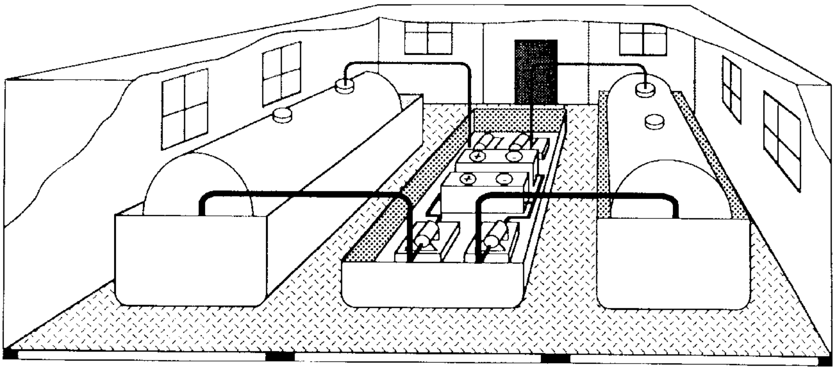

Figure 18.28 Schematic of a redox-flow battery in the megawatt hour range [29]

20 h of discharge time at full power [29]. As no mass production is established, these data are subject to speculations on the mid-term achievable cost figures.

The energy efficiency for the vanadium battery has been demonstrated to be 80 to 85% for the cell itself. As the system requires peripherals (mainly pumps for the electrolytes), the system efficiency can be in the range of 75%, which is considerably better in comparison with the hydrogen system described in Section 18.5.2. No self-discharge of the electrolytes in the tanks occurs. An optimum operation temperature for redox-flow batteries is defined by an optimum of the solubility of all the salts in the electrolyte while avoiding any recrystallisation of a salt.

18.5.2 Hydrogen/Oxygen Storage Systems

The other major technology with external storage is the use of liquid water (discharged state) and its gaseous components hydrogen and oxygen (charged state) [32].

Water can be split into hydrogen and oxygen gas by the fundamental reaction (18.16).

$$2H_2 + O_2 \rightleftarrows 2H_2O \tag{18.16}$$

Electrolysis of water starts at 1.23 V/cell. A hydrogen storage system consists of three major components that are listed below:

1. An electrolyser for the production of the gases from electric power,
2. Gas storage for the hydrogen and, depending on the system's design, for the oxygen. Hydrogen is commonly stored either in pressure tanks or metal-hydride tanks.
3. A fuel cell to reconvert the gases into water and electric power. Hydrogen is taken from the storage and oxygen either from gas storage or from air.

Electrolyser/fuel cell systems have been demonstrated; the technology, however, still has to go through a long process of maturation until it reaches the market at acceptable costs and with high reliability.