Saving for a Rainy Day: Problem Handouts

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Problem Statement

You have been invited to spend the weekend at your cousin's new cabin in the Poconos. She and her husband, having decided to "live simply", have constructed their home far from the beaten path, with an eye to being as energy efficient as possible. They have installed solar cells and collectors for generating electricity and heating their home, but are still trying to decide on the best way to trap and store energy for use at night and on cloudy days. They had planned to construct a tank containing some substance that can absorb the energy of sunlight, and then use that energy to provide heat for their home. They have found some plans for how to distribute the heat from such a storage reservoir throughout the house, but are still unsure about what materials to use for the tank and that substance. They had originally thought of having a copper tank full of water, since they have a friend who is willing to give them a half-dozen 3' x 3' x 1" copper sheets left from one of his art projects. Now, though, they are intrigued by a magazine article that discussed the use of "phase-change materials" to store energy.

They show you some tables that appeared in the article. (See Tables 1 and 2).

The problem here is that neither your cousin nor her spouse have much of a background in science, and they do not know what to make of the data in these tables, and so cannot proceed with their decision making. They are hoping that you might be able to interpret this, and give them some advice about choosing a heat storage system (both the tank material and the substance to be kept in it) that will enable them to store as much heat as possible, within a reasonable physical space. They would like to be able to store enough energy for three days' use; the article gives an estimate of about 480,000 BTU as the thermal energy needed to heat a house similar to theirs for a day. What advice would you give?

Questions to consider:

1. Consider the data supplied in these tables; what information can you get from these?
2. Will your cousin's original idea work; *i.e.*, will they be able to store enough energy to meet their requirements? Indicate any assumptions you might need to make here.
3. Suppose that instead of using water in the tank above, they decide to try one of the phase-change materials. Which would be best from an energy-storage standpoint, and why?
4. What advice will you give?

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Data Tables

Table 1. Heat Storage Material

Material	**Specific Heat**	**Density**	**Heat capacity**
	(BTU/lb/°F or cal/g/°C)	(lb/ft^3)	($BTU/ft^3/°F$)
Water	1.00	62	62
Steel	0.12	490	59
Copper	0.09	555	50
Aluminum	0.22	170	37

Table. 2. Properties of Phase-Change Materials

Material	**Density**	**Heat of fusion**	**Melting temperature**
	(lb/ft^3)	(BTU/lb)	(°F)
Glauber's salt $Na_2SO_4 \cdot 10\ H_2O$	91	108	88-90
Hypo $Na_2S_2O_3 \cdot 5\ H_20$	104	90	118-120
Paraffin	51	75	112
Calcium chloride $CaCl_2 \cdot 6\ H_2O$	102	75	84-102