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Instantaneous Water Heaters (IWH)

IWH Application Case Study Handbook

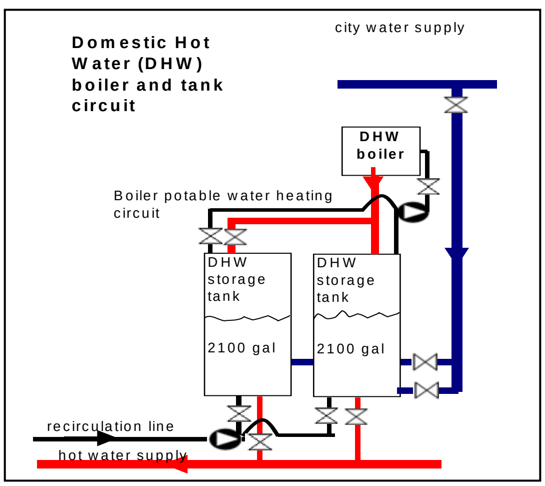
Introduction

This handbook provides the reader with some Case Study comparisons between two approaches to domestic water heating in commercial spaces, Instantaneous Water Heaters (IWH), versus, storage tanks. The comparisons are made using published ASHRAE sizing and system design standards. The economic comparisons are based on lowest cost equipment scenarios and should not be taken to imply market pricing for these items.

The objective of this handbook is to allow the reader to develop an understanding of what type of installations are ideal for IWH. In many scenarios IWH is the lowest first cost, has the lower operating cost, and is the easiest to maintain. There are however, certain situations where the traditional storage tank heater approach may offer the lowest first cost. Beyond first installed cost, the following introduction compares and contrasts some of the other facts and feature differences between IWH and storage tank systems.

In North American buildings the common approach to heating "domestic water" has involved a storage tank that has either a dedicated domestic water heating boiler, or an immersion heater in the storage tank.

ASHRAE provides designers with tank, boiler, and user flow demand calculation techniques for a wide variety of users (schools, apartments, hospitals, hotels, etc.)



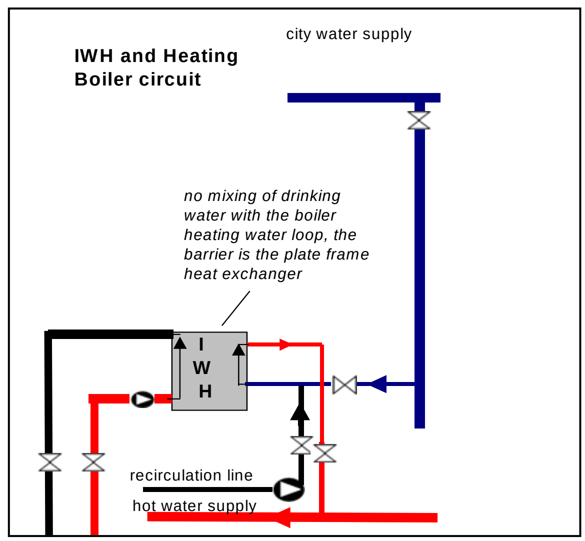
The ASHRAE tank sizing calculations are developed based on historical experience and engineering calculations to provide the user with a time duration supply of hot water. The large tanks allow a smaller boiler to build up a reserve of heated water for periods of high demand. If the actual period of high demand exceeds the design estimates the user runs out of hot water.

Instantaneous water heaters, unlike hot water storage tank systems, are able to provide the user with an endless duration of hot water at the maximum design flow rate. Traditionally, storage tank capacity has been much less costly than boiler supply capacity, and has led to the widespread popularity of large sized tanks with smaller boiler sizing. IWH can offer peak flow demand with marginal to no increase in boiler capacity by drawing heat energy from the space heating boilers. In the case studies this concept of a "combined boiler" system is demonstrated.

Although a storage tank system can sometimes offer cost saving on the original equipment costs, a tank system usually has the following less attractive characteristics:

- storage tanks require a lot of space
- storage tanks can become an amplifier for legionaries disease
- storage tanks suffer radiant and convection heat loss
- storage tanks require continuous recirculation to the boiler

With IWH there is no mixing between the city supply of water and the boiler circuit / loop of water (separated by the heat exchanger plates), no heat losses from the tank, no risk of legionaries disease, and no time limit on the supply of full peak design flow. Also, the IWH system can use a lower cost heating boiler design rather than the more costly drinking water boiler design with copper-nickel piping.



The IWH first installed cost can be lower than the traditional storage tank system in the following situations:

- there is a building heating system in places and the building heat boilers can be sequenced to provide year round heat to the IWH (combined boilers -this enables a sizing advantage for the boiler capacity required for the domestic hot water, as per ASHRAE)
- larger buildings or complexes where the hot water heating load is a smaller fraction of the available building heat load
- mechanical room space is at a premium, and the space savings of the IWH system are valued (today's mechanical square footage is estimated at between $80/sqft, and $110/sqft USD).

The following pages compare the first installed cost of IWH against the traditional storage tank domestic hot water approach for 5 cases. The cost comparison is for tank, boiler, and IWH equipment costs only, and do not allow for additional labor savings, saving in piping, or savings on valves that the IWH option offers.

Case Study #1

The schematic drawing below illustrates the typical layout of the Domestic Hot Water circuit and the space heating circuit in the mechanical room for a 300 Unit Apartment Building. The actual size and configuration of the boilers will vary depending on the geographic location, the size of the apartment units, and any additional heating requirements in the complex other than just the rental units (example, lobbies, halls, recreation spaces, gyms, and other spaces)

ASHRAE guidelines were used in the sizing of the boilers and storage tank configurations.

Case 1 Apartment, 300 Unit, located NE US / Central Ontario

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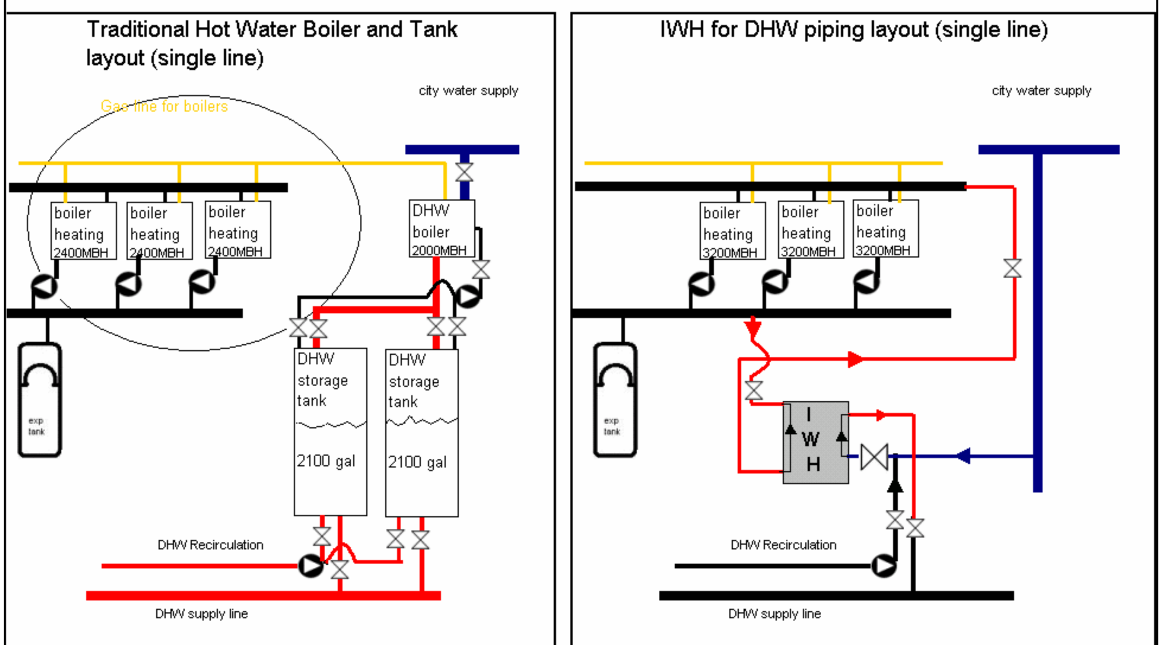


A one-line schematic layout comparison between the traditional
*Multiple boilers used for sequencing and redundancy on heating

DHW boiler and storage tank configuration to the new IWH system configuration.

Eliminate 2 hot water storage tanks (4200gal), increase capacity of 3 boilers to 3200MBH from 2400MBH,eliminate a 2000 MBH water boiler

Add in one IWH unit (70 gpm)
Benefits - no heat losse on storage tanks, sharing of boilers, increase redundancy, gas lines all run to one area, no legionelle amplifier due to removal of storage tanks, easier installation, no recovery mode.

For the 300 Unit Apartment building mechanical room a comparison is made on the following table between the storage tank approach and the IWH approach.

The space savings using the IWH approach are 124 sqft, and combined with the equipment cost savings (boilers and IWH, versus boilers and storage tank) the total first cost advantage of IWH is $13,623. The equipment unit prices are the best estimate of current costs that would be realized by the end user, after all mark ups through distribution, contractors, etc. The boiler and tank equipment market prices are "aggressively" low in favor of the storage tank option, and are not meant to imply or be representative of the actual prices paid for any specific make or models of boilers.

The annual operating cost savings are calculated for the storage tank approach as the sum of the radiant heat losses in the storage tank, and the electrical energy for the circulation pump from the boiler. The annual operating costs for the IWH are the sum of the PFX pressurizing pump that has an energy saving shut off after 10 minutes of no hot water demand. The annual operating savings in this case are $1256 per year. This analysis does not allow for the additional labor savings that would be realized with the IWH option.

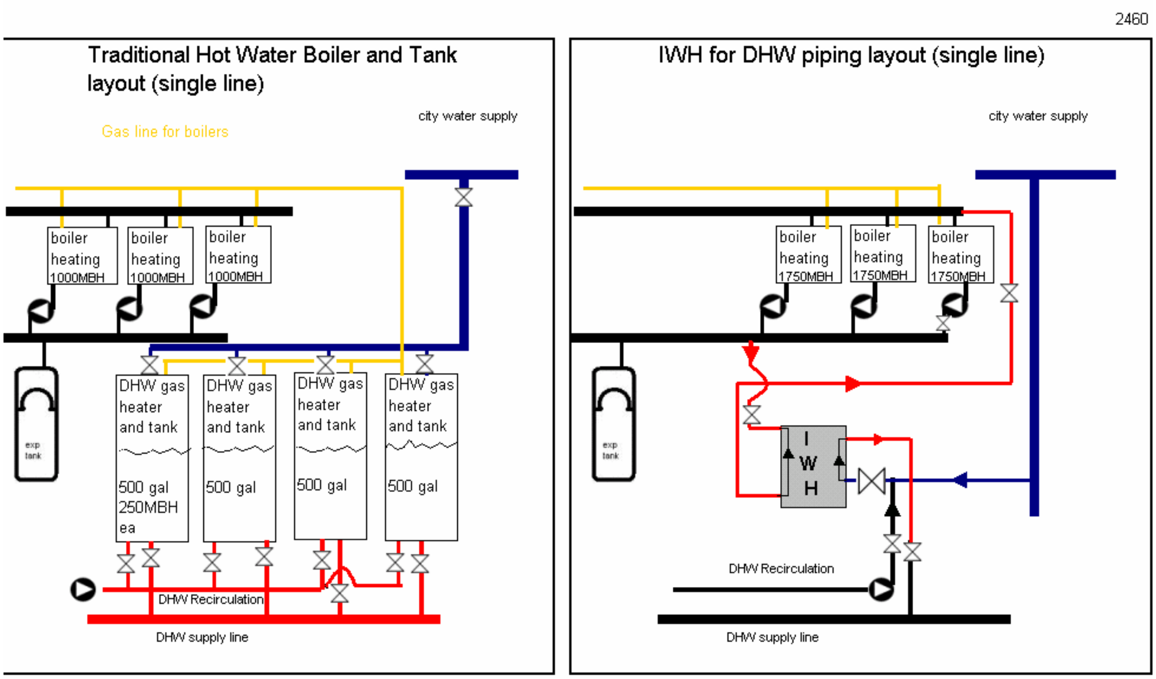
Case 1 **Apartment, 300 Unit, located NE US / Central Ontario**

	Storage Tank Approach			**IWH Approach**				
Equipment	**Base Case**	**base sqft**	**MBH(out)**	**IWH system**	**IWH sqft**	**MBH(out)**	**Price ($USD)**	
Heating boilers (2400MBH)	3	56.0	5940	0	0.0	0	$5,940.00	
Heating boilers (3200MBH)		0.0		3	71.8	7920	$7,840.00	
83%	**eff**							
Hot water boiler (2000MBH)	1	8.1	1039.5		0.0		$3,920.00	
DHW storage tanks (2100 gal)	2	180.0			0.0		$8,100.00	
IWH (70 gpm)		0.0		1	9.0		$13,863.00	
							enhanced	
Storage tank circulator HP	*3*							
Circ motor efficiency	*0.68*							
Hours per day	*24*							
IWH PFx motor HP	*5*							
IWH PFx motor eff	*0.92*							
IWH PFX motor hrs per day	*14*							
Energy cost cent/kWhr	*0.09*							
totals		244.1	6979.5		80.8	7920		
				target MBH out instantaneous		*7880*		
DHW boiler,tanks,IWH	total equipment cost=		$ 37,940.00	total equipment cost=		$37,383.00		
space cost for equipment	space cost (sqft) =		$19,526.67	space cost (sqft) =		$6,460.00	$80.00	per sqft
			$0.00			$0.00		
	Annual tank heat loss $		$ 532.00	Annual elec. Pump Hx=		$ 1,850.92		
	Tank re-circ annual elec		$ 2,575.73				**IWH Savings**	
Installed equipment cost 70gpm			$ 57,466.67			$ 43,843.00	**$13,623.67**	equipment
Annual operating cost			$ 3,107.73			$ 1,850.92	**$1,256.81**	per yr
(Installed equipment cost 80gpm)			$ 57,466.67			$ 51,188.00	**$6,278.67**	
Boilers		57%	$ 21,740.00		63%	$ 23,520.00		
tanks		43%	$ 16,200.00		0%	$ -		
IWH		0%	$ -		37%	$ 13,863.00		
		100%	$ 37,940.00		100%	$ 37,383.00		

Case Study #2

The second case considered is a 140 Unit apartment building in a warmer climate than Case 1. The mechanical room heating circuit components are sized as below. In the storage tank approach, 4 up-right tanks with integral gas fired burners are used.

Case 2 Apartment, 140 units, Southern US



A one-line schematic layout comparison between the traditional

DHW boiler and storage tank configuration to the new IWH system configuration.

Eliminate 4 hot water gas fired heater-tanks, eliminate 12 valves
Increase heating boiler ratings from 3 x 1000MBH to 3 x 1500 MBH

Add in one IWH unit (40 gpm)
Benefits - no heat loss on storage tanks, sharing of boilers, increase redundancy, gas lines all run to one area, no legionelle amplifier due to removal of storage tanks, easier installation, no recovery mode.

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The space savings using the IWH approach are 96 sqft, and the installed costs (boilers and IWH, versus boilers and storage tank) are estimated at over $6000 less for the IWH. The unit prices are an estimate of the costs that would be realized by the end user, after all mark ups through distribution, contractors, etc.

This analysis does not allow for the additional labor savings that would be realized with the IWH option.

Case 2 **Apartment, 140 units, Southern US**

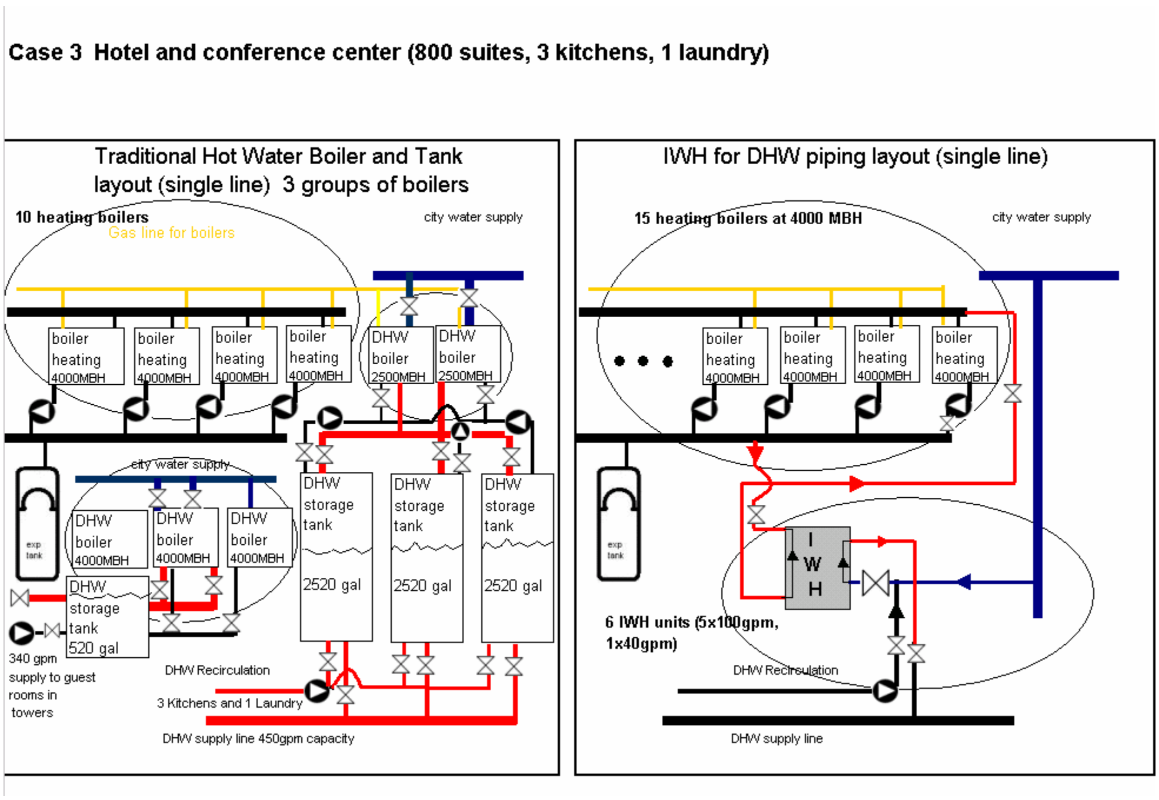
	Storage Tank Approach			**IWH Approach**				
Equipment	**Base Case**	**base sqft**	**MBH(out)**	**IWH system**	**IWH sqft**	**MBH(out)**	**Price ($USD)**	
Heating boilers (1000MBH)	3	20.2	2467.5	0	0.0	0	$2,930.00	
Heating boilers (1750MBH)		0.0		3	23.1	3701.25	$3,980.00	
82%	**eff**							
Hot water boiler (253MBH)	4	108.0	832.37		0.0		$2,402.00	
with tank (500 gal)	0	0.0			0.0		$0.00	
IWH (40 gpm)		0.0		1	9.0		$7,948.00	
Storage tank circulator HP	*3*							
Circ motor efficiency	*0.68*							
Hours per day	*24*							
IWH PFx motor HP	*3*							
IWH PFx motor eff	*0.92*							
IWH PFX motor hrs per day	*14*							
Energy cost cent/kWhr	*0.09*							
		128.2	3299.87		32.1	3701.25		
				target MBH out instantaneous		*4383.63*		
DHW boiler,tanks,IWH	total equipment cost=		$ 18,398.00	total equipment cost=		$19,888.00		
space	space cost (sqft) =		$10,253.33	space cost (sqft) =		$2,565.00	$80.00	per sqft
	Annual tank heat loss $		$ 532.00	Annual elec. Pump Hx=		$ 1,110.55		
	Tank re-circ annual elec		$ 2,575.73				IWH Savings	
Installed equipment cost			$ 28,651.33			$ 22,453.00	$6,198.33	22%
Annual operating cost			$ 3,107.73			$ 1,110.55	$1,997.18	
Boilers		100%	$ 18,398.00		60%	$ 11,940.00		
tanks		0%	$ -		0%	$ -		
IWH		0%	$ -		40%	$ 7,948.00		
		100%	$ 18,398.00		100%	$ 19,888.00		

Case Study #3

The third case considered is a large hotel and conference center as described below. A typical base case storage tank approach is represented in the schematic layout below, where the kitchens and laundry are on a separate domestic hot water circuit from the guest rooms.

With the IWH option, the guest room and kitchen/laundry circuits are combined as the instantaneous capacity of the IWH configuration is equal or greater to the anticipated maximum demand of all users. If the design requires a higher hot water temperature for the kitchen's and laundry, the output of 3 of the IWH units can be dedicated to those applications, with a higher temperature setpoint.

The 6 IWH units would be run in parallel with the Armstrong Master/Slave logic available on our Enhanced Controller. This logic sequences the operation of the IWH units for more refined temperature control during low demand periods.



Below is the cost an space analysis comparing the IWH option to the base case storage tank approach. The net equipment costs and space costs are actually higher for the IWH option. The reason for this higher cost has to do with the large variability in flow from the kitchen / laundry relative to the space heating load. For these large hot water heat demands the storage tank approach is typically less expensive than IWH. One major advantage to hotels, hospitals, and kitchens that IWH provides is the health and safety advantage of not increasing the risk of Legionelle.

The energy savings resulting from the IWH approach provide a 3 year payback period on the initial cost differential.

Case 3 **Hotel and conference center (800 suites, 3 kitchens, 1 laundry)**

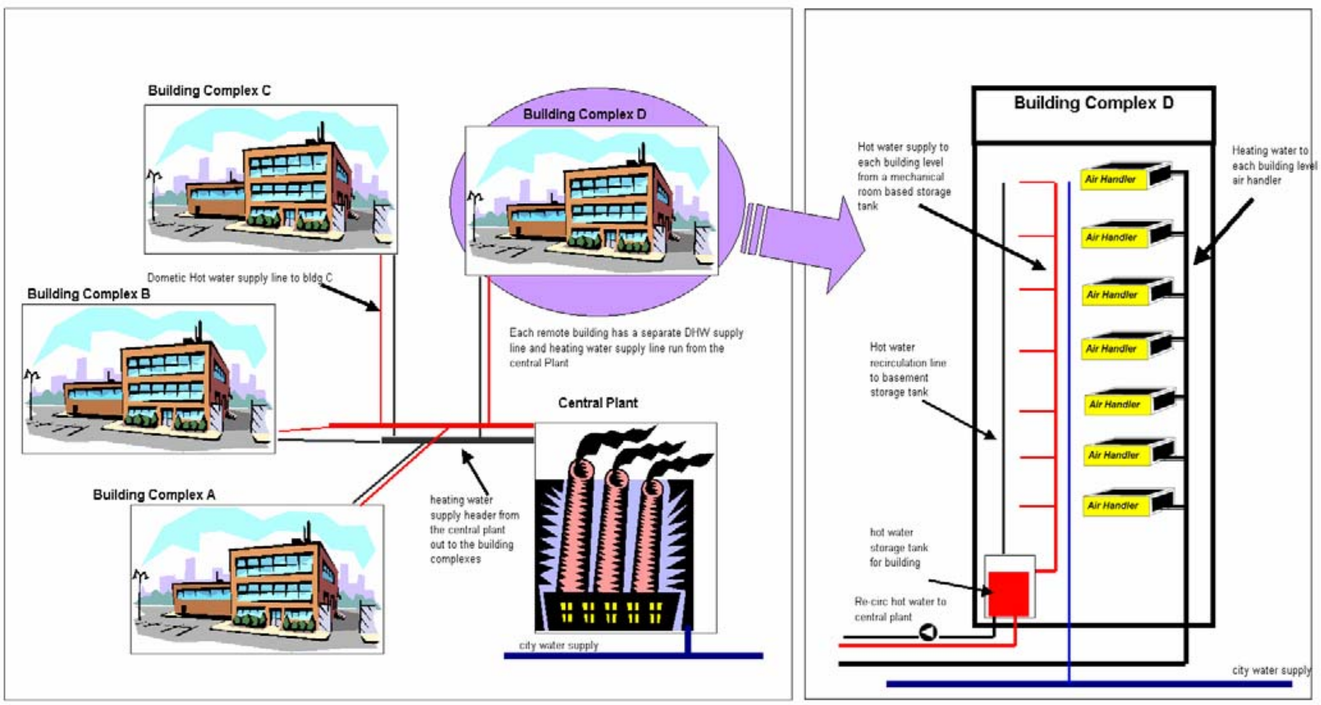
83%	**Storage Tank Approach**			**IWH Approach**				
Equipment	**Base Case**	**base sqft**	**MBH(out)**	**IWH system**	**IWH sqft**	**MBH(out)**	**Price ($USD)**	
Heating boilers (4000MBH)	10	291.7	33000	15	437.5	49500	$ 8,050.00	
DHW boilers (2500 MBH)	2	39.7	4125	0	0.0	0	$6,286.00	
DHW boilers (4000 MBH)	3	87.5	9900	0	0.0	0	$8,460.00	
DHW storage tanks (518 gal)	1	29.2			0.0		$3,255.00	
DHW storage tanks (2520 gal)	3	297.0					$8,900.00	
IWH (40 gpm) (58gpm@72F)				1	9.0		$7,948.00	
IWH 100 gpm (147gpm@72F)				5	45.0		$17,672.00	
Storage tank circulator HP	*3*							
Circ motor efficiency	*0.68*							
Hours per day	*24*							
IWH PFx motor HP	*5*							
IWH PFx motor eff	*0.92*							
IWH PFX motor hrs per day	*6*	time weighted avg.						
Energy cost cent/kWhr	*0.09*							
		745.0	47025		491.5	49500		
				target MBH out instantaneous		*59700*		
DHW boiler,tanks,IWH	total equipment cost=		$ 148,407.00	total equipment cost=		$217,058.00		
space	space cost (sqft) =		$81,953.21	space cost (sqft) =		$54,065.00	$110.00	per sqft
	Annual tank heat loss $		$ 5,852.00	Annual elec. Pump Hx=		$ 2,379.75		
	Tank re-circ annual elec		$ 10,302.91				IWH Savings	
Installed equipment cost			$ 230,360.21			$ 271,123.00	-$40,762.79	
Annual operating cost			$ 16,154.91			$ 2,379.75	$13,775.16	
						Payback	3.0	years
Boilers		80%	$ 118,452.00		56%	$ 120,750.00		
tanks		20%	$ 29,955.00		0%	$ -		
IWH		0%	$ -		44%	$ 96,308.00		
		100%	$ 148,407.00		100%	$ 217,058.00		

Case Study #4

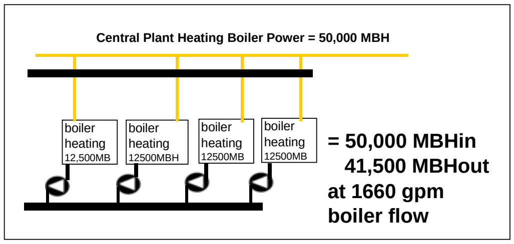
The fourth case considered involves a central heating plant that services four district office complexes. Each office traditionally would have its own hot water storage tank fed hot water from the main plant, or heated with an immersion heater. The considered here is the scenario with insulated domestic hot water piping runs between the central plant and the office complexes (in close proximity, approximately 1000 ft).

Case 4 New Construction - Muti complex center with a Central Plant

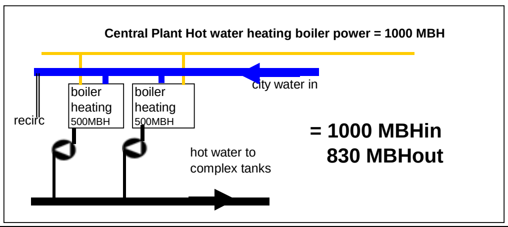
Traditional Central Plant Configuration with Hot Water and Heating water distribution network to remote complexes



Case 4 - Multi Office complex with central heating and Hot water Plant



Heating Boiler and distribution circuit		
Plant supply(input)	50000	MBH (gas energy)
Flow Max	1660	gpm
boiler supply T	245	F
boiler return T	195	F
Boiler output	41500	MBH
Heat loss piping	8300	MBH
Complex Wtr T	240	F
Complex Wtr T	200	F
sqft per complex	126000	sqft per complex
delivered heat	33200	MBH to all complexes
heat per complex	8300	MBH available
Heat requirememt	8316	MBH per complex



Hot water Boilers and distribution circuit			
Plant supply	1000.0	MBH	
Flow Max	20.0	per complex	
Number of staff	1050.0	per complex, fixture units =	157.5
Hot Wtr enegy	250.0	MBH per complex	
Domestic Wtr T	60.0	F	
DHW T supply	130.0	F	
Pipe temp drop	5.0	F	
Tank size	1040.0	gal	
heat loss	379.6	BTU/hr	
Heat required	756.3	MBH for 4 complexes	
Heat supplied	830.0	MBH	
Heat required/bldg	189.1	MBH per complex	
IWH BS flow	200	gpm from heating supply	

Material costs between central plant and remote complexes	description	units (ft)	price/unit**	cost	Est cost installed	Totals
Traditional Hot water tanks (heat flow 1660 gpm = 8" pipe, hot water piping = 2" pipe)						$ 111,155.20
Heating water distribution piping (underground	Insulated 8" dia piping	1600	8.41	13456	$ 21,529.60	
Hot water distribution piping (underground)	Insulated 2" copper piping	1600	16	25600	$ 40,960.00	
Heating water return pipes	Insulated 8" dia piping	1600	8.41	13456	$ 21,529.60	
Hot water Recirc pipes	Insulated 2" dia piping	1600	10.6	16960	$ 27,136.00	
IWH Hot water circuits (total heat flow from boiler for heating and water = 1660 gpm)						$ 43,059.20
Heating water distribution piping (underground	Insulated 8" dia piping	1600	8.41	13456	$ 21,529.60	
Heating water return pipes	Insulated 8" dia piping	1600	8.41	13456	$ 21,529.60	
				Savings with IWH on UG piping		**$ 68,096.00**

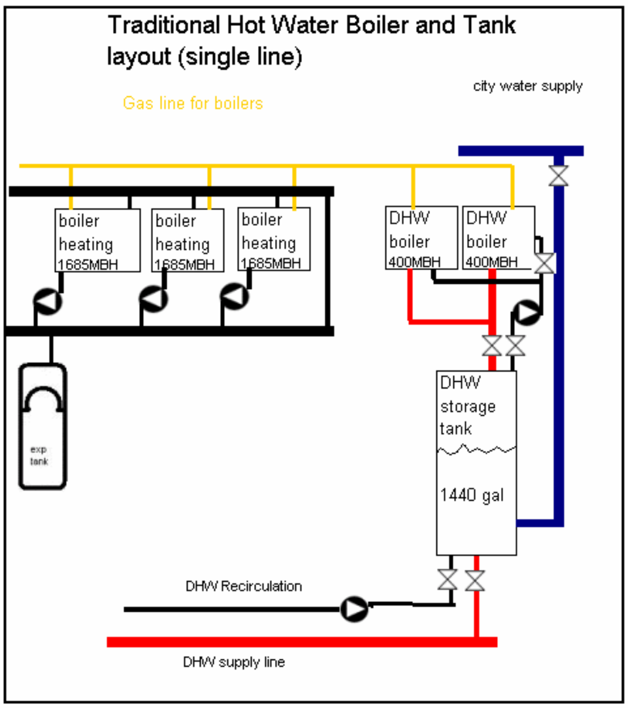
Combined Boiler Sizing Factor

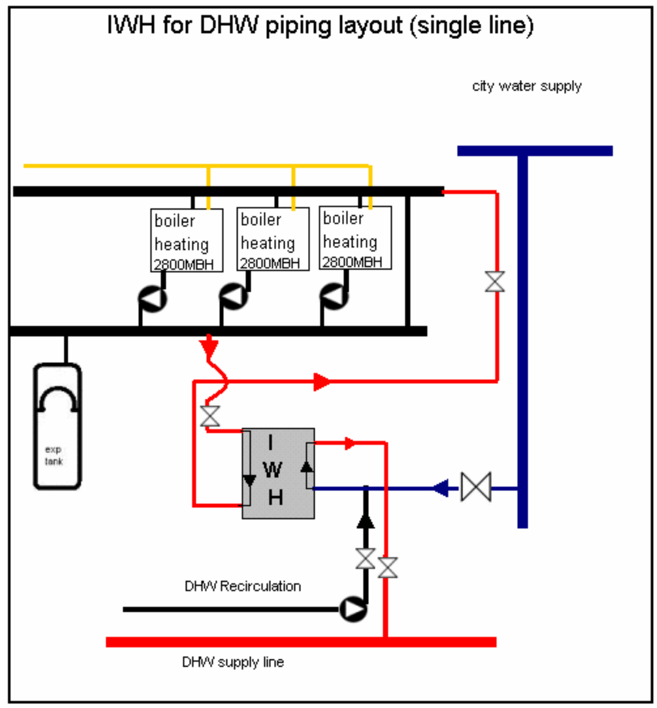
HWtr load to space heat load ratio	3%	ratio is below 25%, therefor no water heating req'd
ASHRAE hot water load on combined boilr	0	MBH (1)
Building heat system boiler load	41500	MBH (2)
Total boiler demand for combo boilers	41500	MBH (1+2)
boiler at 83% eff	50000	MBH
12500 MBH units	*4*	

	Central Plant with DHW Boilers			**Central Plant with IWH at Buildings**			IWH Job multi
83%	50,000MBH + 1000 MBH			50,000 MBH			IWH Rep multi
Equipment	**Base Case**	**base sqft**	**MBH(out)**	**IWH system**	**IWH sqft**	**MBH(out)**	**Price ($USD)**
Heating boilers (12500MBH)	4	361.1	41500	4	361.1	41500	$ 25,156.25
Heating boilers (15000MBH)	0	0.0	0	0	0.0	0	$27,135.00
DHW boilers (500 MBH)	2	6.3	830	0	0.0	0	$2,200.00
	0		0			0	
	0	0.0	0		0.0	0	
DHW storagetanks (1040 gal)	4	233.6			0.0		$6,850.00
CW inlet temp = 60 F							
IWH (40 gpm) (50gpm@60F)				4	36.0		$7,948.00
Underground piping				0			
Insulated 8" dia piping	1600						$8.41
Insulated 2" copper piping	1600			0			$16.00
Insulated 8" dia piping	1600						$8.41
Insulated 2" dia piping	1600						$10.60
Insulated 8" dia piping				1600			$8.41
Insulated 8" dia piping				1600			$8.41
		600.9	42330		397.1	41500	
				target MBH out instantaneous		*41500*	
DHW boiler,tanks,IWH	total equipment cost=		$ 132,425.00	total equipment cost=		$132,417.00	
space	space cost (sqft) =		$48,074.22	space cost (sqft) =		$31,768.89	$80.00 per sqft
intall piping and labour	piping cost =		$111,155.20	piping cost =		$43,059.20	
	Annual tank heat loss $		$ 4,256.00	Annual elec. Pump Hx=		$ 9,518.99	(10 hours operation)
	Tank re-circ annual elec		$ 10,302.91				**IWH Savings**
Installed equipment cost			$ 291,654.42			$ 207,245.09	**$84,409.33**
Annual operating cost			$ 14,558.91			$ 9,518.99	**$5,039.92**
Boilers		79%	$ 105,025.00		76%	$ 100,625.00	
tanks		21%	$ 27,400.00		0%	$ -	
IWH		0%	$ -		24%	$ 31,792.00	
		100%	$ 132,425.00		100%	$ 132,417.00	

The net savings of IWH over the storage tank approach is approximately $84,000. The total boiler and tank, versus IWH and boiler equipment costs are very close in total, however the savings in piping costs, and space costs make the $84,000 advantage for IWH.

Case 5 Hotel, 180 suites, 10 story, 20 suites per floor, main floor lobby and meeting rooms





A one-line schematic layout comparison between the traditional
*Multiple boilers used for sequencing and redundancy on heating

DHW boiler and storage tank configuration to the new IWH system configuration.

Eliminate 1 hot water storage tank (1440gal), increase 3 boilers to 2800MBH from 1685 MBH, eliminate 2 x 400MBH DHW boilers.

Add in one IWH unit (70 gpm)
Benefits - no heat losse on storage tanks, sharing of boilers, increase redundancy, gas lines all run to one area, no legionelle amplifier due to removal of storage tanks, easier installation, no recovery mode.

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Case 5 **Hotel, 180 suites, 10 story, 20 suites per floor, main floor lobby and meeting rooms**

heating req'd = 66 btu/sqft = 4950 MBH DHW req'd 70 gpm Max

DHW temp = 140 deg F city water temp = 55 deg F	**Storage Tank Approach**			**IWH Approach**			all prices are estimates of end customer price	
Equipment	**Base Case**	**base sqft**	**MBH(out)**	**IWH system**	**IWH sqft**	**MBH(out)**	**Price ($USD)**	**list**
boiler eff =	83%							
Heating boilers (1685MBH) 83x25"	3	43.2	4157.7375	0	0.0	0	$3,970.00	
Heating boilers (2800 MBH) 73"x42"				3	63.9	6909	$6,540.00	
Hot water boiler (400MBH) 55.5 x 25"	2	19.3	658		0.0		$2,400.00	
with tank (1440 gal) 48x192"	1	64.0	1440		0.0		$5,830.00	
82%	**eff**							
IWH (70 gpm)		0.0		1	9.0		$12,712.00	
Storage tank circulator HP	*3*							
Circ motor efficiency	*0.68*							
Hours per day	*24*							
IWH PFx motor HP	*3*							
IWH PFx motor eff	*0.92*							
IWH PFX motor hrs per day	*8*							
Energy cost cent/kWhr	*0.09*							
total installed cost ignoring savings on installation, piping, gas lines, cranes,footings etc		126.5	6255.7375		72.9	6909		
DHW boiler,tanks,IWH	total equipment cost=		$ 22,540.00	total equipment cost=		$32,332.00		
space	space cost (sqft) =		$10,120.00	space cost (sqft) =		$5,830.00	$80.00	per sqft
	Annual tank heat loss $		$ 1,330.00	Annual elec. Pump Hx=		$ 634.60		
	Tank re-circ annual elec		$ 2,575.73				IWH Savings	
Installed equipment cost			$ 32,660.00			$ 38,162.00	-$5,502.00	-17%
Annual operating cost			$ 3,905.73			$ 634.60	$3,271.13	
					payback period		**1.68 yrs**	
Boilers		74%	$ 16,710.00		61%	$ 19,620.00		
tanks		26%	$ 5,830.00		0%	$ -		
IWH		0%	$ -		39%	$ 12,712.00		
		100%	$ 22,540.00		100%	$ 32,332.00		

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ASHRAE Published Fixture Unit Data

Hot Water Demand in Fixture Units (Instantaneous)

Unit	Apartments	Hospitals	Hotels / Dorms	Office Bldg.	Schools
Lavatories	0.75	1	1	1	1
Bathtubs	1.5	1.5	1.5	-	-
Dishwashers	1.5	5 per 250 seats	5 per 250 seats	-	-
Therapeutic bath	-	5	-	-	-
Kitchen sink	0.75	3	1.5	1.5	3
Slop sink	1.5	2.5	2.5	2.5	2.5
Showers	1.5	1.5	1.5	-	1.5

Hot Water Demand in Gallons / hr (Storage)

Unit	Apartments	Hospitals	Hotels / Dorms	Office Bldg.	Schools
Lavatories	2	6	8	6	15
Bathtubs	20	20	20	-	-
Dishwashers	15	50	50	-	20
Therapeutic bath	-	400	-	-	-
Kitchen sink	10	20	30	20	20
Slop sink	20	20	30	20	20
Showers	30	75	75	30	225
Demand Factor	0.3	0.25	0.25	0.3	0.4
Storage Capacity	1.25	0.6	0.8	2	1

Preliminary Hot Water Demand Estimate (Instantaneous)

Type of Building	Unit	Fixture Units per unit
Hospital or nursing home	Bed	2.5
Hotel or motel	Room	2.5
Office building	Person	0.15
Elementary school	Student	0.3*
Jr. and sr. high school	Student	0.3*
Apartment house	Apartment	3

Hot Water Utilization Temperatures

Use	Temp. (F)
Hand washing	105
Shaving	115
Showers & tubs	110
Therapeutic baths	110
Dishwashing	140
Comm. laundry	180
Resident. laundry	140
Surgical scrubbing	110

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