QM
Biomass DH Plants

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Volume 5

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Quality Management for Biomass District Heating Plants

Standard hydraulic schemes

Part II (short version)

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1. Introduction

This document contains a translation of the introduction to the German original version of “Standard Hydraulic Schemes - Part II” (see chapter 1.1. to 1.3.) and short versions (fact sheets) of the standard hydraulic schemes – Part II for WE11 to WE16 (see chapter 2).

1.1. General

The present "Standard Hydraulic Schemes - Part II" (Volume 5 of the series of publications “QM Holzheizwerke” - Publication series QM for Biomass DH Plants) are to be regarded as a supplement and extension to the "Standard hydraulic schemes - Part I" (Volume 2 of the Publication series QM for Biomass DH Plants).

In addition to the circuits WE1 to WE6 of the "Standard Hydraulic Schemes - Part I", six further practice-proven solutions WE11 to WE16 are presented here. In particular, in addition to the parallel circuits of multi-boiler systems, series circuits are also defined as standard hydraulic schemes. Furthermore, those control strategies are taken into account that do not use an external setpoint signal for the control of the firing rate, but instead use the boiler outlet temperature as the control variable.

The introduction contained in "Standard Hydraulic Schemes - Part I" as well as the contents presented in chapters 8 and 9 (low-pressure difference and pressure differential heat consumers) are to be applied analogously when implementing the standard hydraulic schemes described in this volume.

Important: Safety devices (safety temperature limiters, safety pressure limiters, water level limiters, safety valves, thermal discharge safety devices, pressure expansion vessels, etc.) are not explicitly mentioned in the description of the standard hydraulic schemes in the text and are not shown in the hydraulic or control schemes. These devices must be designed and installed in accordance with the country-specific regulations and codes of practice or the boiler supplier's specifications.

The same applies to all other equipment required for proper operation of the installation (e.g. grate cooling, pressurisation systems, water treatment systems, solids separators, draining and venting devices, shut-off valves, on-site indicators and other measuring devices).

1.2. Overview Part II

To avoid confusion with Part I, the numbering in this Part II starts with the abbreviated designation WE11.

The following standard hydraulic schemes are included in this volume:
WE11 Monovalent biomass heating system without storage
WE12 Monovalent biomass heating system with storage
WE13 Bivalent multi-boiler system in parallel connection without storage tank
WE14 Bivalent multi-boiler system in parallel connection with storage tank
WE15 Bivalent multi-boiler system in series connection without storage tank
WE16 Bivalent multi-boiler system in series connection with storage tank

An overview of the symbols used, a glossary and the title page for the description of the selected standard hydraulic scheme can be found in the appendices.

1.3. Differences between Part I and Part II

1.3.1. Additional series circuits in Part II

Both Part I and Part II describe parallel circuits. Apart from the number and type of boilers, the following circuits are hydraulically identical (only the control concept is different):

- WE1 corresponds to WE11 "Monovalent biomass heating system without storage".
- WE2 corresponds to WE12 "Monovalent biomass heating system with storage".
- WE3 and WE5 correspond to WE13 "Bivalent multi-boiler system in parallel connection without storage tank".
- WE4 and WE6 correspond to WE14 "Bivalent multi-boiler system in parallel connection with storage tank".

Circuit	General advantages	General disadvantages
Parallel connection Important feature: The return flow of all heat production units has the same temperature.	■ Particularly suitable for heat production units that operate at the same temperature level. This is typically the case with biomass, oil and non-condensing gas boilers. ■ Depending on the required boiler return temperature protection and the boiler outlet temperature, the heat production units can be operated with correspondingly high spreads (difference between boiler inlet and outlet temperature) and thus lower volume flows (taking into account the minimum volume flow). This can result in lower pump energy costs. ■ Later extensions are much easier to realise than with the series connection. → All three points applicable to WE3 to WE6 in Part I and WE13 and WE14 in Part II.	■ Coarser dosage of the outputs of the individual heat production units than with series connection.
Series connection Important feature: The temperature in the ring circuit increases gradually according to the heat input of the respective heat production units via the individual subcircuits.	■ The gradual control of the main supply temperature allows a better dosed power output of the individual heat production units. This is the main advantage when used in biomass heating systems. ■ Particularly suitable for heat production units that operate at widely varying temperature levels. In biomass heating systems, it therefore makes sense to connect the Eco at the beginning of the loop (for low-load operation, the Eco should have a bypass control on the flue gas side). → Both points applicable for WE15 and WE16 in Part II ■ Furthermore, there would be advantages in biomass heating systems in combination with gas condensing boilers if the gas condensing boiler were located at the beginning of the ring circuit. → The last point is not taken into account in the present standard hydraulic schemes.	■ Due to the gradual increase of the flow temperature in the ring circuit, the return flow of the heat production units installed at the end of the ring circuit has relatively high temperatures, which means that higher volume flows and thus higher pump energy costs may be required for the power output of these heat production units. ■ Later extensions are more difficult to realise than with the parallel connection.

Table 1: General advantages and disadvantages of parallel and series connection

In addition to the parallel circuits, this Part II also contains two series circuits:

- WE15 "Bivalent multi-boiler system in series connection without storage tank".
- WE16 "Bivalent multi-boiler system connected in series with storage tank".

The general advantages and disadvantages of the parallel and series circuits are described in Table 1

1.3.2. Different control concept in Part II

Part I - Multi-boiler system without storage tank: The main control variable is the main supply temperature. This can be recorded at two measuring points: before the bypass or after the bypass. As long as the bypass is flowed through from top to bottom, both measuring points provide the same measured value. However, as soon as the flow on the boiler side becomes smaller than that on the consumer side, the bypass is flowed through from bottom to top. In principle, this corresponds to the operation of a storage tank with zero water content. Different variants are described in Part I; the main variant is as follows:

- The main control variable, the main supply temperature, is measured upstream of the bypass because the system was designed so that the bypass always flows from top to bottom during normal operation.
- The control variable is a sequence of the setpoints for the firing rates of the two boilers.
- No control of the boiler outlet temperatures (the control valves in the boiler circuits are only needed to maintain the return flow; boilers without a control valve can also be used to maintain the return flow).
- The boiler water temperatures of the two boilers are only limited upwards by the internal controllers

Part I - Multi-boiler system with storage tank: The main control variable is the storage tank state of charge and the control variables are the setpoints of the firing rates of the two boilers as a sequence. The controller tries to keep the storage tank state of charge constant (e.g. at 50%). If more output is suddenly demanded or too much output is produced, the storage tank can be discharged or charged and thus compensate for the disturbance until the control loop has reacted to the new conditions. The outlet temperature of both boilers is controlled to a constant value (e.g. 85°C) via the control valves. The boiler inlet temperatures are limited to a minimum value (boiler return temperature protection).

Part II - Multi-boiler system in parallel connection without storage tank: In contrast to Part I, the circuit operates without an external setpoint signal for the firing rate. Short functional description:

- The main control variable is the main supply temperature, measuring point after the bypass.
- The control values are the strokes of the control valves in the boiler circuits (with minimum limitation of the boiler inlet temperature to maintain the return flow).
- The boiler outlet temperatures of the boilers are controlled by the internal controllers; the setpoints are specified by the master I&C system

Part II - Multi-boiler system in parallel connection with storage tank: In contrast to Part I, the circuit operates without an external setpoint signal for the firing rate. Short functional description:

- The main control variable for the biomass boilers is the storage charging state
- The main control variable for the Oil/gas boiler is the main supply temperature after the storage tank.
- The control values are the strokes of the control valves in the boiler circuits (with minimum limitation of the boiler inlet temperature to maintain the return flow).
- The boiler outlet temperatures of the boilers are controlled by the internal controllers; the setpoints are specified by the master I&C system

The control strategy in Part I balances production and consumption by directly adjusting the firing rates, and the desired main supply temperature is obtained as the average of the boiler outlet temperatures (floating for systems without storage) or by controlling the boiler outlet temperatures via the boiler circuit valves (for systems with storage).

The control strategy in Part II balances production and consumption by adjusting the boiler circuit valves, and the desired main supply temperature is the average of the internally controlled boiler outlet temperatures.

The structure of the controllers and controlled systems for parallel circuits in Part I and Part II are very similar. Thus, the degree of difficulty of the control loops is also similar and similar control parameters result.

For the circuits in Part II, it must be noted that for the boiler circuit valves, the relationship between stroke and flow must be as linear as possible (depending on the valve characteristic and valve authority). If this is not guaranteed, the control can easily become unstable and/or the heat output of boilers controlled in parallel experiences impermissibly large deviations.

1.3.3. Further remarks on Part I and Part II

Standard hydraulic schemes for heat consumers: In Part I, standard hydraulic schemes for low-pressure difference connections (Chapter 8) and differential pressure affected connections (Chapter 9) are described. These also apply without restrictions to Part II. (Since no design information is required for heat consumers in either Part I or Part II, they have been omitted in Part II for reasons of space).

Low-pressure difference connection: In Part I, a low-pressure difference connection is defined in each principle scheme. This is not drawn in Part II. However, it is of course also possible to connect low-pressure-differential consumers in Part II (analogue to Part I).

Bypasses in the boiler circuits: In Part I, bypasses are defined in all boiler circuits. It is up to the main planner whether he wants to implement these or not. Of course, these bypasses can also be implemented in Part II (analogous to Part I). Criteria for the installation of bypasses are:

- The three-way valve can be dimensioned smaller
- The control range of the three-way valve can be fully utilized
- However, it must be ensured that the main return temperature never rises above the design value, otherwise the output of the boiler can no longer be delivered.

Temperature difference across biomass boilers: In Part I, the examples are designed for a temperature difference of 15 K; in Part II, the design is for 30 K. This does not mean, however, that the circuits in Part I would require a smaller temperature difference than those in Part II. The same criteria apply to both Part I and Part II:

- A smaller temperature difference counteracts unwanted temperature stratification in the boiler
- A smaller temperature difference allows a lower boiler outlet temperature (at a given minimum permissible boiler inlet temperature).
- A larger temperature difference results in a smaller boiler circuit pump and saves electrical power

→ Ultimately, the minimum permissible boiler flow and the minimum permissible boiler inlet temperature (both specified by the biomass boiler manufacturer) are always decisive for the design.

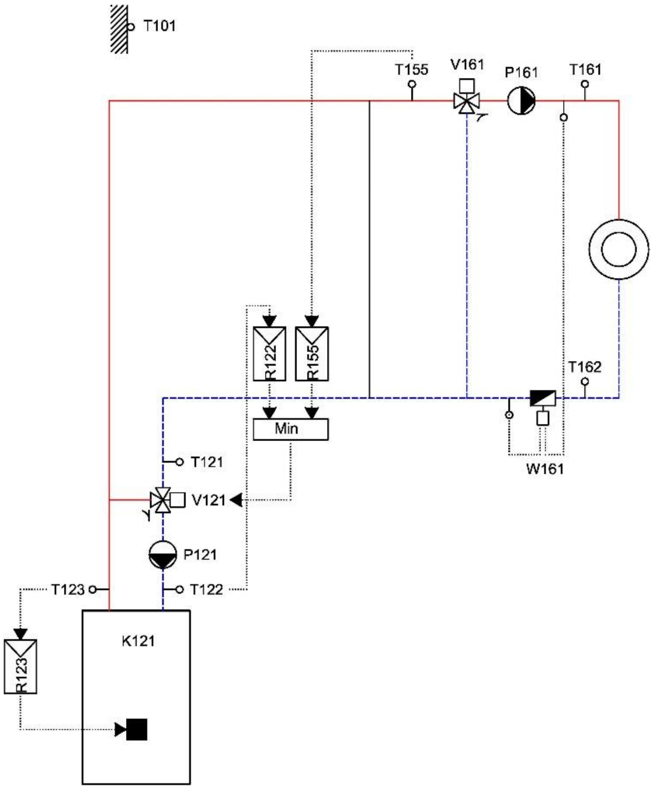
Speed-controlled boiler circuit pumps: Neither Part I nor Part II recommends or prohibits speed-controlled boiler circuit pumps. If such are used, the following must be observed:

- It must be possible to exclude a negative influence on other control loops.
- The flow through the boiler with the minimum volume flow specified by the boiler supplier, by maintaining a lower limit value of the pump speed specified by the master I&C system, must be guaranteed.
- The same applies mutatis mutandis if a speed-controlled pump is used with the Eco.

Sensor in "dead water": The sensor for the main supply temperature after the bypass can be in "dead water" (without flow, the sensor does not provide a valid value). If no minimum flow can be guaranteed here, an additional maximum priority must be provided on the return sensor after the bypass. In Part I, this maximum priority is implemented in Appendix 2, for example (see Part I, Figure 81, sensors T342 and T344).

2. Short versions of Standard hydraulic schemes – Part II

QM Biomass DH Plants	Short version of standard hydraulic scheme WE11: Monovalent biomass heating system without storage tank		WE11
	First release: 01/11/2010	Last edit: 01/11/2010	
	Basis: Standard hydraulic schemes - Part II [2], chapter 11		



What are the special features of the circuit?

- **Difference to WE1:** In WE11, the control variable of the main controller R155 is not the firing rate, but the stroke of the boiler circuit valve V121.
- 100% of the annual heat demand (heating, hot water and process heat demand) with biomass energy
- Load peaks must be covered by the biomass boiler (use the load characteristic drawn in the EXCEL table [3] with load peaks).
- Low-load operation (summer) by biomass boiler only possible if sufficiently large summer load
- Heat capacity reserve for expansion only possible in exceptional cases due to the low load problem
- Heat production can be expanded hydraulically and in terms of control technology as required (does not apply when implementing the minimum solution)

How should the system be designed?

Heat capacity demand	100...500 kW	501...1000 kW	> 1000 kW
Annual heat prod. with biomass	100%	→ WE13 (bivalent parallel connection) → WE15 (bivalent series connection)	
Biomass boiler output	100% with load peaks		
Number of full operating hours biomass boiler	> 1500 h/a		
Low-load operation	Summer operation possible if sufficient summer load according to FAQ 12 [4].		
Fuel	Max. P45; with autom. ignition W ≤ 45%		

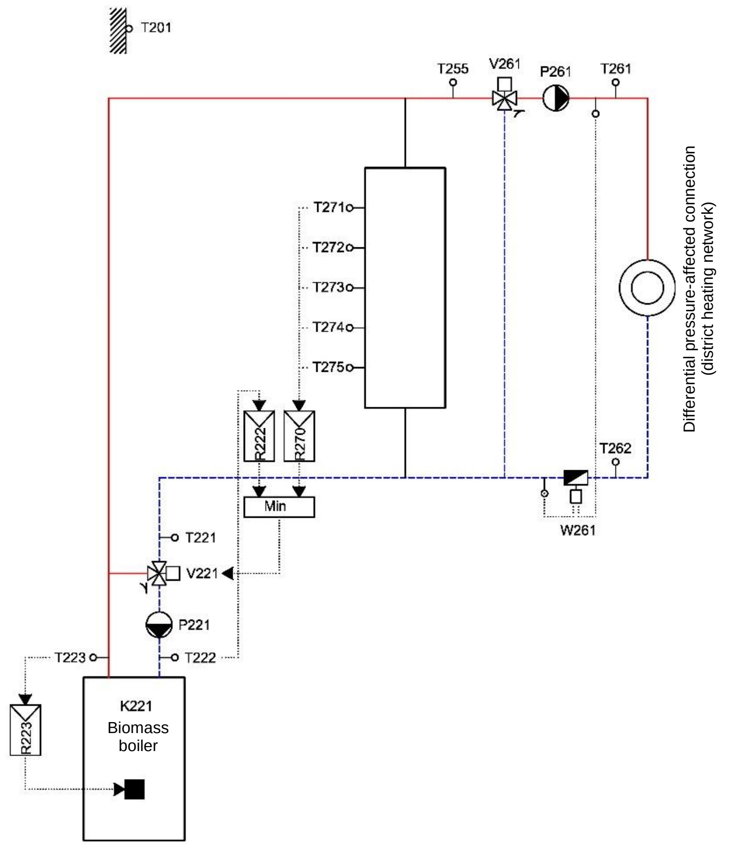
- Check the heat capacity demand for plausibility with the EXCEL table "Demand assessment" [3].
- Boiler pump dimensioning: Boiler outlet temperature - boiler inlet temperature ≤ 15 K
- Distance boiler inlet temperature - return high level ≥ 5 K
- Boiler circuit valve and pre-control: Valve authority ≥ 0,5

What other requirements must be observed?

- All heat consumer circuits with the lowest possible return temperature
- Make the circuit actually low in pressure difference by means of bypass; i.e. shortest possible bypass and pipe diameter bypass = pipe diameter of main flow
- Interconnection of biomass boiler, bypass and pre-control actually low-pressure differential (short pipes, large pipe diameters)
- Ensure proper mixing at the sensor for the main supply temperature T155 (install a static mixer if necessary).

	■ The safety of the biomass boiler is to be ensured by the internal I&C system of the biomass boiler; safety organs and expansion system are to be designed in accordance with the country-specific regulations	
How is the system controlled and regulated?	■ The internal boiler controller R123 controls the boiler outlet temperature T123 to a constant value; the setpoint must be higher than the setpoint of the main controller R155 ■ The biomass boiler has a boiler return temperature protection (R122); the controlled variable is the boiler inlet temperature and the manipulated variable is the stroke of the boiler circuit valve. ■ The main control variable is the temperature after the T155 bypass. ■ The main controller R155 has PI characteristics (tends to have a long integration time and a large P-band); the controlled variable is the temperature after the bypass T155 and the manipulated variable is the stroke of the boiler circuit valve. ■ A minimum priority switches switch the lower control signal to the boiler circuit valve (i.e. the boiler return temperature protection has higher priority than the main controller). **Permissible minimum solution (analogous to WE1):** In "Standard hydraulic schemes - Part II" [2], R155 is realised by the higher-level I&C system. This has the advantage that the circuit can be expanded at any time later and the automatic data recording is solved from the beginning. As a permissible minimum solution, however, instead of the temperature after the bypass T155, the boiler outlet temperature T123 can also be controlled solely via the internal PLC of the biomass boiler. The automatic data recording must then be realised via the PLC of the biomass boiler or via a data logger.	
Which standard measured variables must be recorded for operational optimisation?	■ Outdoor air temperature T101 ■ Biomass boiler inlet temperature, T122 ■ Biomass boiler outlet temperature, T123 ■ Main supply temperature after bypass, T155 ■ Main return temperature after bypass, T121 ■ Supply temperature of the differential pressure-affected connection (district heating network), T161 ■ Return temperature of the differential pressure-affected connection (district heating network), T162	■ Stroke boiler circuit control valve V121 ■ Heat meter of the differential pressure-affected connection (district heating network), W161 * ■ Exhaust gas temperature biomass boiler ■ Residual oxygen biomass boiler <u>The measuring points for the particle separator are to be recorded according to the design</u>
	* The heat meter must be equipped with an interface for recording the heat quantity [kWh] or water quantity [m³]; the graphical representation, however, must be in terms of power [kW] or volume flow [m³/h].	
Literature	[1] Hans Rudolf Gabathuler, Hans Mayer: Standard hydraulic schemes - Part I. Straubing: C.A.R.M.E.N. e.V., second, expanded edition 2010. (Publication series QM for Biomass DH Plants - Volume 2) [2] Alfred Hammerschmid, Anton Stallinger: Standard hydraulic schemes - Part II. Straubing: C.A.R.M.E.N. e.V., 2006. (Publication series QM for Biomass DH Plants - Volume 5) [3] Demand assessment with EXCEL tool. Free download of the EXCEL tool and the manual under www.qm-biomass-dh-plants.com [4] Frequently Asked Questions (FAQ's). Free download (German version only: www.qmholzheizwerke.ch)	

QM Biomass DH Plants	**Short version of standard hydraulic scheme WE12:** **Monovalent biomass heating system with storage tank**		**WE12**
	First release: 01/11/2010	Last edit: 01/11/2010	
	Basis: Standard hydraulic schemes - Part II [2], Chapter 12		



What are the special features of the circuit?	■ **Difference to WE2:** In WE12, the control variable of the main controller R270 is not the firing rate, but the stroke of the boiler circuit valve V221. ■ 100% of the annual heat demand (heating, hot water and process heat demand) with biomass energy ■ Load peaks covered by storage, i.e. the biomass boiler can be designed without taking load peaks into account (use the dashed load characteristic curve of the EXCEL table [3]). ■ Low-load operation (summer) by biomass boiler only possible if sufficiently large summer load ■ Heat capacity reserve for expansion only possible in exceptional cases due to the low load problem ■ Heat production can be extended hydraulically and in terms of control technology as required

How should the system be designed?

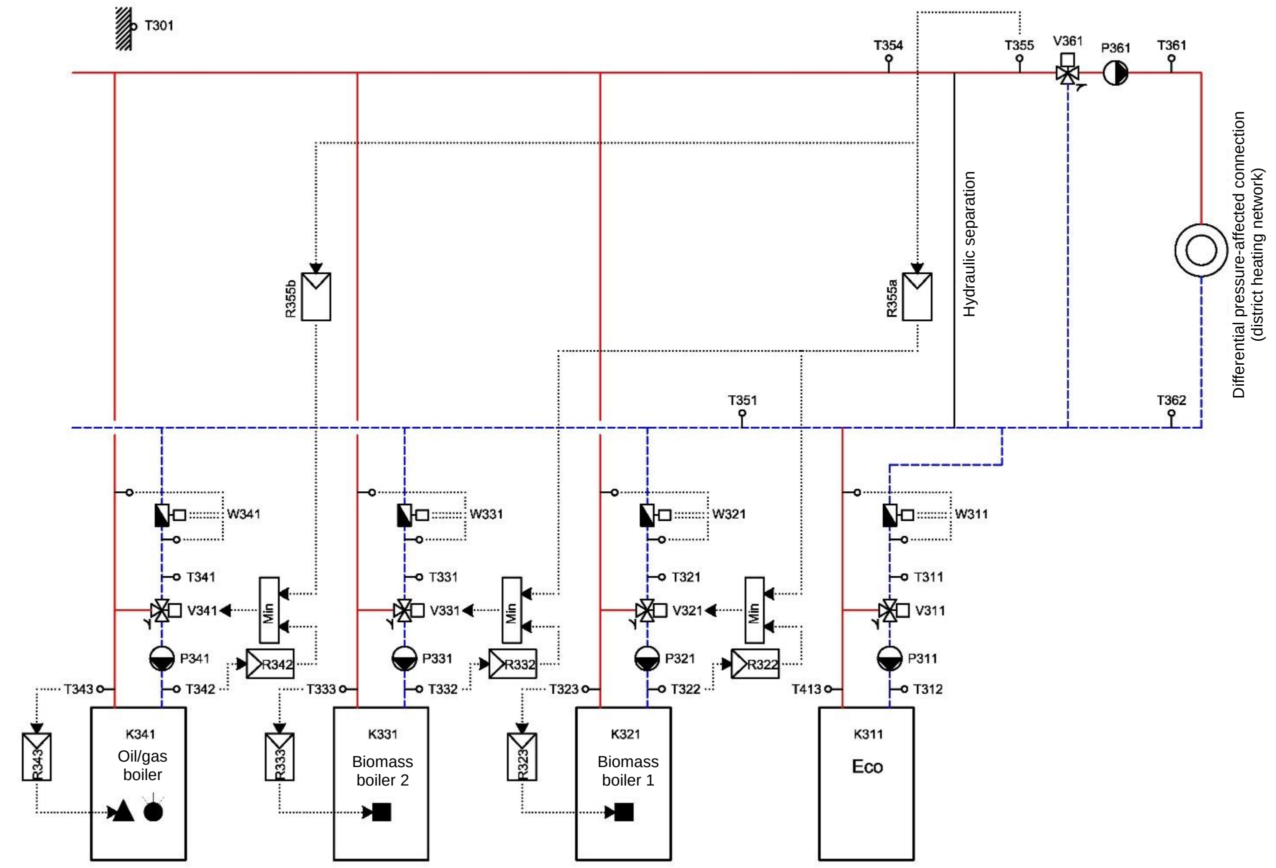
Heat capacity demand	**100...500 kW**	**501...1000 kW**	**> 1000 kW**
Annual heat prod. with biomass	100%	→ WE14 (bivalent parallel connection) → WE16 (bivalent series connection)	
Biomass boiler output	100% without load peaks		
Number of full operating hours biomass boiler	> 2000 h/a		
Low-load operation	Summer operation possible if sufficient summer load according to FAQ 12 [4].		
Fuel	Max. P45; with autom. ignition W ≤ 45%		

■ Check the heat capacity demand for plausibility with the EXCEL table "Demand assessment" [3].
■ Boiler pump dimensioning: Boiler outlet temperature - boiler inlet temperature ≤ 15 K
■ Distance boiler inlet temperature - return high level ≥ 5 K
■ Boiler circuit valve and pre-control: Valve authority ≥ 0,5
■ Storage volume ≥ 1 h storage capacity (based on nominal power)

What other requirements must be observed?	■ All heat consumer circuits with the lowest possible return temperature ■ Interconnection of biomass boiler, storage tank and pre-control actually low pressure differential (short pipes, large pipe diameters) ■ Consistently design storage as stratified storage

	■ Storage tank connections with cross-section enlargement (speed reduction), baffle plate (refraction of the water jet) and, if necessary, siphoned (prevention of one-pipe circulation). ■ Storage tank connections only at the top and bottom (no connections in between) ■ No pipes inside the storage tank (danger of a "thermal agitation") ■ No division between several tanks; if this requirement cannot be met: no connections between the tanks, consider each tank as a control unit (the warmer tank can be colder at the bottom than the colder tank at the top). ■ The safety of the biomass boiler is to be ensured by the internal I&C system of the biomass boiler; safety organs and expansion system are to be designed in accordance with the country-specific regulations
How is the system controlled and regulated?	■ The internal boiler controller R223 regulates the boiler outlet temperature to a constant value; the storage tank is charged with this temperature ■ The biomass-fired boiler has a boiler return temperature protection (R222); the controlled variable is the boiler inlet temperature and the manipulated variable is the stroke of the boiler circuit valve. ■ The main control variable is the storage tank charging status, which is recorded via sensors T271...T275 and calculated as a value of 0...100%. ■ The R270 main controller has PI characteristics (tends to have a long integration time and a large P-band); the control variable is the storage tank state of charge and the control variable is the stroke of the boiler circuit valve. ■ A minimum priority switches switch the lower control signal to the boiler circuit valve (i.e. the boiler return temperature protection has higher priority than the main controller). ■ The setpoint of the storage tank charging state is 60...80% (select step value!) ■ The upper storage tank area (at 60% setpoint of the storage tank charging state about 60% of the storage tank) serves as a buffer as long as the load is greater than the firing rate ■ The lower storage tank area (at 60% setpoint of the storage tank charging state about 40% of the storage tank) serves as a buffer as long as the load is smaller than the firing rate ■ The aim is to achieve a firing rate that is as continuously controlled as possible in accordance with the load.
Which standard measured variables must be recorded for operational optimisation?	■ Outdoor air temperature T201 ■ Biomass boiler inlet temperature, T222 ■ Biomass boiler outlet temperature, T223 ■ Main supply temperature after storage tank, T255 ■ Main return temperature after storage tank, T221 ■ Storage tank temperature (top), T271 ■ Storage tank temperature, T272 ■ Storage tank temperature (middle), T273 ■ Storage tank temperature, T274 ■ Storage tank temperature (bottom), T275 ■ Supply temperature of the differential pressure-affected connection (district heating network), T261 ■ Return temperature of the differential pressure-affected connection (district heating network), T262 ■ Stroke boiler circuit control valve V221 ■ Heat meter of the differential pressure-affected connection (district heating network), W261 * ■ Actual value of the storage tank charging state ■ Exhaust gas temperature biomass boiler ■ Residual oxygen biomass boiler <u>The measuring points for the particle separator are to be recorded according to the design</u> * The heat meter must be equipped with an interface for recording the heat quantity [kWh] or water quantity [m³]; the graphical representation, however, must be in terms of power [kW] or volume flow [m³/h].
Literature	[1] Hans Rudolf Gabathuler, Hans Mayer: Standard hydraulic schemes - Part I. Straubing: C.A.R.M.E.N. e.V., second, expanded edition 2010. (Publication series QM for Biomass DH Plants - Volume 2) [2] Alfred Hammerschmid, Anton Stallinger: Standard-Schaltungen - Teil II. Straubing: C.A.R.M.E.N. e.V., 2006. (Publication series QM for Biomass DH Plants - Volume 5) [3] Demand assessment with EXCEL tool. Free download of the EXCEL tool and the manual under www.qm-biomass-dh-plants.com [4] Frequently Asked Questions (FAQ's). Free download (German version only: www.qmholzheizwerke.ch)

QM Biomass DH Plants	**Short version of standard hydraulic scheme WE13: Multi-boiler biomass heating system in parallel connection without storage tank**		**WE13**
	First release: 01/11/2010	Last edit: 01/11/2010	
	Basis: Standard hydraulic schemes - Part II [2], Chapter 13		



What are the special features of the circuit?

- **Difference to WE3 or WE7:** In WE13, the control variables of the main controllers R355a and R355b are not the firing rates, but the stroke of the respective boiler circuit valve.
- 80...90% of the annual heat demand (heating, hot water and process heat demand) with biomass energy
- Peak loads must be covered by the boilers
- Low-load operation (summer) by the small biomass boiler usually possible, otherwise by the oil/gas boiler
- High security of supply due to oil/gas boiler
- Heat capacity reserve for expansion possible through oil/gas boiler (with corresponding reduction of the biomass coverage ratio)
- Heat production can be extended hydraulically and in terms of control technology as required

How should the system be designed?

Heat capacity demand	**100...500 kW**	**501...1000 kW**	**> 1000 kW**
Annual heat prod. with biomass	80...90%		
Biomass boiler output 1	60...70%*		20...23%
Biomass boiler output 2	–		40...47%
Oil/gas boiler capacity	Min. like biomass boiler, max. 100%.		Min. 100% - small biomass boiler, max. 100%
Number of full operating hours biomass boiler	> 2500 h/a, target 4000 h/a		
Low-load operation	If FAQ 12 [4] not fulfilled, by oil/gas boiler		Compliance with FAQ 12 [4] with the small biomass boiler or oil/gas boiler
Fuel	Max. P45; with autom. ignition W ≤ 45%	No restriction; with autom. ignition W ≤ 45%	

* Guiding value for systems with predominantly space heating

- Check the heat capacity demand for plausibility with the EXCEL table "Demand assessment" [3].
- Boiler pump sizing: Boiler outlet temperature - boiler inlet temperature ≤ 15 K
- Difference boiler inlet temperature - return high level ≥ 5 K

	■ Boiler circuit valves and pre-control: Valve authority ≥ 0,5
What other requirements must be observed?	■ All heat consumer circuits with the lowest possible return temperature ■ Make the circuit actually low in pressure difference by means of bypass; i.e. shortest possible bypass and pipe diameter bypass = pipe diameter of main flow ■ Interconnection of biomass boiler, oil/gas boiler, bypass and pre-control actually low pressure differential (short pipes, large pipe diameters) ■ Ensure proper mixing at the sensor for the main supply temperature T355 (install a static mixer if necessary). ■ The safety of the boilers is to be ensured by the internal I&C system of the boilers; safety devices and expansion system are to be designed in accordance with the country-specific regulations
How is the system controlled and regulated?	■ The internal boiler controllers R323, R333 and R343 control the three boiler outlet temperatures to the same value; the setpoint must be higher than the setpoint of the main controller R355a ■ All boilers have a boiler return temperature protection (R322, R332 and R342); the controlled variable is the boiler inlet temperature and the manipulated variable is the stroke of the boiler circuit valve. ■ The sequence control first works manually: "Boiler 1 alone" - manual switchover to "Boiler 2 alone" - manual switchover to "automatic sequence control". ■ The automatic sequence control then works as follows: "Parallel operation boiler 1 and 2" (both boilers receive the same setpoint for the firing rate) - "Parallel operation boiler 1 and 2 + oil/gas boiler". ■ The main control variable is the main supply temperature after the bypass T355 ■ The main controllers R355a and R355b have PI characteristics (tend to have a long integration time and a large P-band); they use the main supply temperature after the bypass T355 as the controlled variable and the strokes of the boiler circuit valves as the control variables. ■ In the automatic sequence control, the main controller of the oil/gas boiler R355b is enabled or disabled by means of suitable enable and disable criteria; in addition, the setpoint for R355b is set about 3 K lower than the setpoint of R355a ■ A minimum priority switch switches the lower control signal to the boiler circuit valve in each case (i.e. the boiler return temperature protection has higher priority than the main controller).
Which standard measured variables must be recorded for operational optimisation?	■ Outdoor air temperature T301 ■ Inlet temperature Biomass boiler 1, T322 ■ Outlet temperature Biomass boiler 1, T323 ■ Inlet temperature Biomass boiler 2, T332 ■ Outlet temperature Biomass boiler 2, T333 ■ Inlet temperature Oil/gas boiler, T342 ■ Outlet temperature Oil/gas boiler, T343 ■ Main supply temperature before bypass, T354 ■ Main supply temperature after bypass, T355 ■ Main return temperature according to Eco, T351 ■ Supply temperature of the differential pressure-affected connection (district heating network), T361 ■ Return temperature of the differential pressure-affected connection (district heating network), T362 ■ Stroke boiler circuit valve Biomass boiler 1 V321 ■ Stroke boiler circuit valve Biomass boiler 2 V331 ■ Stroke boiler circuit valve Oil/gas boiler V341 ■ Eco heat meter, W311 * ■ Heat meter Biomass boiler 1, W321 * ■ Heat meter Biomass boiler 2, W331 * ■ Heat meter Oil/gas boiler, W341 * ■ Oil/gas meter, if modulating oil/gas boiler ** ■ Operating hours stage 1/2, if two-stage oil/gas boiler ■ Flue gas temperature Biomass boiler 1 ■ Residual oxygen Biomass boiler 1 ■ Flue gas temperature Biomass boiler 2 ■ Residual oxygen Biomass boiler 2 ■ Exhaust gas temperature Oil/gas boiler <u>The measuring points for the particle separator(s) shall be recorded according to the type of construction</u>
	* The heat meter must be equipped with an interface for recording the heat quantity [kWh] or water quantity [m³]; the graphical representation, however, must be in terms of power [kW] or volume flow [m³/h]. ** The oil/gas meter must be equipped with an interface for recording the oil or gas quantity [dm³ or m³]; the graphical representation, however, must be in the form of a volume flow [dm³/h or m³/h].
Literature	[1] Hans Rudolf Gabathuler, Hans Mayer: Standard hydraulic schemes - Part I. Straubing: C.A.R.M.E.N. e.V., second, expanded edition 2010. (Publication series QM for Biomass DH Plants - Volume 2) [2] Alfred Hammerschmid, Anton Stallinger: Standard-Schaltungen - Teil II. Straubing: C.A.R.M.E.N. e.V., 2006. (Publication series QM for Biomass DH Plants - Volume 5) [3] Demand assessment with EXCEL tool. Free download of the EXCEL tool and the manual under www.qm-biomass-dh-plants.com [4] Frequently Asked Questions (FAQ's). Free download (German version only: www.qmholzheizwerke.ch)

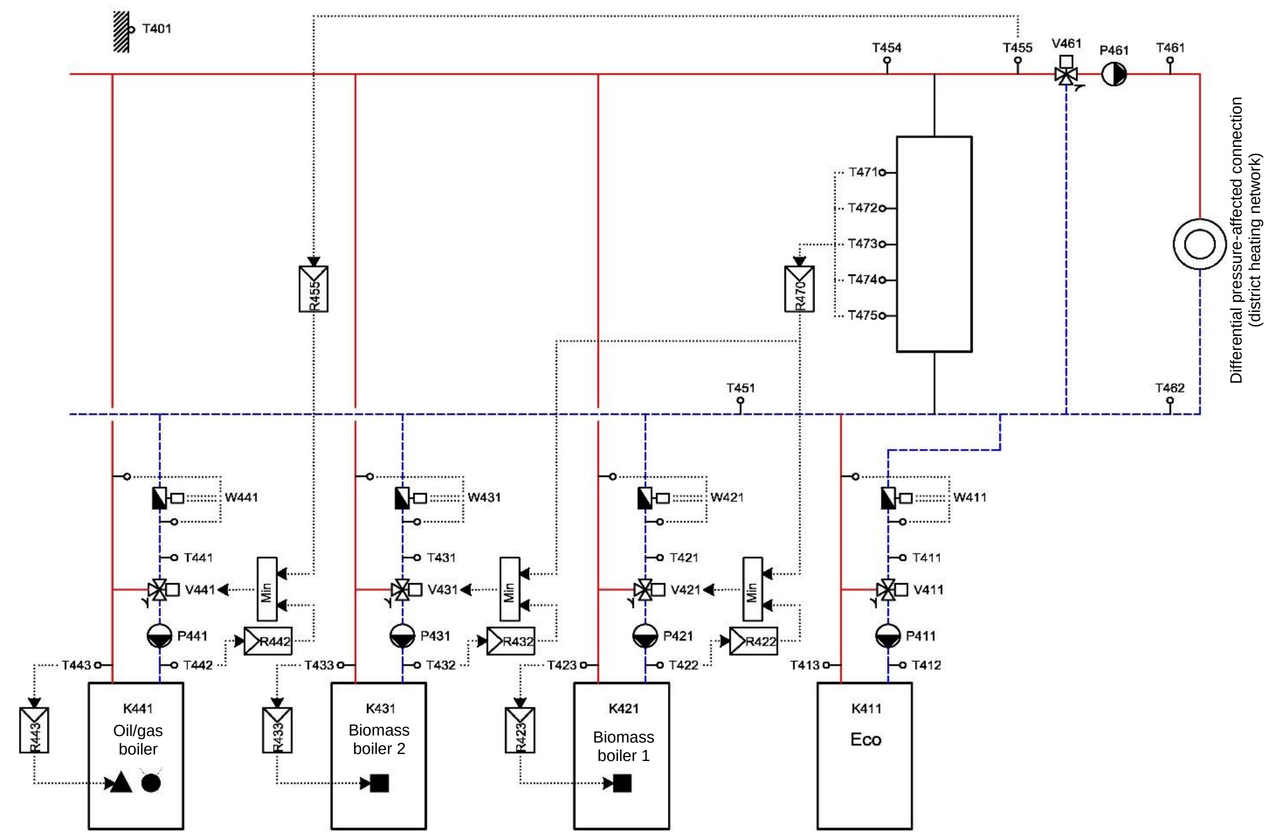
QM Biomass DH Plants

Short version of standard hydraulic scheme WE14: Multi-boiler biomass heating system in parallel connection with storage tank

WE14

First release: 01/11/2010 | Last edit: 01/11/2010

Basis: Standard hydraulic schemes - Part II [2], Chapter 14



What are the special features of the circuit?

- **Difference to WE4 or WE8:** In WE14, the control variables of the main controllers R355a and R355b are not the firing rates, but the stroke of the respective boiler circuit valve.
- 80...90% of the annual heat demand (heating, hot water and process heat demand) with biomass energy
- Peak loads are covered by storage tanks, i.e. the boilers can be designed smaller.
- Low-load operation (summer) by the small biomass boiler usually possible, otherwise by the oil/gas boiler
- High security of supply due to oil/gas boiler
- Heat capacity reserve for expansion possible through oil/gas boiler (with corresponding reduction of the biomass coverage ratio)
- Heat production can be extended hydraulically and in terms of control technology as required

How should the system be designed?

Heat capacity demand	100...500 kW	501...1000 kW	> 1000 kW
Annual heat prod. with biomass	80...90%		
Biomass boiler output 1	50...60%*		17...20%*/**
Biomass boiler output 2	–		33...40%*/**
Oil/gas boiler capacity	Min. as for biomass boiler, max. at 100%.		Min. 100% - small biomass boiler, max. 100%
Number of full operating hours biomass boiler	> 3500 h/a, target 4000 h/a		> 3000 h/a, target 4000 h/a
Low-load operation	If FAQ 12 [4] not fulfilled, by oil/gas boiler		Compliance with FAQ 12 [4] with the small biomass boiler or oil/gas boiler
Fuel	Max. P45; with autom. ignition W ≤ 45%	No restriction; with autom. ignition W ≤ 45%	

* Guiding value for systems with predominantly space heating

** Only 1 biomass boiler may possibly make sense for systems without summer operation

- Check the Heat capacity demand for plausibility with the EXCEL table "Demand assessment" [3].
- Boiler pump sizing: Boiler outlet temperature - boiler inlet temperature ≤ 15 K
- Difference boiler inlet temperature - return high level 5 ≥ K

	■ Boiler circuit valves and pre-control: Valve authority ≥ 0,5 ■ Storage volume ≥1 h Storage capacity (related to the nominal output of the larger biomass boiler)
What other requirements must be observed?	■ All heat consumer circuits with the lowest possible return temperature ■ Interconnection of biomass boiler, oil/gas boiler, storage tank and pre-control actually low pressure differential (short pipes, large pipe diameters) ■ Consistently design storage as stratified storage ■ Storage tank connections with cross-section enlargement (speed reduction), baffle plate (refraction of the water jet) and, if necessary, siphoned (prevention of one-pipe circulation). ■ Storage tank connections only at the top and bottom (no connections in between) ■ No pipes inside the storage tank (danger of a "thermal agitation") ■ No division between several tanks; if this requirement cannot be met: no connections between the tanks, consider each tank as a control unit (the warmer tank can be colder at the bottom than the colder tank at the top). ■ The safety of the boilers is to be ensured by the internal I&C system of the boilers; safety devices and expansion system are to be designed in accordance with the country-specific regulations
How is the system controlled and regulated?	■ The internal boiler controllers R423, R433 and R443 regulate the three boiler outlet temperatures to the same value; the storage tank is charged with this temperature ■ All boilers have a return high level (R422, R432 and R442); the controlled variable is the boiler inlet temperature and the manipulated variable is the stroke of the boiler circuit valve. ■ The sequence control first works manually: "Boiler 1 alone" - manual switchover to "Boiler 2 alone" - manual switchover to "automatic sequence control". ■ The automatic sequence control then works as follows: "Parallel operation boiler 1 and 2" (both boilers receive the same setpoint for the firing rate) - "Parallel operation boiler 1 and 2 + oil/gas boiler". ■ The main control variable of the main controller R470 is the storage tank state of charge, which is recorded via sensors T471...T475 and calculated as a value of 0...100%. ■ The R470 main controller has PI characteristics (tends to have a long integration time and a large P-band); it uses the storage tank state of charge as the controlled variable and the strokes of the boiler circuit valves as the control variable. ■ The controller for the R455 oil/gas boiler has PI characteristics (tends to have a long integration time and a large P-band); it uses the main supply temperature downstream of the storage tank as the controlled variable and the stroke of the boiler circuit valve as the control variable. ■ In the automatic sequence control, the controller of the oil/gas boiler R455 is unblocked or blocked by means of suitable unblocking and blocking criteria; in addition, the setpoint for R455 is set about 3 K lower than the setpoints of the internal boiler controllers R423, R433 and R443 ■ A minimum priority switch switches the lower control signal to the boiler circuit valve in each case (i.e. the return flow maintenance has higher priority than the main controller or the controller of the oil/gas boiler). ■ The setpoint of the storage tank charging state is 60...80% (select step value!) ■ The upper storage tank area (at 60% setpoint of the storage tank charging state about 60% of the storage tank) serves as a buffer as long as the load is greater than the firing rate ■ The lower storage tank area (at 60% setpoint of the storage tank charging state about 40% of the storage tank) serves as a buffer as long as the load is smaller than the firing rate ■ The aim is to achieve a firing rate that is as continuously controlled as possible in accordance with the load.
Which standard measured variables must be recorded for operational optimisation?	■ Outdoor air temperature T401 ■ Inlet temperature Biomass boiler 1, T422 ■ Outlet temperature Biomass boiler 1, T423 ■ Inlet temperature Biomass boiler 2, T432 ■ Outlet temperature Biomass boiler 2, T433 ■ Inlet temperature Oil/gas boiler, T442 ■ Outlet temperature Oil/gas boiler, T443 ■ Main supply temperature before storage tank, T454 ■ Main supply temperature after storage tank, T455 ■ Main return temperature according to Eco, T451 ■ Storage tank temperature (top), T471 ■ Storage tank temperature, T472 ■ Storage tank temperature (middle), T473 ■ Storage tank temperature, T474 ■ Storage tank temperature (bottom), T475 ■ Supply temperature of the differential pressure-affected connection (district heating network), T461 ■ Return temperature of the differential pressure-affected connection (district heating network), T462 ■ Stroke boiler circuit valve Biomass boiler 1 V421 ■ Stroke boiler circuit valve Biomass boiler 2 V431 ■ Stroke boiler circuit valve Oil/gas boiler V441 ■ Eco heat meter, W411 * ■ Heat meter Biomass boiler 1, W421 * ■ Heat meter Biomass boiler 2, W431 * ■ Heat meter Oil/gas boiler, W441 * ■ Oil/gas meter, if modulating oil/gas boiler ** ■ Operating hours stage 1/2, if two-stage oil/gas boiler ■ Actual value of the storage tank charging state ■ Flue gas temperature Biomass boiler 1 ■ Residual oxygen Biomass boiler 1 ■ Flue gas temperature Biomass boiler 2 ■ Residual oxygen Biomass boiler 2 ■ Exhaust gas temperature Oil/gas boiler <u>The measuring points for the particle separator(s) shall be recorded according to the type of construction</u> * The heat meter must be equipped with an interface for recording the heat quantity [kWh] or water quantity [m³]; the graphical representation, however, must be in terms of power [kW] or volume flow [m³/h]. ** The oil/gas meter must be equipped with an interface for recording the oil or gas quantity [dm³ or m³]; the graphical representation, however, must be in the form of a volume flow [dm³/h or m³/h].
Literature	[1] Hans Rudolf Gabathuler, Hans Mayer: Standard hydraulic schemes - Part I. Straubing: C.A.R.M.E.N. e.V., second, expanded edition 2010. (Publication series QM for Biomass DH Plants - Volume 2) [2] Alfred Hammerschmid, Anton Stallinger: Standard-Schaltungen - Teil II. Straubing: C.A.R.M.E.N. e.V., 2006. (Publication series QM for Biomass DH Plants - Volume 5)

[3] Demand assessment with EXCEL tool. Free download of the EXCEL tool and the manual under www.qm-biomass-dh-plants.com
[4] Frequently Asked Questions (FAQ's). Free download (German version only: www.qmholzheizwerke.ch)

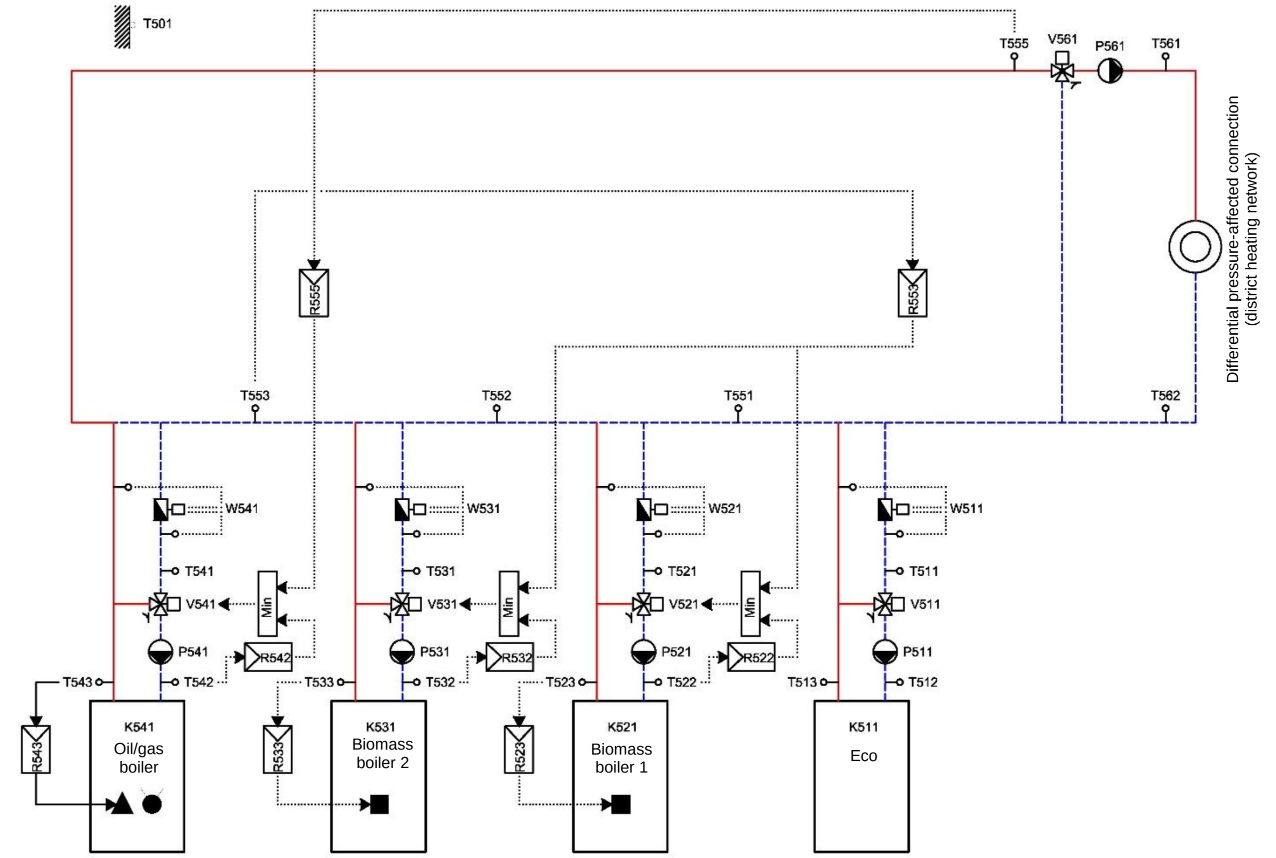
QM Biomass DH Plants

Short version of standard connection WE15:
Multi-boiler biomass heating system in series connection without storage tank

First release: 01/11/2010 | Last edit: 01/11/2010

Basis: Standard hydraulic schemes - Part II [2], Chapter 15

WE15



What are the special features of the circuit?

- **Difference to WE3 or WE7:** In WE15, the control variables of the main controllers R553 and R555 are not the firing rates, but the stroke of the respective boiler circuit valve.
- **Difference to WE3, WE7 and WE13:** In WE15 the boilers are not connected in parallel, but in series in the sequence Biomass boiler 1 - Biomass boiler 2 - Oil/gas boiler.
- 80...90% of the annual heat demand (heating, hot water and process heat demand) with biomass energy
- Peak loads must be covered by the boilers
- Low-load operation (summer) by the small biomass boiler usually possible, otherwise by the oil/gas boiler
- High security of supply due to oil/gas boiler
- Heat capacity reserve for expansion possible through oil/gas boiler (with corresponding reduction of the biomass coverage ratio)
- Heat production can be expanded hydraulically and in terms of control technology (if a boiler is added, the entire hydraulics must be recalculated, balanced and adjusted).

How should the system be designed?

Heat capacity demand	**100...500 kW**	**501...1000 kW**	**> 1000 kW**
Annual heat prod. with biomass	80...90%		
Biomass boiler output 1	60...70%*		20...23%
Biomass boiler output 2	–		40...47%
Oil/gas boiler capacity	Min. like biomass boiler, max. 100%.		Min. 100% - small biomass boiler, max. 100%
Number of full operating hours biomass boiler	> 2500 h/a, target 4000 h/a		
Low-load operation	If FAQ 12 [4] not fulfilled, by oil/gas boiler		Compliance with FAQ 12 [4] with the small biomass boiler or oil/gas boiler
Fuel	Max. P45; with autom. ignition W ≤ 45%	No restriction; with autom. ignition W ≤ 45%	

	* Guiding value for systems with predominantly space heating
	■ Check the Heat capacity demand for plausibility with the EXCEL table "Demand assessment" [3]. ■ Boiler pump design: Boiler outlet temperature - boiler inlet temperature ≤ 15 K (for oil/gas boilers, a smaller temperature difference may be necessary than for biomass boilers). ■ Distance boiler inlet temperature - return high level ≥ 5 K ■ Boiler circuit valves and pre-control: Valve authority ≥ 0,5
What other requirements must be observed?	■ All heat consumer circuits with the lowest possible return temperature ■ Ensure that all sensors in the main circuit (especially the control sensors T553 and T555) are properly mixed (install a static mixer if necessary). ■ The safety of the boilers is to be ensured by the internal I&C system of the boilers; safety devices and expansion system are to be designed in accordance with the country-specific regulations
How is the system controlled and regulated?	■ The internal boiler controllers R523, R533 and R543 control the three boiler outlet temperatures; the setpoints must be higher than the setpoints of the main controller R553 or the controller for the oil/gas boiler R555 ■ All boilers have a boiler return temperature protection (R522, R532 and R542); the controlled variable is the boiler inlet temperature and the manipulated variable is the stroke of the boiler circuit valve. ■ The sequence control first works manually: "Boiler 1 alone" - manual switchover to "Boiler 2 alone" - manual switchover to "automatic sequence control". ■ The automatic sequence control then works as follows: "Parallel operation boiler 1 and 2" (both boilers receive the same setpoint for the firing rate) - "Parallel operation boiler 1 and 2 + oil/gas boiler". ■ The main control variable is the common supply temperature after the two biomass boilers T553 ■ The R553 main controller has PI characteristics (tends to have a long integration time and a large P-band); it uses the common supply temperature downstream of the two biomass boilers as the controlled variable and the strokes of the boiler circuit valves as the manipulated variables. ■ The controller for the oil/gas boiler R555 has PI characteristics (tends to have a long Integration time and a large P-band); it uses the main supply temperature of all boilers T555 as the controlled variable and the stroke of the boiler circuit valve as the manipulated variable. ■ In the automatic sequence control, the controller of the oil/gas boiler R555 is enabled or disabled by means of suitable enable and disable criteria; the setpoints for R555 and R553 must be lower than the setpoints of the internal boiler controllers R523, R533 and R543. ■ A minimum priority switch switches the lower control signal to the boiler circuit valve in each case (i.e. the return flow maintenance has higher priority than the main controller or the controller of the oil/gas boiler).
Which standard measured variables must be recorded for operational optimisation?	■ Outdoor air temperature T501 ■ Inlet temperature Biomass boiler 1, T522 ■ Outlet temperature Biomass boiler 1, T523 ■ Inlet temperature Biomass boiler 2, T532 ■ Outlet temperature Biomass boiler 2, T533 ■ Inlet temperature Oil/gas boiler, T542 ■ Outlet temperature Oil/gas boiler, T543 ■ Main return temperature according to Eco, T551 ■ Supply temperature according to Biomass boiler 1, T552 ■ Supply temperature according to Biomass boiler 2, T553 ■ Main supply temperature of all boilers, T555 ■ Supply temperature of the differential pressure-affected connection (district heating network), T561 ■ Return temperature of the differential pressure-affected connection (district heating network), T562 ■ Stroke boiler circuit valve Biomass boiler 1 V521 ■ Stroke boiler circuit valve Biomass boiler 2 V531 ■ Stroke boiler circuit valve Oil/gas boiler V541 ■ Eco heat meter, W511 * ■ Heat meter Biomass boiler 1, W521 * ■ Heat meter Biomass boiler 2, W531 * ■ Heat meter Oil/gas boiler, W541 * ■ Oil/gas meter, if modulating oil/gas boiler ** ■ Operating hours stage 1/2, if two-stage oil/gas boiler ■ Flue gas temperature Biomass boiler 1 ■ Residual oxygen Biomass boiler 1 ■ Flue gas temperature Biomass boiler 2 ■ Residual oxygen Biomass boiler 2 ■ Exhaust gas temperature Oil/gas boiler The measuring points for the particle separator(s) shall be recorded according to the type of construction
	* The heat meter must be equipped with an interface for recording the heat quantity [kWh] or water quantity [m³]; the graphical representation, however, must be in terms of power [kW] or volume flow [m³/h]. ** The oil/gas meter must be equipped with an interface for recording the oil or gas quantity [dm³ or m³]; the graphical representation, however, must be in the form of a volume flow [dm³/h or m³/h].
Literature	[1] Hans Rudolf Gabathuler, Hans Mayer: Standard hydraulic schemes - Part I. Straubing: C.A.R.M.E.N. e.V., second, expanded edition 2010. (Publication series QM for Biomass DH Plants - Volume 2) [2] Alfred Hammerschmid, Anton Stallinger: Standard-Schaltungen - Teil II. Straubing: C.A.R.M.E.N. e.V., 2006. (Publication series QM for Biomass DH Plants - Volume 5) [3] Demand assessment with EXCEL tool. Free download of the EXCEL tool and the manual under www.qm-biomass-dh-plants.com [4] Frequently Asked Questions (FAQ's). Free download (German version only: www.qmholzheizwerke.ch)

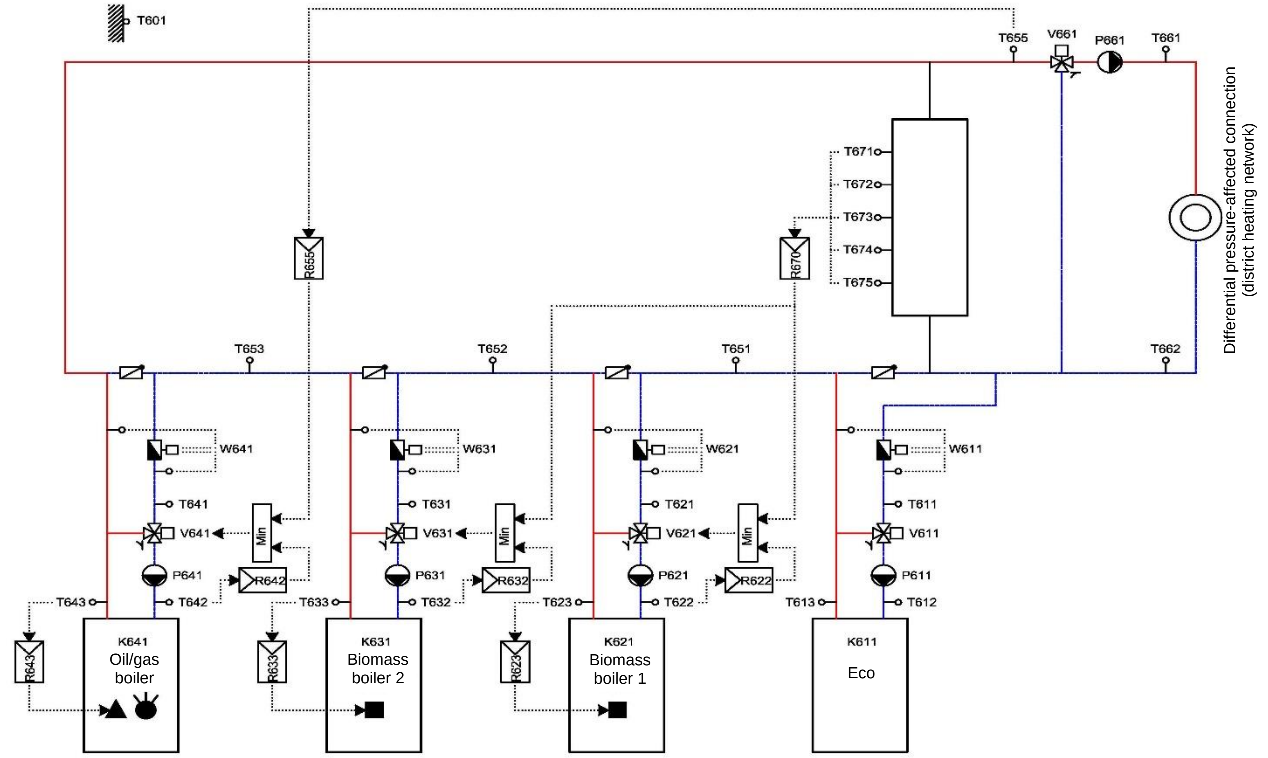
QM Biomass DH Plants

Short version of standard connection WE16:
Multi-boiler biomass heating system in series connection with storage tank

First release: 01/11/2010 | Last edit: 01/11/2010

Basis: Standard hydraulic schemes - Part II [2], Chapter 16

WE16



What are the special features of the circuit?

- **Difference to WE4 or WE8:** In WE16, the control variables of the main controllers R670 and R655 are not the firing rates, but the stroke of the respective boiler circuit valve.
- **Difference to WE4, WE8 and WE14:** In WE16 the boilers are not connected in parallel, but in series in the sequence Biomass boiler 1 - Biomass boiler 2 - Oil/gas boiler.
- 80...90% of the annual heat demand (heating, hot water and process heat demand) with biomass energy
- Peak loads are covered by storage tanks, i.e. the boilers can be designed smaller.
- Low-load operation (summer) by the small biomass boiler usually possible, otherwise by the oil/gas boiler
- High security of supply due to oil/gas boiler
- Heat capacity reserve for expansion possible through oil/gas boiler (with corresponding reduction of the biomass coverage ratio)
- Heat production can be expanded hydraulically and in terms of control technology (if a boiler is added, the entire hydraulics must be recalculated, balanced and adjusted).

How should the system be designed?

Heat capacity demand	100...500 kW	501...1000 kW	> 1000 kW
Annual heat prod. with biomass	80...90%		
Biomass boiler output 1	50...60%*		17...20%*/**
Biomass boiler output 2	–		33...40%*/**
Oil/gas boiler capacity	Min. as for biomass boiler, max. at 100%.		Min. 100% - small biomass boiler, max. 100%
Number of full operating hours biomass boiler	> 3500 h/a, target 4000 h/a		> 3000 h/a, target 4000 h/a
Low-load operation	If FAQ 12 [4] not fulfilled, by oil/gas boiler		Compliance with FAQ 12 [4] with the small biomass boiler or oil/gas boiler
Fuel	Max. P45; with autom. ignition $W \leq 45\%$	No restriction; with autom. ignition $W \leq 45\%$	

* Guiding value for systems with predominantly space heating

** Only 1 biomass boiler may possibly make sense for systems without summer operation

- Check the heat capacity demand for plausibility with the EXCEL table "Demand assessment" [3].
- Boiler pump design: Boiler outlet temperature - boiler inlet temperature ≤ 15 K (for oil/gas boilers, a smaller temperature difference may be necessary than for biomass boilers).

	■ Difference boiler inlet temperature – boiler return temperature protection ≥ 5 K ■ Boiler circuit valves and pre-control: Valve authority ≥ 0,5 ■ Storage volume ≥1 h Storage capacity (related to the nominal output of the larger biomass boiler)
What other requirements must be observed?	■ All heat consumer circuits with the lowest possible return temperature ■ Consistently design storage as stratified storage ■ Storage tank connections with cross-section enlargement (speed reduction), baffle plate (refraction of the water jet) and, if necessary, siphoned (prevention of one-pipe circulation). ■ Storage tank connections only at the top and bottom (no connections in between) ■ No pipes inside the storage tank (danger of a "thermal agitation") ■ No division between several tanks; if this requirement cannot be met: no connections between the tanks, consider each tank as a control unit (the warmer tank can be colder at the bottom than the colder tank at the top). ■ The safety of the boilers is to be ensured by the internal I&C system of the boilers; safety devices and expansion system are to be designed in accordance with the country-specific regulations
How is the system controlled and regulated?	■ The internal boiler controllers R623, R633 and R643 control the three boiler outlet temperatures; the setpoints must be higher than the temperature at which the storage tank is charged ■ All boilers have a boiler return temperature protection (R622, R632 and R642); the controlled variable is the boiler inlet temperature and the manipulated variable is the stroke of the boiler circuit valve. ■ The sequence control first works manually: "Boiler 1 alone" - manual switchover to "Boiler 2 alone" - manual switchover to "automatic sequence control". ■ The automatic sequence control then works as follows: "Parallel operation boiler 1 and 2" (both boilers receive the same setpoint for the firing rate) - "Parallel operation boiler 1 and 2 + Oil/gas boiler". ■ The main control variable of the main controller R670 is the storage tank state of charge, which is recorded via sensors T671...T675 and calculated as a value of 0...100%. ■ The R670 main controller has PI characteristics (tends to have a long integration time and a large P-band); it uses the storage tank state of charge as the controlled variable and the strokes of the boiler circuit valves as the control variables. ■ The controller for the oil/gas boiler R655 has PI characteristics (tends to have a long integration time and a large P-band); it uses the main supply temperature of all boilers T655 as the controlled variable and the stroke of the boiler circuit valve as the manipulated variable. ■ In the automatic sequence control, the controller of the oil/gas boiler R655 is unblocked or blocked by means of suitable unblocking and blocking criteria; the setpoint for R655 must be lower than the setpoints of the internal boiler controllers R623, R633 and R643 ■ A minimum priority switches switch the lower control signal to the boiler circuit valve in each case (i.e. the return flow maintenance has higher priority than the main controller or the controller of the oil/gas boiler). ■ The setpoint of the storage tank charging state is 60...80% (select step value!) ■ The upper storage tank area (at 60% setpoint of the storage tank charging state about 60% of the storage tank) serves as a buffer as long as the load is greater than the firing rate ■ The lower storage tank area (at 60% setpoint of the storage tank charging state about 40% of the storage tank) serves as a buffer as long as the load is smaller than the firing rate ■ The aim is to achieve a firing rate that is as continuously controlled as possible in accordance with the load.
Which standard measured variables must be recorded for operational optimisation?	■ Outdoor air temperature T601 ■ Inlet temperature Biomass boiler 1, T622 ■ Outlet temperature Biomass boiler 1, T623 ■ Inlet temperature Biomass boiler 2, T632 ■ Outlet temperature Biomass boiler 2, T633 ■ Inlet temperature Oil/gas boiler, T642 ■ Outlet temperature Oil/gas boiler, T643 ■ Main return temperature according to Eco, T651 ■ Supply temperature according to Biomass boiler 1, T652 ■ Supply temperature according to Biomass boiler 2, T653 ■ Main supply temperature of all boilers, T655 ■ Storage tank temperature (top), T671 ■ Storage tank temperature, T672 ■ Storage tank temperature (middle), T673 ■ Storage tank temperature, T674 ■ Storage tank temperature (bottom), T675 ■ Supply temperature of the differential pressure-affected connection (district heating network), T661 ■ Return temperature of the differential pressure-affected connection (district heating network), T662 ■ Stroke boiler circuit valve Biomass boiler 1 V621 ■ Stroke boiler circuit valve Biomass boiler 2 V631 ■ Stroke boiler circuit valve Oil/gas boiler V641 ■ Heat meter Eco, W611 * ■ Heat meter Biomass boiler 1, W621 * ■ Heat meter Biomass boiler 2, W631 * ■ Heat meter Oil/gas boiler, W641 * ■ Oil/gas meter, if modulating oil/gas boiler ** ■ Operating hours stage 1/2, if two-stage oil/gas boiler ■ Actual value of the storage tank charging state ■ Flue gas temperature Biomass boiler 1 ■ Residual oxygen Biomass boiler 1 ■ Flue gas temperature Biomass boiler 2 ■ Residual oxygen Biomass boiler 2 ■ Exhaust gas temperature Oil/gas boiler The measuring points for the particle separator(s) shall be recorded according to the type of construction * The heat meter must be equipped with an interface for recording the heat quantity [kWh] or water quantity [m³]; the graphical representation, however, must be in terms of power [kW] or volume flow [m³/h]. ** The oil/gas meter must be equipped with an interface for recording the oil or gas quantity [dm³ or m³]; the graphical representation, however, must be in the form of a volume flow [dm³/h or m³/h].
Literature	[1] Hans Rudolf Gabathuler, Hans Mayer: Standard hydraulic schemes - Part I. Straubing: C.A.R.M.E.N. e.V., second, expanded edition 2010. (Publication series QM for Biomass DH Plants - Volume 2) [2] Alfred Hammerschmid, Anton Stallinger: Standard-Schaltungen - Teil II. Straubing: C.A.R.M.E.N. e.V., 2006. (Publication series QM for Biomass DH Plants - Volume 5) [3] Demand assessment with EXCEL tool. Free download of the EXCEL tool and the manual under www.qm-biomass-dh-plants.com [4] Frequently Asked Questions (FAQ's). Free download (German version only: www.qmholzheizwerke.ch)