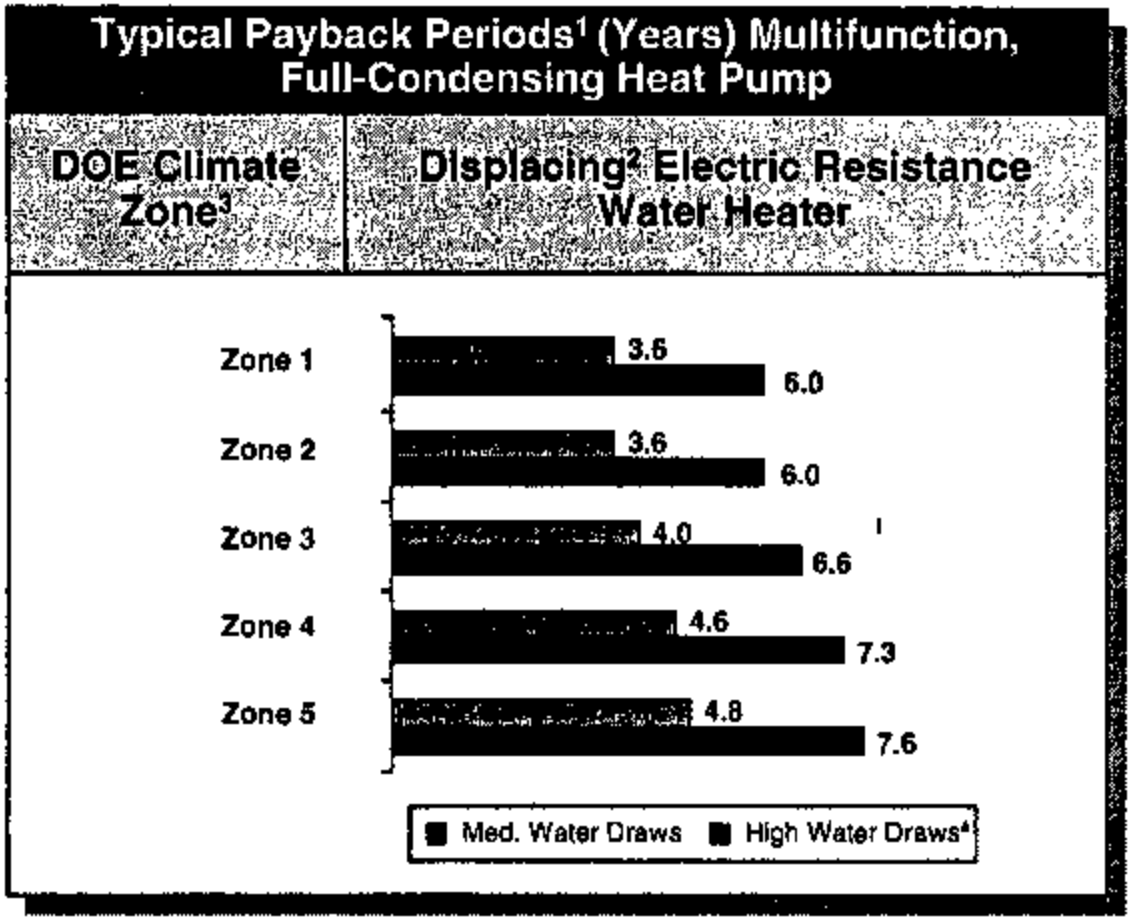
1 Without incentives. Marginal rates of $0.06/kWh, $6.26/MMBtu, and $1.00/gal. fuel oil (assumes natural gas service is available at the household, and in the vicinity of the water heater.) See Appendix D for calculations and additional electric rates.

2 Not necessarily the product **replaced**. The product **displaced** is the product that would have been installed absent a joint industry/DOE program. 3 If the HPWH uses space-conditioned air as the heat source, it will impact space-conditioning loads. Hence, the overall energy use and cost will be dependent on the space-conditioning system. See Appendix D for space-conditioning impact calculations.

4 Assumed space-conditioning efficiencies: 10-SEER/7.4-HSPF electric Heat Pump; 10-SEER electric A/C; 80% AFUE Oil Furnace; 80% AFUE Gas Furnace.

5 See Appendix A for discussion of water draws.

Typical Payback Periods[1] (Years) Multifunction, Full-Condensing Heat Pump



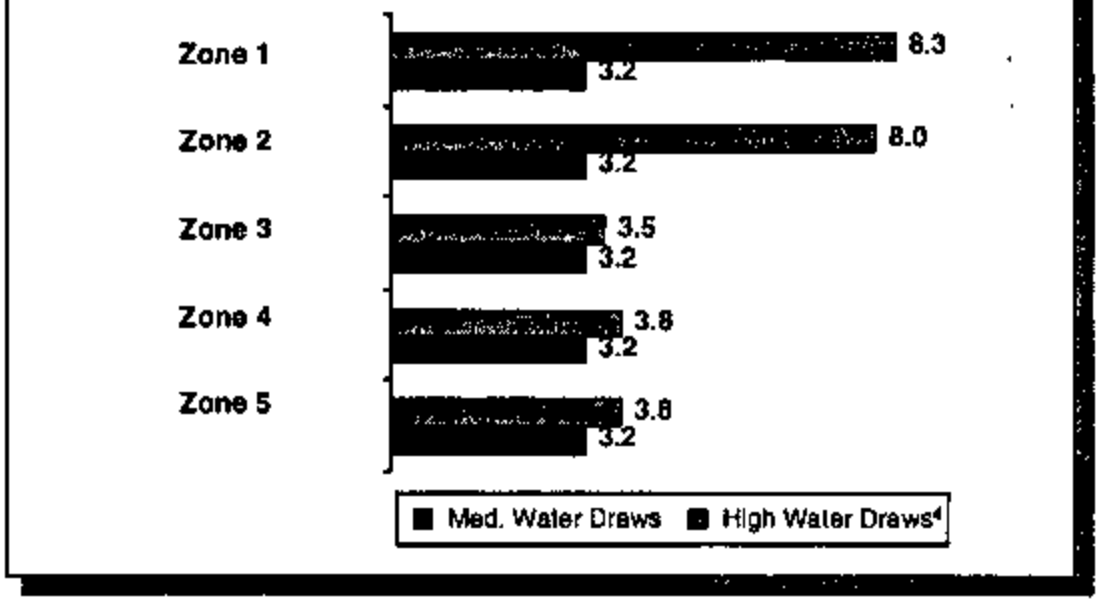
1 Without Incentives. Marginal electric rate of $0.06/kWh (assumes natural gas service is available at the household, and in the vicinity of the water heater.) See Appendix D for calculations and additional electric rates.

2 Not necessarily the product **replaced**. The product **displaced** is the product that would have been installed absent a joint industry/DOE program.

3 See Appendix A for discussion of DOE Climate zones.

4 See Appendix A for discussion of water draws.

Typical Payback Periods[1] (Years) High-Efficiency Electric Resistance

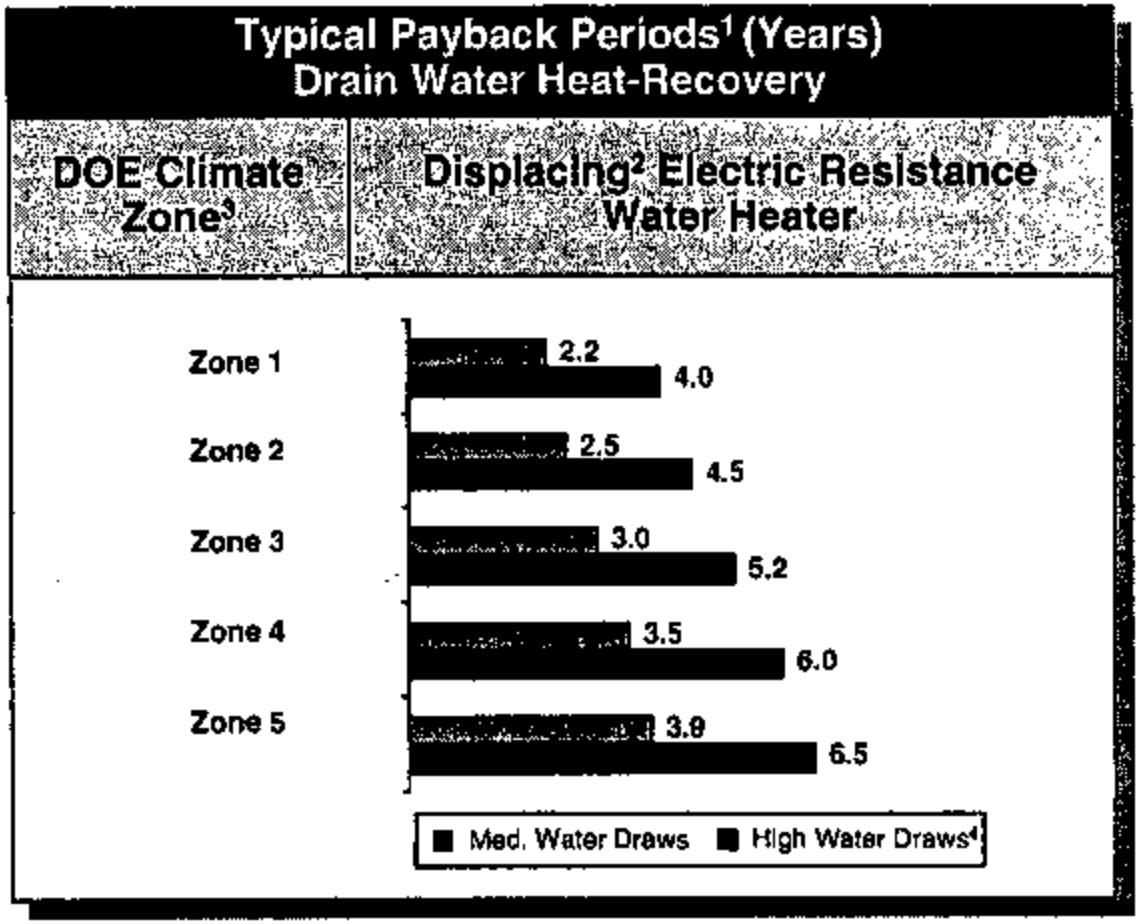


1 Without incentives. Marginal electric rate of $0.06/kWh (assumes natural gas service is available at the household, and in the vicinity of the water heater.) See Appendix D for calculations and additional electric rates.

2 Not necessarily the product **replaced**. The product **displaced** is the product that would have been installed absent a joint industry/DOE program.

3 See Appendix A for discussion of DOE Climate zones.

4 See Appendix A for discussion of water draws.



1 Without Incentives. Marginal electric rate of $0.06/kWh (assumes natural gas service is available at the household, and in the vicinity of the water heater.) See Appendix D for calculations and additional electric rates.

2 Not necessarily the product **replaced**. The product **displaced** is the product that would have been installed absent a joint industry/DOE program.

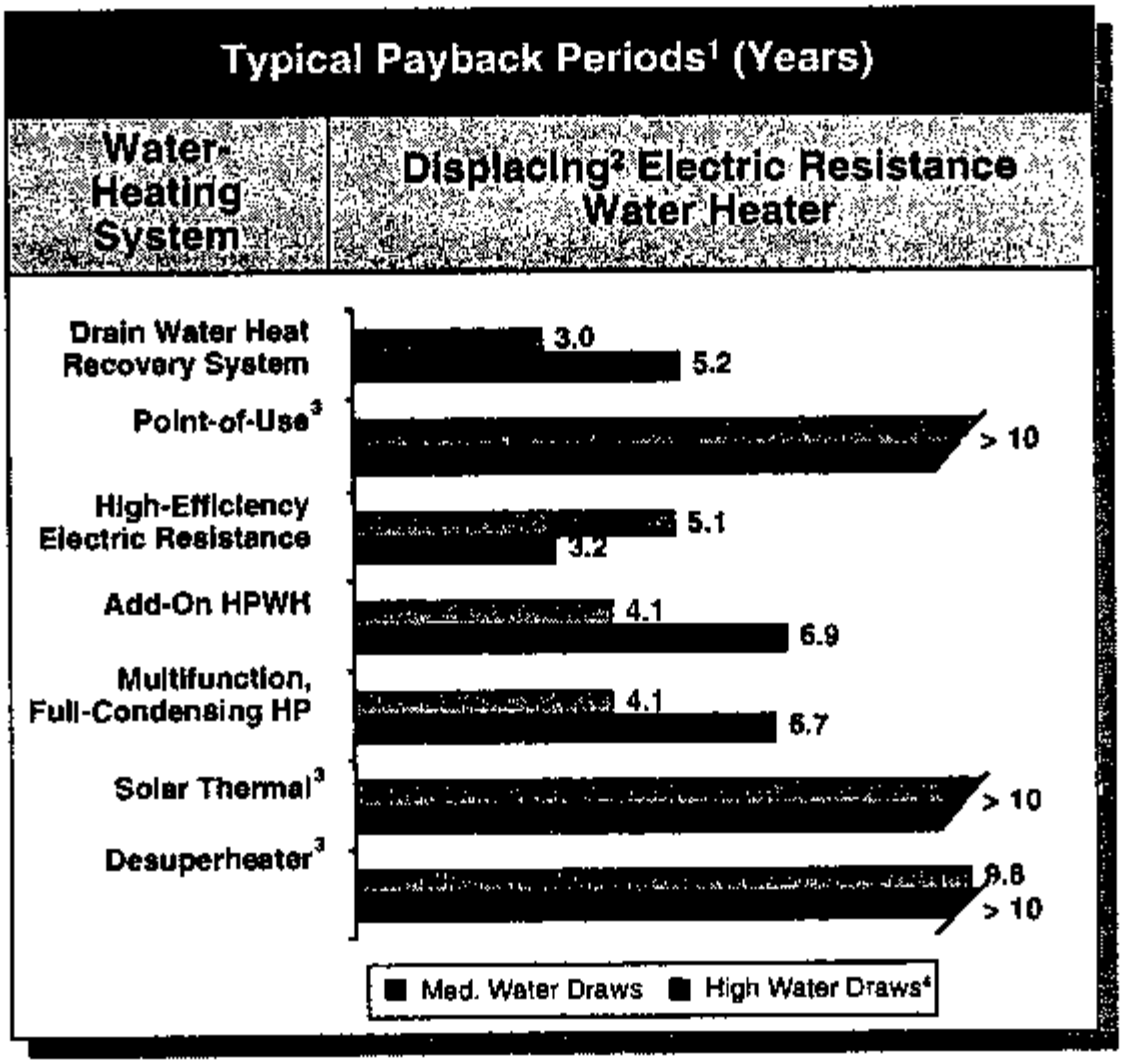
3 See Appendix A for discussion of DOE Climate zones.

4 See Appendix A for discussion of water draws.

The following technologies have paybacks[1] less than ten years relative to the electric water-heating baseline cases.

- Multifunction, full-condensing heat pump (air source)
- Add-on HPWH
- High-efficiency electric resistance
- Storage tank with drain-water recovery

[1] Without incentives. Marginal electric rate of $0.06/kWh. See Appendix D for calculations and additional electric rates.



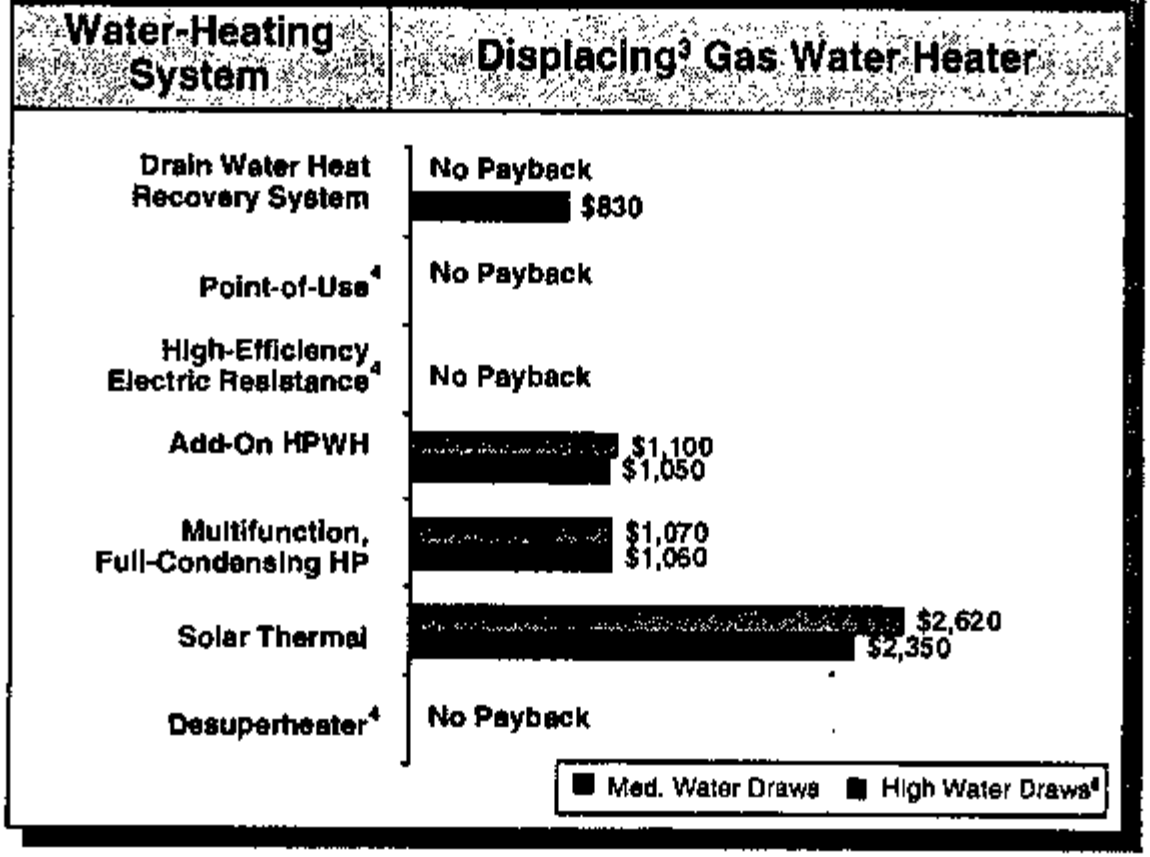
1 Without incentives. Marginal electric rate of $0.06/kWh (assumes natural gas service is available at the household, and in the vicinity of the water heater.) See Appendix D for calculations and additional electric rates.

2 Not necessarily the product **replaced**. The product **displaced** is the product that would have been installed absent a joint industry/DOE program.

3 For the five climate conditions evaluated, solar thermal, desuperheater, and point-of-use water heaters generally did not achieve payback within 10 years.

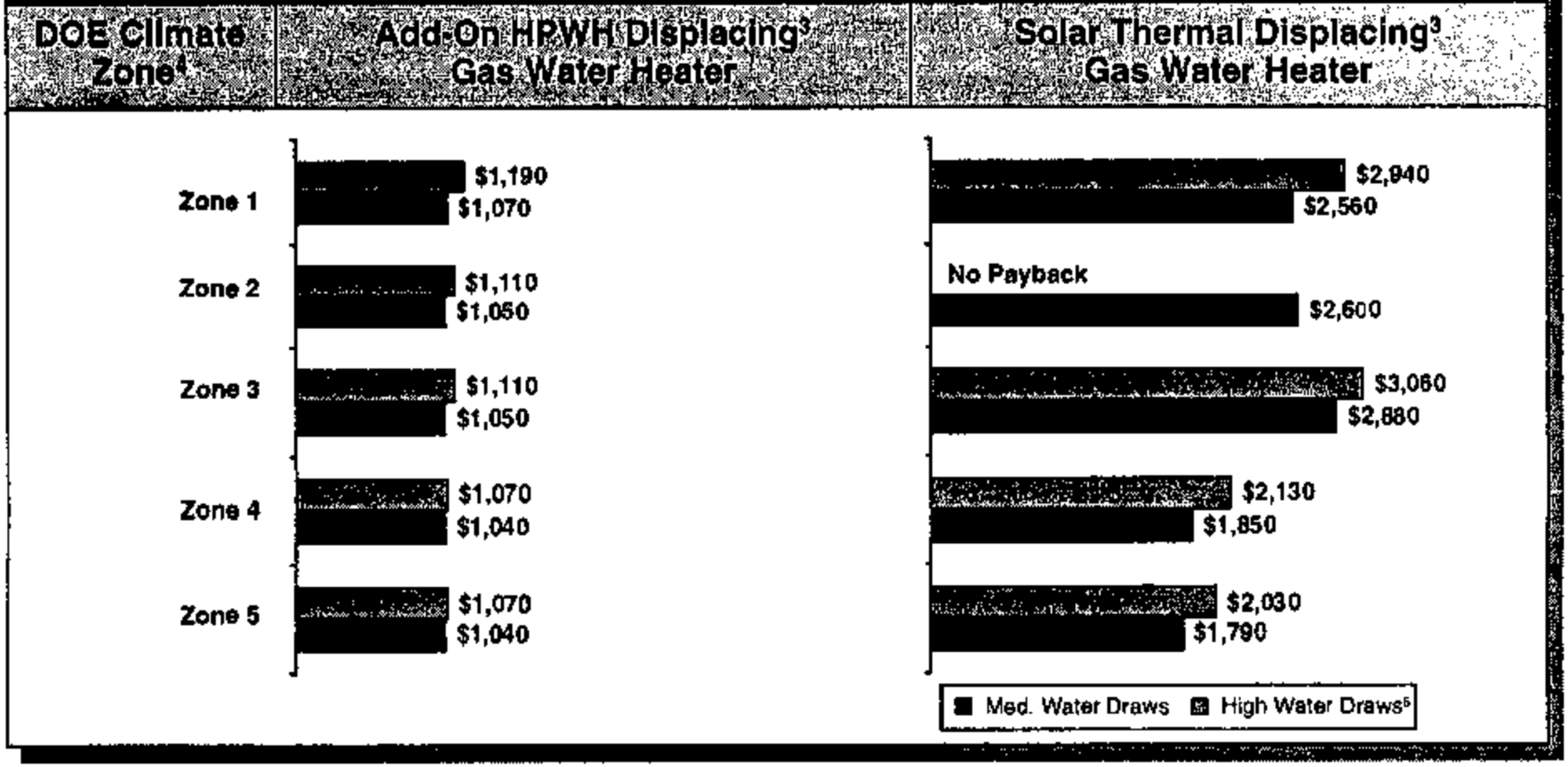
4 See Appendix A for discussion of water draws.

Minimum Gas-Water-Heater Installed Cost for Electric Technology to Achieve 5-Year Payback[1,2] ($)



1. Without incentives. Marginal electric rate of $0.06/kWh , $8.26/MMBtu, and $1.00/gal. fuel oil. See Appendix D for calculations and additional electric rates.
2. Space-conditioning impacts of gas-fired water heaters (i.e., increased infiltration associated with free convection through exhaust flues) are neglected.
3. Not necessarily the product **replaced**. The product **displaced** is the product that would have been installed absent a joint industry/DOE program.
4. For the five climate conditions evaluated, high-efficiency electric resistance, point-of-use, and desuperheater water heaters generally did not achieve energy cost savings relative to gas.
5. See Appendix A for discussion of water draws.

Minimum Gas-Water-Heater Installed Cost for Electric Technology to Achieve 5-Year Payback[1,2] ($)



1 Without incentives. Marginal electric rate of $0.06/kWh , $6.28/MMBtu, and $1.00/gal. fuel oil. See Appendix D for calculations and additional electric rates.

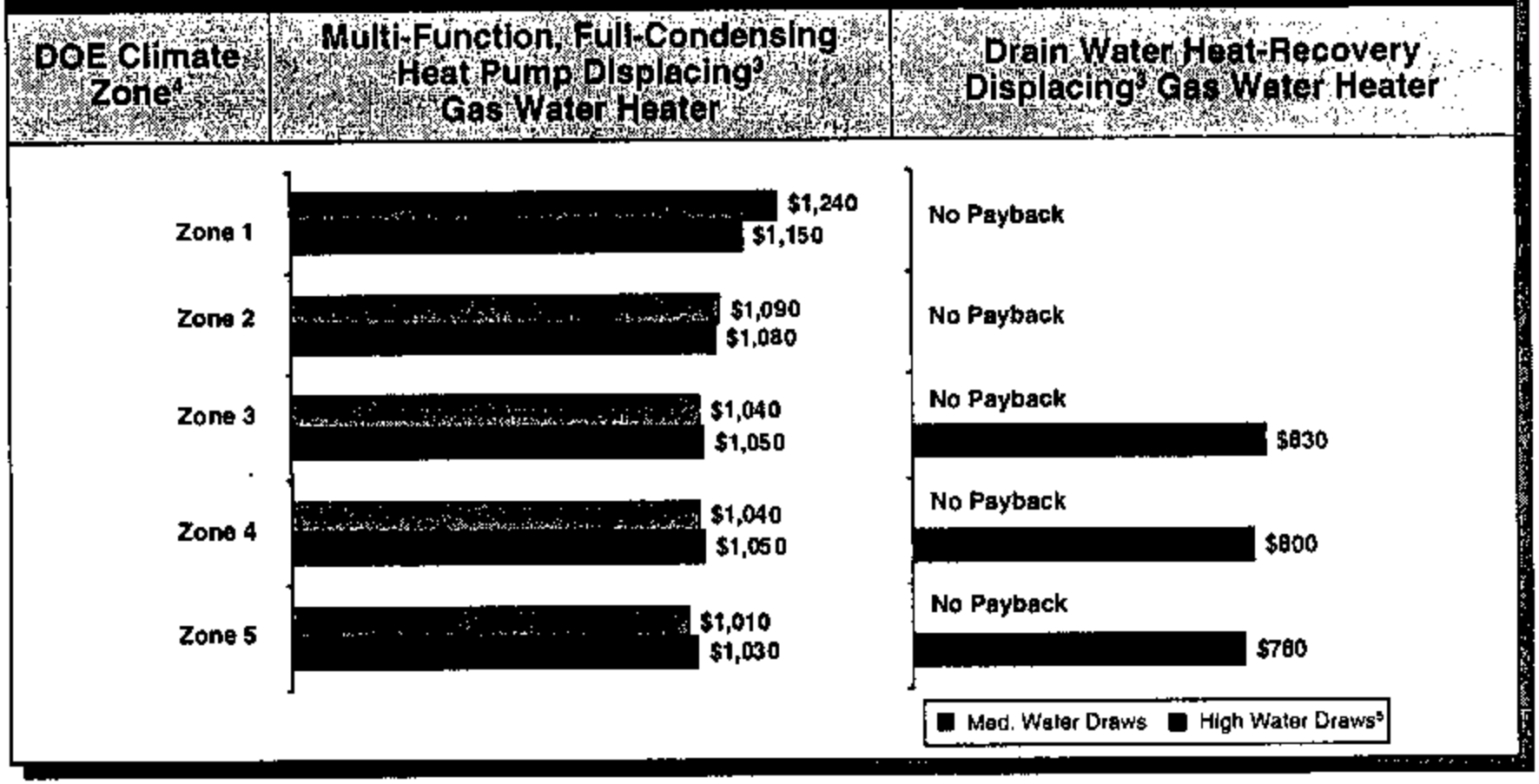
2 Space-conditioning impacts of gas-fired water heaters (i.e., increased infiltration associated with free convection through exhaust flues) are neglected.

3 Not necessarily the product **replaced**. The product **displaced** is the product that would have been installed absent a joint industry/DOE program. Assumes natural gas service is available at the household, and in the vicinity of the water heater.

4 See Appendix A for discussion of DOE Climate zones.

5 See Appendix A for discussion of water draws.

Minimum Gas-Water-Heater Installed Cost for Electric Technology to Achieve 5-Year Payback[1,2] ($)



1. Without incentives. Marginal electric rate of $0.06/kWh and $6.28/MMBtu. See Appendix D for calculations and additional electric rates.
2. Space-conditioning impacts of gas-fired water heaters (i.e., increased infiltration associated with free convection through exhaust flues) are neglected.
3. Not necessarily the product **replaced**. The product **displaced** is the product that would have been installed absent a joint industry/DOE program.
4. See Appendix A for discussion of DOE Climate zones.
5. See Appendix A for discussion of water draws.

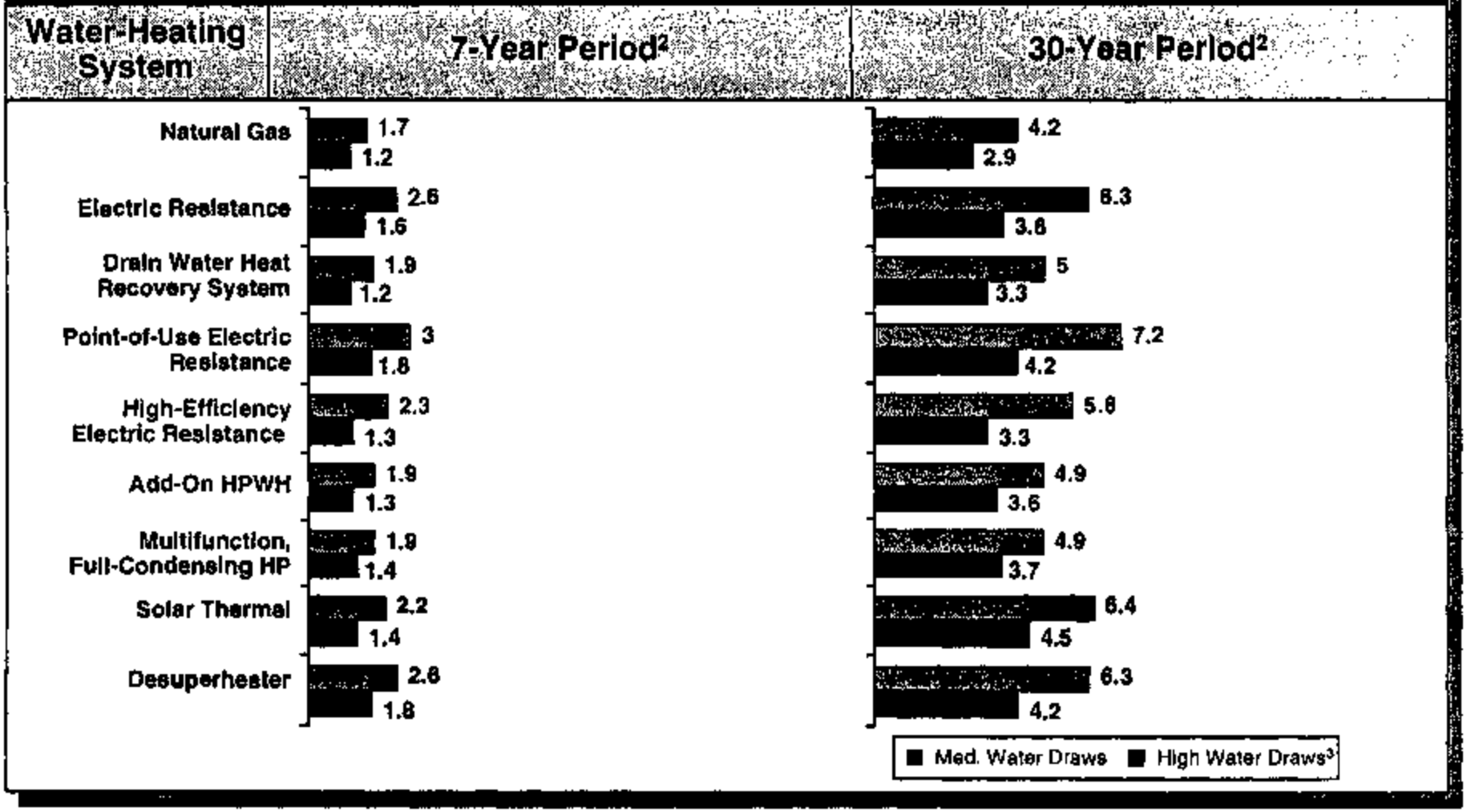
The following technologies achieve annual energy cost savings relative to the gas water heater[1,2].

- Storage tank with drain-water heat recovery
- Add-on HPWH
- Multi-function, full-condensing heat pump
- Solar thermal

1 Without incentives. Marginal electric rate of $0.06/kWh and $6.26/MMBtu. See Appendix D for calculations and additional electric rates.

2 Desuperheater achieved annual energy cost savings in Climate Zone 5, New Orleans for medium draws.

Typical Life-Cycle Cost[1] (1000$)—6% Discount Rate[4]



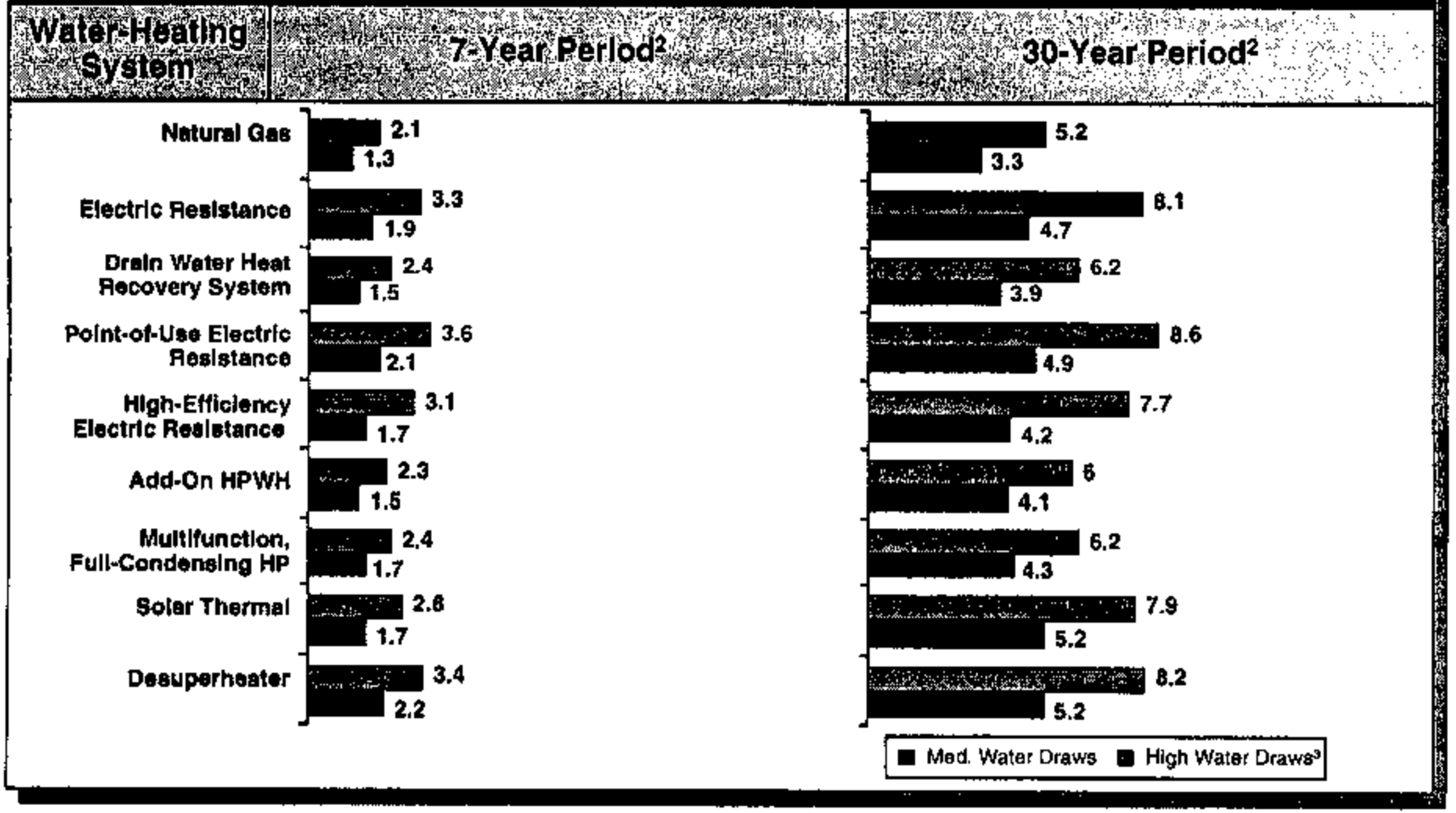
1 Life-Cycle Cost = NPV (Annual Energy Costs($) x number of years) ~ Salvage Value($) + Installed Costs($) + NPV (Annual Operation and Maintenance Costs($) x number of years) + Capital Recovery Costs($). Water-heating costs and calculations are characterized in Appendix D.

2 7-year period reflects typical residence occupancy. 30-year period represents typical mortgage lifespan

3 See Appendix A for discussion of water draws.

4 Corresponds to an annual inflation rate of 3%. ("Analysis of Various Water Heating Systems," California Energy Commission.)

Typical Life-Cycle Cost[1] (1000$)—6% Discount Rate[4]



1 Life-Cycle Cost = NPV (Annual Energy Costs($) x number of years) – Salvage Value($) + Installed Costs($) + NPV (Annual Operation and Maintenance Costs($) x number of years) + Capital Recovery Costs($). Water-heating costs and calculations are characterized in Appendix D.

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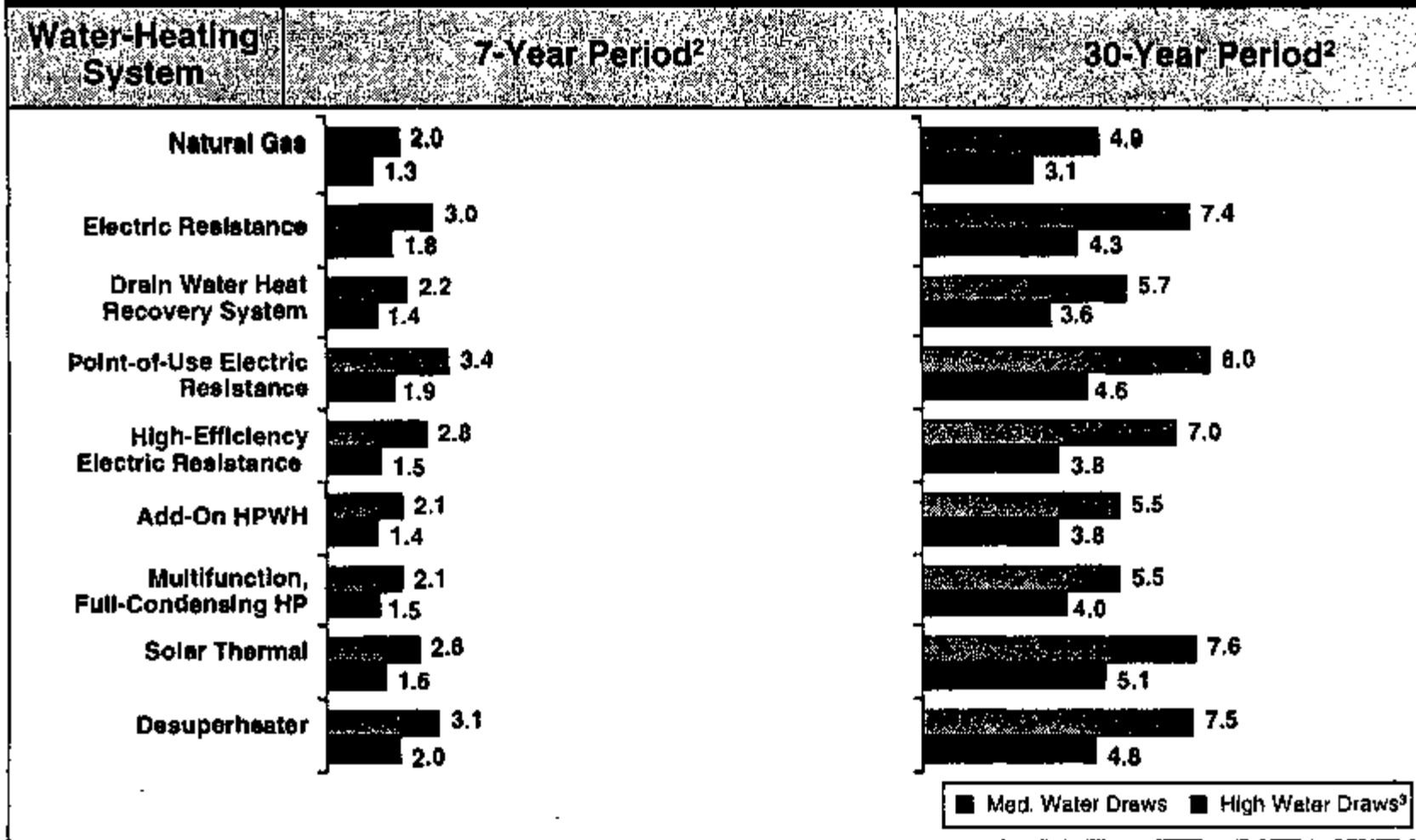

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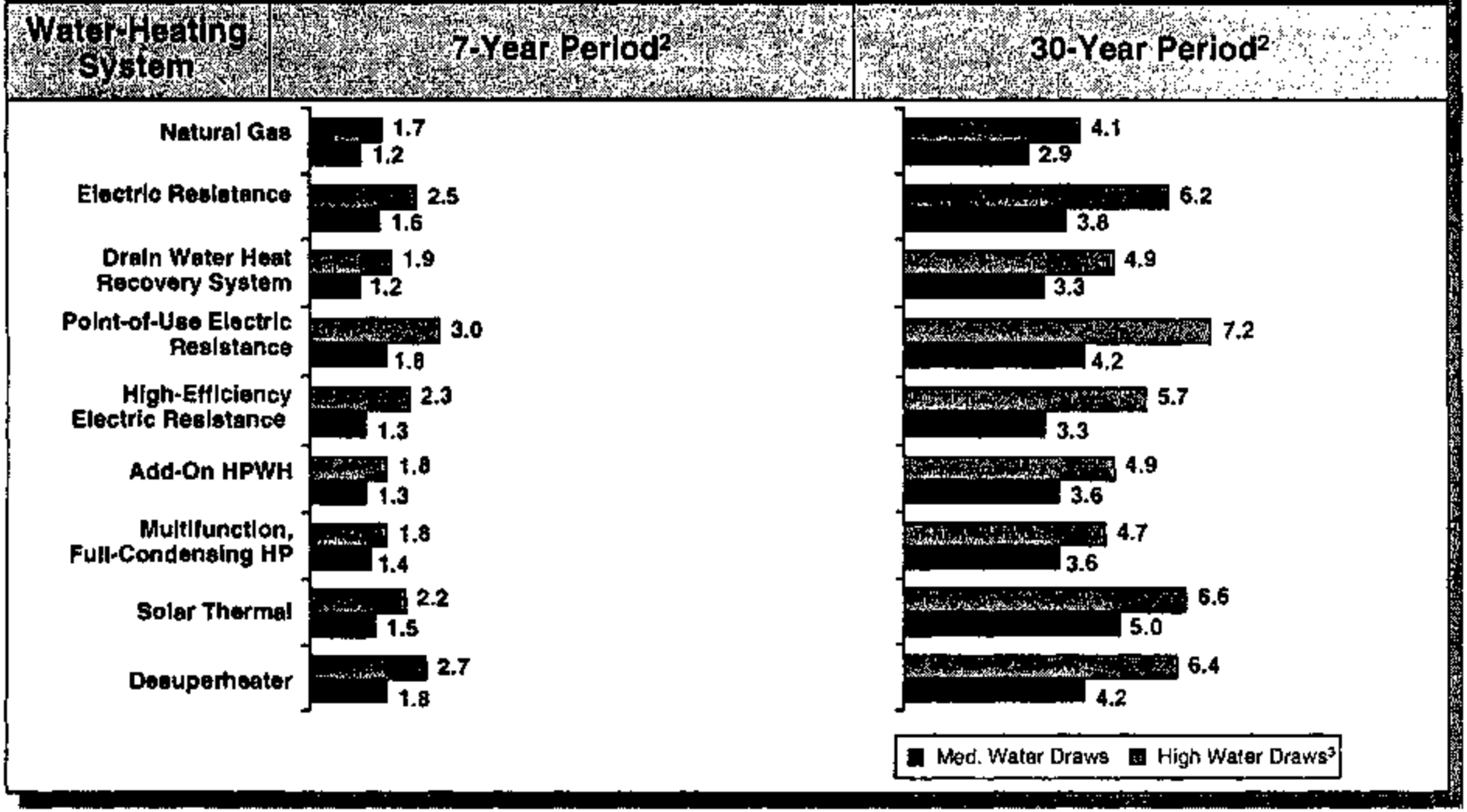

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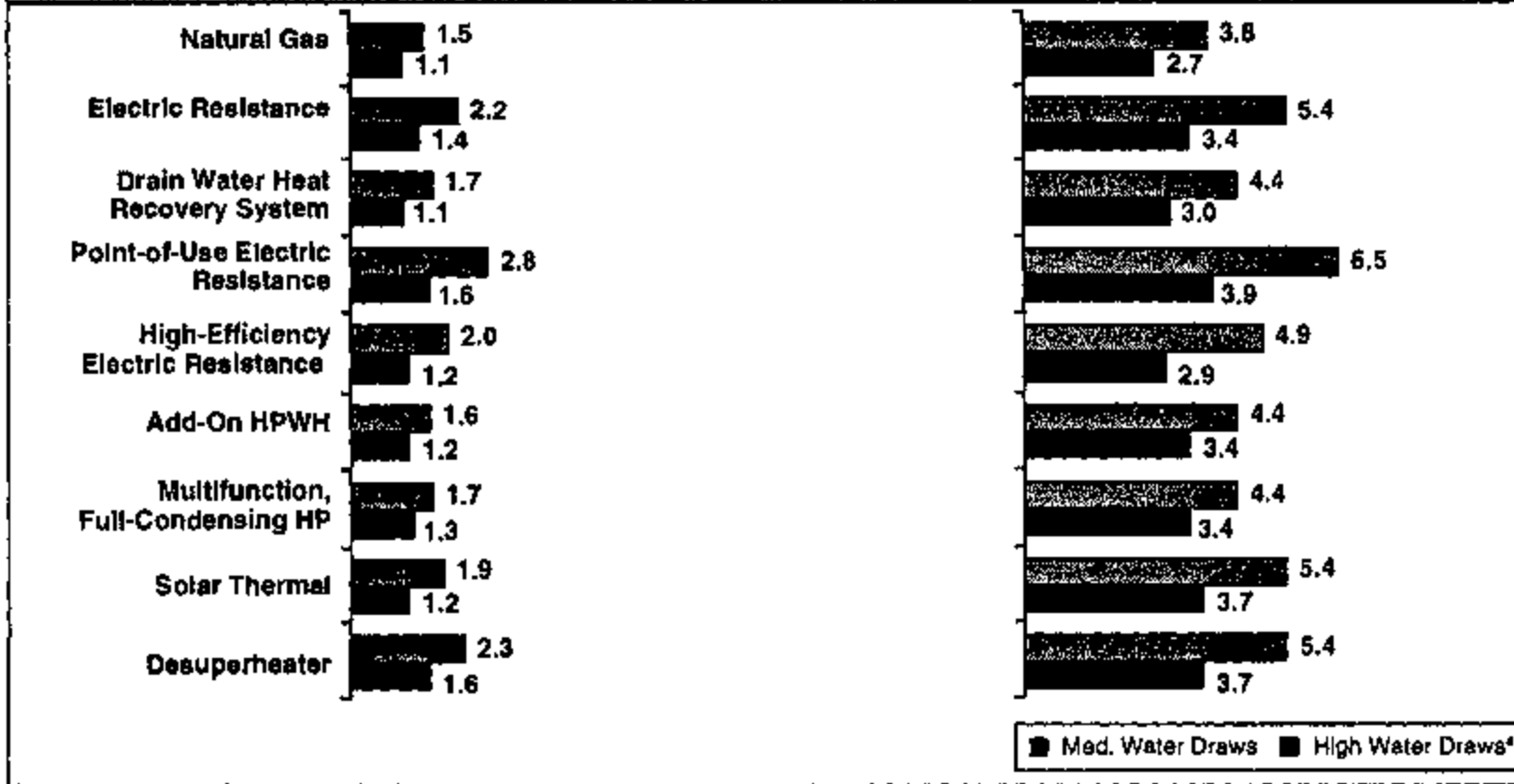

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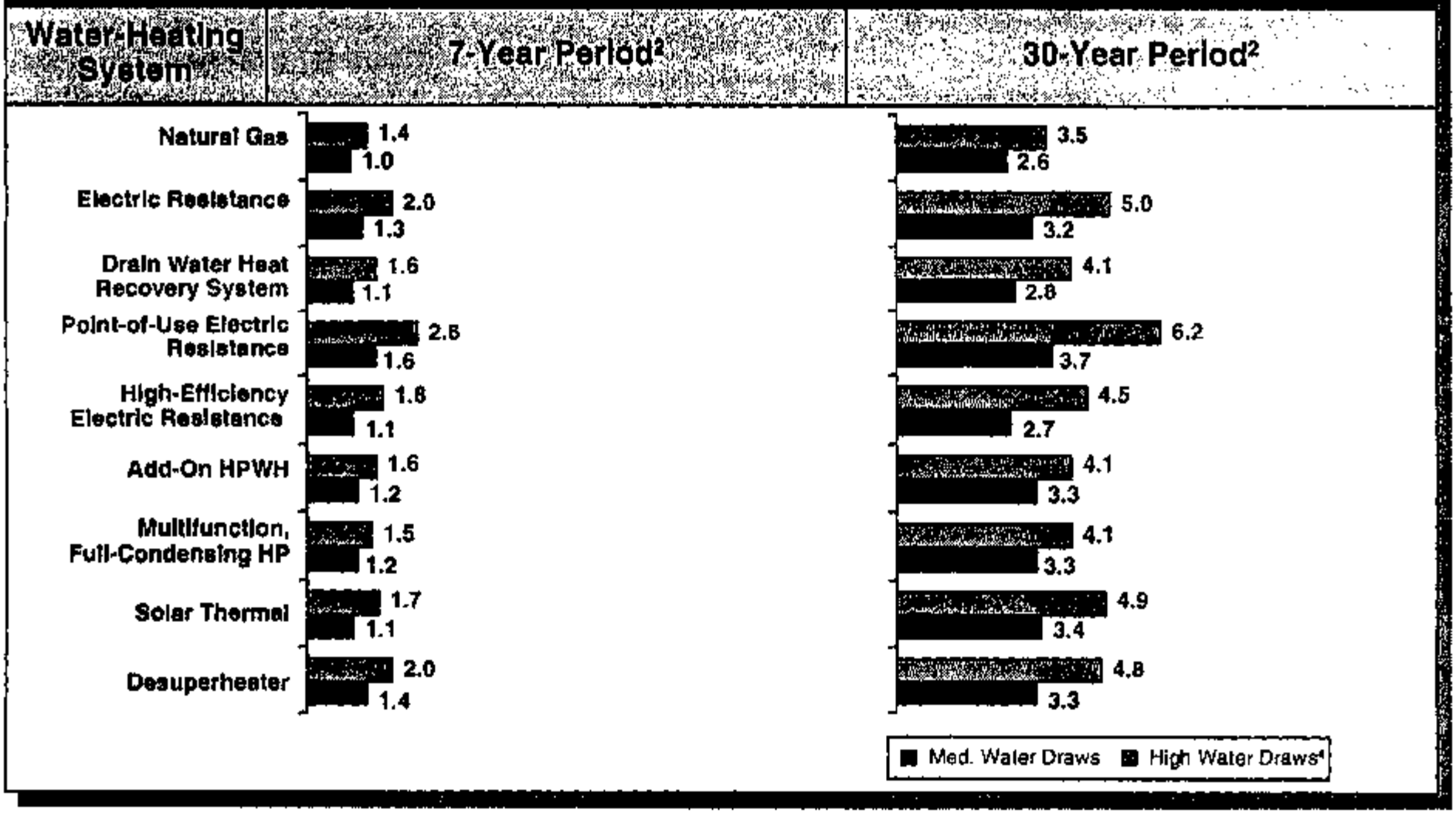

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