Example calculation:

Given a 100-gallon vat of juice at 50 °F, what is the BTU requirement to make 10 gallons of syrup?

Part A. Raise the temperature of the juice to 226 °F.

834 lb x 176 °F x 1 BTU lb^{-1} $°F^{-1}$= 146,784 BTU.
At 100% efficiency, requires ~1.6 gallons of propane.

Part B. Vaporize 90 gallons of water and leave 10 gallons of syrup.

750 lb x 970 BTU lb^{-1} = 728,080 BTU
At 100% efficiency, requires ~8 gallons of propane.

(The calculated loss of 90 gallons of water is a simplification that introduces <10% error, which will not affect the conclusion.)

As a ballpark figure—which is widely variable according to furnace design and use—40% efficiency is probably a reasonable estimate. Thus, it takes about 2 gallons of propane to make a gallon of syrup (less propane for higher brix juice, warmer juice, or higher furnace efficiency). . . . & if you want the boiling off stage in a kettle/batch pan to take 4 hours, you will need a burner that delivers ~450,000 BTU h^{-1} (at 40% efficiency, but less of course at higher furnace efficiencies).

Given constants:

The latent heat of vaporization of water is 970 BTU lb^{-1}.
Source: http://www.engineeringtoolbox.com/fluids-evaporation-latent-heat-d_147.html
fyi--the calorie is defined analogously to the BTU, so you could take the 540 cal gm^{-1} that I supplied earlier and multiply by 9/5 (= 180/100 = (°F between freezing and boiling)/(°C between freezing and boiling)).

The specific heat of water is 1 BTU lb^{-1} $°F^{-1}$ (by definition of BTU).

Water conversion: 8.34 lb^{-1} gallon.
Source: http://www.acepumps.com/en/index.php?/site/applications/C34/Calc/

Propane—energy released upon combustion: 91,000 BTU gallon $propane^{-1}$
Source: http://www.nwes.com/propane_info.htm

Sources of errors and corrections, a few examples.

The specific heat varies modestly with temperature and is for pure water.

The specific gravity of water varies modestly with temperature.

The latent heat varies modestly with temperature and pressure and the calculation is based on one atmosphere and 212 °F.

Heat requirements for other parts of the system (notably, the furnace and boiling vessel).

Heat loss by the system (notably, radiant loss and bulk-flow loss of gases in the flue).