

University of Arkansas Microelectronics-Photonics Graduate Program

PhD Candidacy Exam – Environmental Topic – March 19, 2010

PROBLEM TO BE SOLVED

This decade of energy challenge focuses market attention on renewable sources of energy. Renewable technologies that are cost competitive and reduce CO₂ production are of particular interest. For instance, solar-thermal energy is very attractive because it can be utilized over 24 hours by storing thermal energy and using it in periods of low solar flux, like nighttime.

At the same time approximately 40% of our current energy consumption is discarded as waste heat. This provides many readily available sources of thermal energy (automobiles, nuclear power plants, and steel production plants, to name a few) that could provide opportunities for efficiency improvements through energy harvesting. While extensive energy storage techniques have been developed (such as solar thermal collectors and thermoelectric devices) there is wide opportunity for new applications.

Unfortunately, current thermoelectric technologies exhibit low efficiency and low cost-competitiveness. Other emerging technologies like thermophotovoltaic may be attractive, especially for new markets in both terrestrial and space mission applications.

Your company has been active in solar technology for some time, and your CEO is interested expanding the company into new areas. As CTO, you have been asked to develop innovative, economic, highly efficient conversion and sustainable technologies in the area of thermal energy conversion using your background in nano-micro materials, devices and processing. While thermal energy is what excited her interest, your proposed area innovation is not necessarily limited to thermoelectric, thermophotovoltaic and thermionic technologies. The company is anticipating a wider market in the coming years, and developing critical cost competitive and practical technologies in materials, devices and processing are an absolute requirement if your company is to survive.

Your proposed device or system is expected to facilitate capture, storage, transformation, and/or utilization of thermal inputs to produce a viable energy source. Applications may include local and/or global approaches, and may address any or all of the supply chain from thermal input to consumer.

YOUR DELIVERABLE

Your task is to write an internal proposal for your corporate officers describing your approach to this issue, with clear specifics on such things as what specific aspect(s) of this problem you feel your company should address and what market(s) your proposed product(s) should target. The proposal should include the following:

- Executive summary (one page)
- Risk assessment roadmap form (one page)
- Full proposal (15 pages maximum)
- Appendix A: Bibliography (no page limit)
- Appendix B: Ranked list of intellectual property documents examined (no page limit)

Be sure you address at least all of the following:

Current Science and Technologies - What is already being done in this area by other researchers, companies and governmental institutions? The current state-of-the-art for both the science and the implementation should be described, making use of diverse resources such as science literature, journals, industry publications, conference proceedings, the internet, patents or other sources of existing public knowledge. **Be sure to cite all references that you use and to quote any word-for-word transfer to your report.**

Your Design Approach – What is the basis for your chosen design approach to the problem? Address why your product is better than the existing product solutions and what product attribute(s) allow suitable market penetration for profitability. Be sure to address both the scientific and engineering issues of the question.

Testing and Qualification - Describe a set of tests and demonstrations that you will use to demonstrate the effectiveness of your approach and to give confidence that the implementation of the solution will launch successfully.

Cost Analysis – Detail the cost and market issues that will impact the pricing strategy of the solution you have proposed. Because the CEO is concerned with potential IP leakage if a device is built outside of the company, subcontracting of the manufacturing or assembly of any proprietary component outside of the company is discouraged.

For instance, your analysis could include such things as the major cost items that would impact the implementation, which elements of your implementation solution would be handled in-house versus externally-sourced, major risk elements that could drive up costs if the primary path item fails, costs of IP licensing needed, etc. For anything you address, be sure to include not just the “what”, but also the justification and/or reasoning behind your decisions. Remember, the marketing team needs a good manufacturing cost estimate for the total system as the product reaches mature product stage in order to determine potential market size.

Intellectual Property - In Appendix B list in rank order of importance all commercial, academic, and governmental IP sources that were consulted while formulating the answer, including key important reference data. For instance, if the IP source is a patent, include the patent number; title; inventor name; and assignee name. The top three items in your ranked list should be discussed within the 15-page document, making comparisons of strengths and weaknesses of these approaches relative to your own. Include your recommendations on how these IP threats should be handled.

Most importantly - this is just a minimum list of issues you might consider. There may be many more. The point is that your report *should contain the evidence* needed to make an effective and compelling case to your CEO in order to insure that she makes the right decision.

Hint - Your report should read like a story – one logical step followed by another. This will help you stay focused! Re-read along the way to be sure that you have one logical step followed by another.