Q4. In a nuclear power station, heat from the nuclear reactor is transferred by circulating carbon dioxide gas through the reactor and then to the boiler where steam is generated. The steam is used in a Rankine Cycle with superheat where it expands isentropically from 100 bar pressure and 600°C to 7 bar. The exhaust steam is condensed by using it in a district heating scheme and returns as saturated water at 7 bar and is returned to the boiler.

(a) The power output of the turbine is 170 MW. Calculate the rate at which heat is used by the district heating scheme. Draw a block diagram of the system.

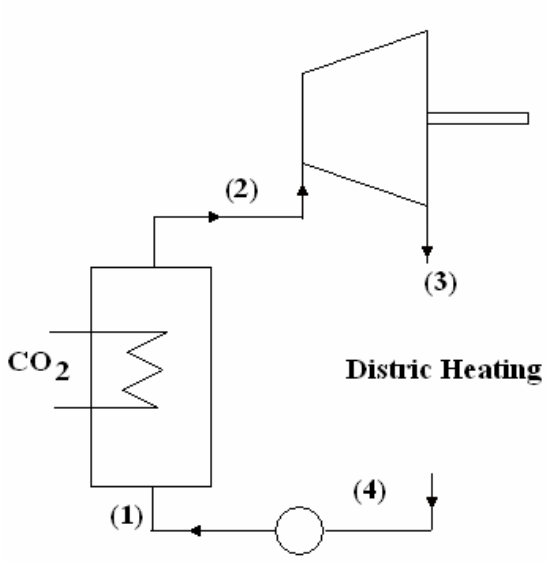
(b) The carbon dioxide is cooled from 620oCto 310oC in the boiler. Calculate the mass flow rate of carbon dioxide if the mean specific heat capacity c_p is 1.143 kJ/kg K. Neglect the feed pump work.

$h_2 = 3624$ kJ/kg
$s_2 = 6.85$ kJ/kg K
$s_3 = 6.85 = 1.992 + x(4.717)$ hence x>1 so it is still superheated at (3)
Interpolation from the tables is required to find h_3.

7 bar			
Temp	165	θ	200
s	6.709	6.85	6.888
h	2764	h_3	2846

$\theta = 165 + 35\ (6.85 - 6.709)/(6.88 - 6.709)$
$\theta = 165 + 28.86$

$h_3 = 2764 + (28.86/35)(\ 2846 - 2764\ ) = 2832$ kJ/kg



TURBINE
P = 170 000 kW = m(3624 – 2832)
m = 214.54 kg/s

Heat To District Heating $h_4 = 697$ kJ/kg

$\Phi = m(h_3 - h_2) = 214.54(2832 - 697) = 458047$ kW or 458 MW

BOILER $h_1 = h4$

$\Phi = m(h_2 - h_1) = 214.54(3624 - 697) = 627960$ kW
If the heat lost by the carbon Dioxide is the same then $627960 = m_g\ c_p\ (\Delta T)$

$627960 = 1.143\ m_g\ (620 - 310)$ $m_g = 1772$ kg/s

These answers do not quite agree with the examiners but are close.