ISAP

Technical Committee on Asphalt Pavements and Environment

Working Group 7
Energy Harvesting

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Scope

- Investigating novel methods to harvest solar energy from asphalt pavements utilizing the-state-of-the-art and/or innovative approaches to reduce heat island effects and global warming etc.

Strategic Plan

- Review literatures and practices to investigate novel methods to harvest solar energy
- Generate different approaches to capture solar energy
- Formulate conceptual design of systems to generate electricity
- Prepare the feasibility study report for the detailed and comprehensive study

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Intelligent Transportation Infrastructure and System (ITIS)

It is not ITS or ITI, but it is ITIS.

Asphalt Pavements

- Hot Mix Asphalt (HMA)
  Warm Mix Asphalt (WMA)
  Cold Mix Asphalt (CMA)
- Heat island effect
- Climate change
- Other consequences

All day long pavements receive solar energy from the sun rays, storing much of them as heat that is left to dissipate by nightfall.

The concept of harvesting solar energy from asphalt pavement is enticing because it offers a way to collect solar energy by utilizing an extensive infrastructure that already exists.

Thus, there is a need to investigate novel methods for solar energy harvesting and conversion with potential economic efficiency substantially beyond that of current technology.

Methods for Harvesting

- Using flexible photovoltaic cells to harvest solar energy in unused areas of pavement
- Embedding highly conductive pipes within asphalt pavement for heat extraction
- Using the Seebeck effect with organic semiconductors embedded in asphalt pavement to generate electricity
- Creating a solar system that uses drop in solar panels as the roadway

(1) Photovoltaic Method

Photovoltaic Method

- A simple and convenient approach to utilize the current photovoltaic technologies
  - Concentrated mostly on the flexible photovoltaic cell for their ease of placement
- These cells can be installed where no or little traffic occurs, e.g., between NJ barrier and the rumble strip in the median
  - A potential product is a Photovoltaic laminate with a potted terminal housing assembly with output cables and quick terminals for ease of application to existing electrical connections

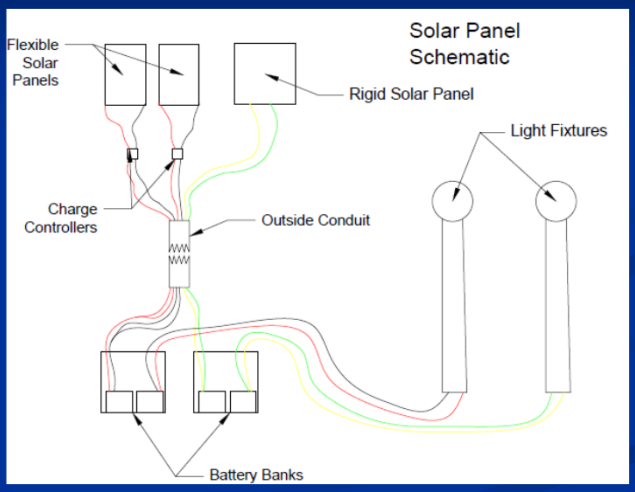
Photovoltaic Method

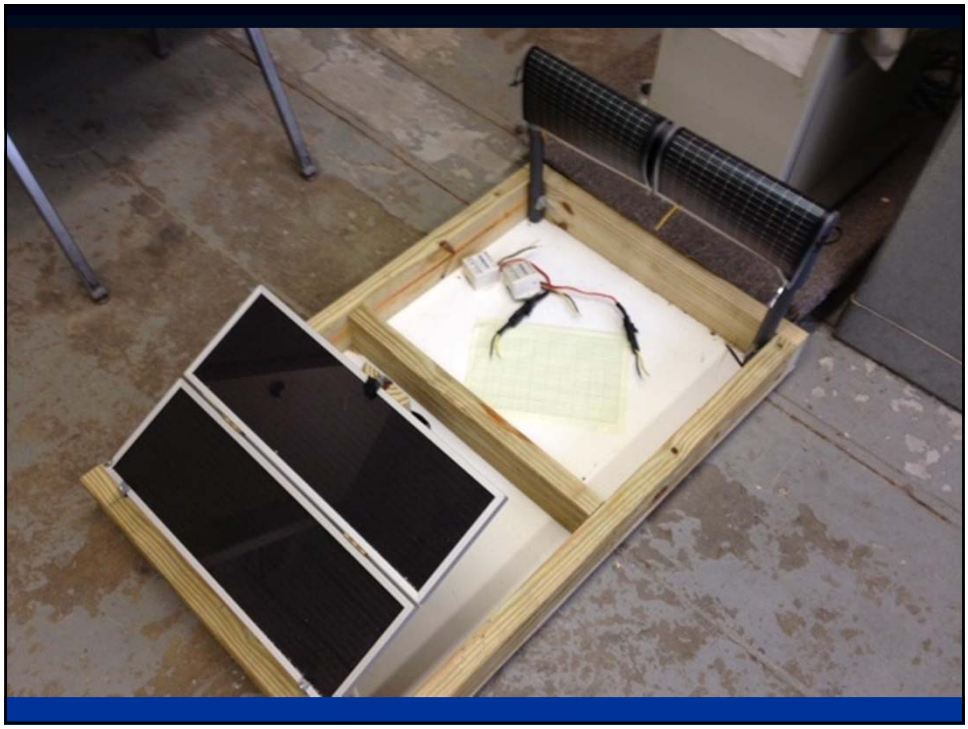
- It has shown that simple flexible panels can be used effectively to simulate real world situations at URI

Photovoltaic Method

- Testing has begun with a main focus on the efficiency differences between flexible and rigid panels
  - It is comprised of a fixed structure on the roof of Bliss Hall, that hold both types of panels
  - The panels are connected to separate battery banks so that power generated by each panel can be compared
  - The battery banks are connected to 2 exterior lamp lights at the entrance of Bliss Hall so that a visual comparison can be shown to students

Photovoltaic Method



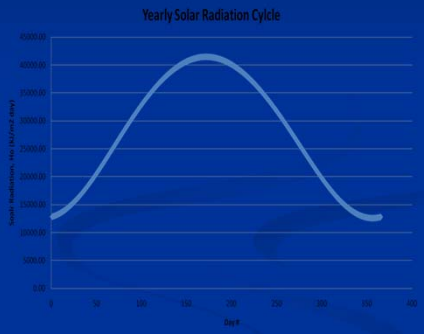


(2) Conductive Pipe Method

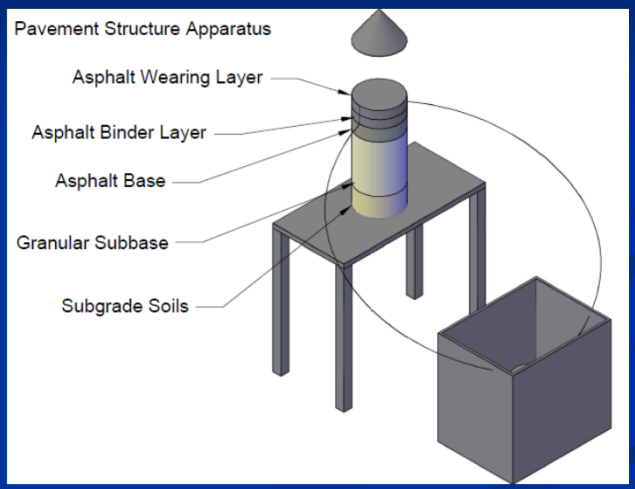
- Pipes embedded within asphalt pavement can cycle water which would heat up as the day goes on because of the absorptive properties of asphalt
- Once heated, this water can be used without further processing to heat buildings or can be processed further through a thermoelectric generator to produce electricity.
- Since the temperature would be already about 140°F (60°C), it may require a small amount of electricity to produce vapor initially.
  - The vapor can be used to make turbines spin to generate electricity, it will become a self-sufficient system.
- Consequently, a pilot study was concentrated on this method.

Conductive Pipe Method

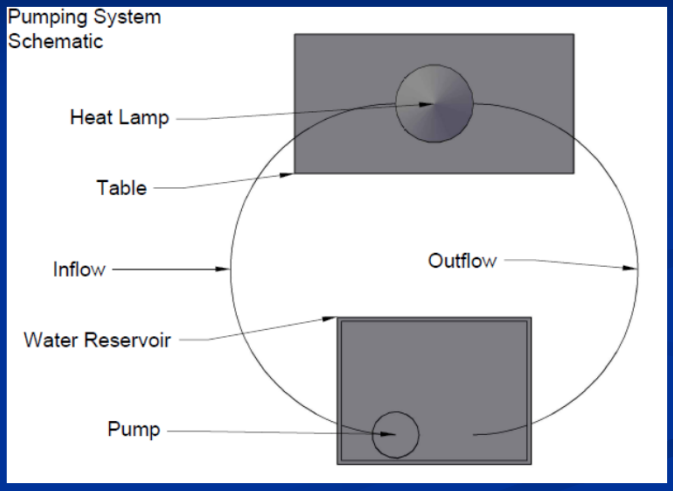
- Primary testing has been completed in a laboratory environment
- Using a sample pavement structure and simple pumping system testing was done to recreate similar research and field conditions
- Modified solar equations were used to approximate the solar exposure that would occur outside



Conductive Pipe Method



Conductive Pipe Method

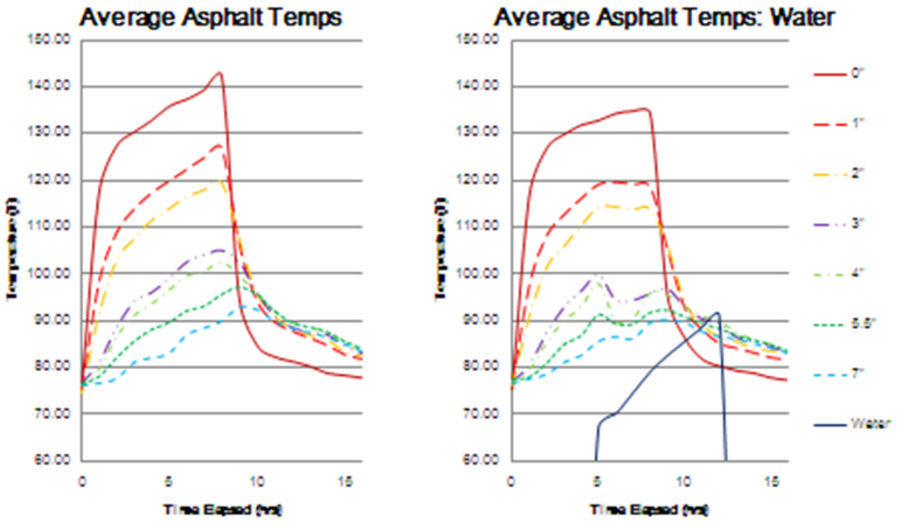


Conductive Pipe Method

Conductive Pipe Method

- Using thermocouples temperatures at different depths could be recorded and observed
- Heat was applied with the use of a basic heat lamp, and set at a height to recreate field solar exposure
- Two different types of testing
  - A typical day of solar radiation to grasp base values for future comparative studies
    - One "day" comprised of 8 hours with light, and 8 hours with no light
  - Water testing involved turning on the pumping system for an 8 hour period after 4 hours of light exposure to see if there was significant differences in temperature

Conductive Pipe Method



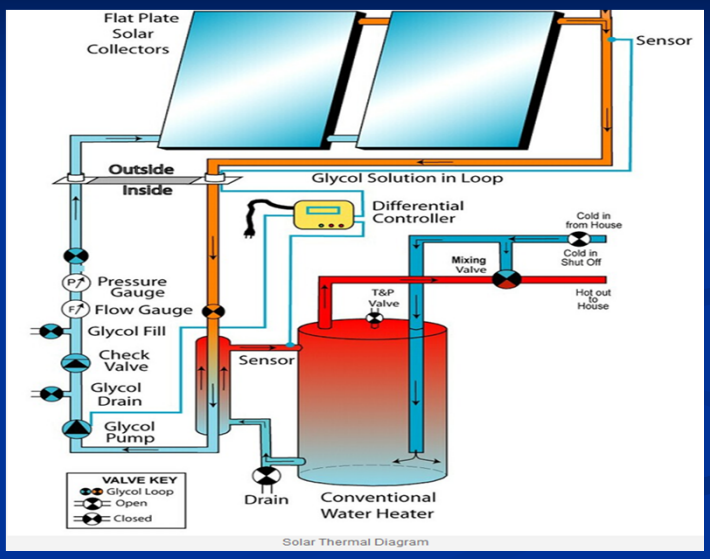
Conductive Pipe Method

Most of the results complied with the estimation from research used, and can be used as a basis for future testing

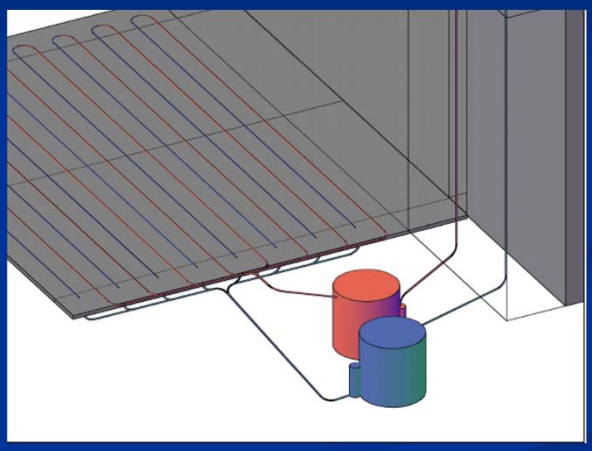
- Only asphalt layers were directly affected by the solar exposure
- These asphalt layers held heat for lengths of time, even after no heat was applied
- There was definite heat transfer that occurred during the water system being turned on
- Variables (pipe diameter, pump duration, pipe thickness, etc) can be changed to focus more on heat extraction, as well as cooling the pavement

Conductive Pipe Method

- Data from these experiments can theoretically be applied to designs for parking structures using asphalt pavement
  - Low volume will ensure low deformation and loss of color in asphalt
  - Exposure to sunlight is maximized do to little obstruction or traffic
- Application of hot water from pipes to icy bridges can lower dependency on salt and deicers
  - Can lead to long life spans of bridges in general
  - Pipes can be run parallel with roadway so as not to be obscured by traffic



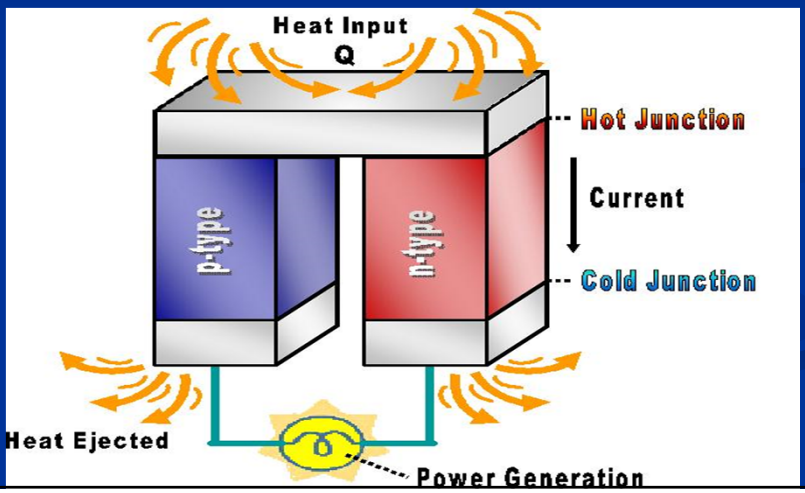
Conductive Pipe Method



(3) Thermoelectric Material Method

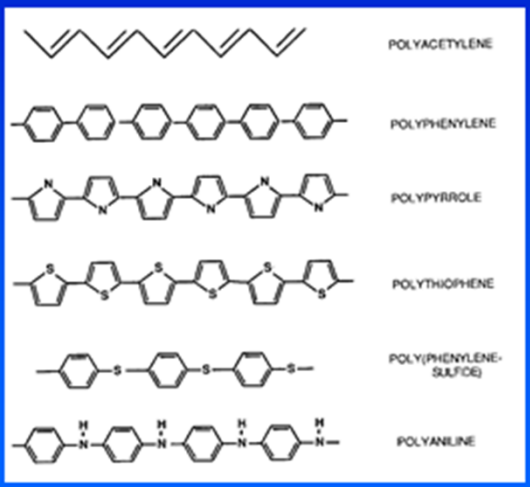
- Seebeck effect has been seen as a way to generate heat for the interiors of automobiles, with common commercial devices using p-type and n-type semiconductors

* Thermoelectric devices can be designed with enough voltage (1-3 volts) to store and convert solar energy to electricity in rechargeable batteries through utilizing the seebeck effect



- Research has shown that there is a way to use organic semiconductors as a potential low cost material for solar energy conversion
- These organic materials have the potential for high power efficiency and are inexpensive to manufacture
- Efficiency for these semiconductors are proportional to the square of the Seeback coefficient, about 10 times higher than traditional metallic thermal couples

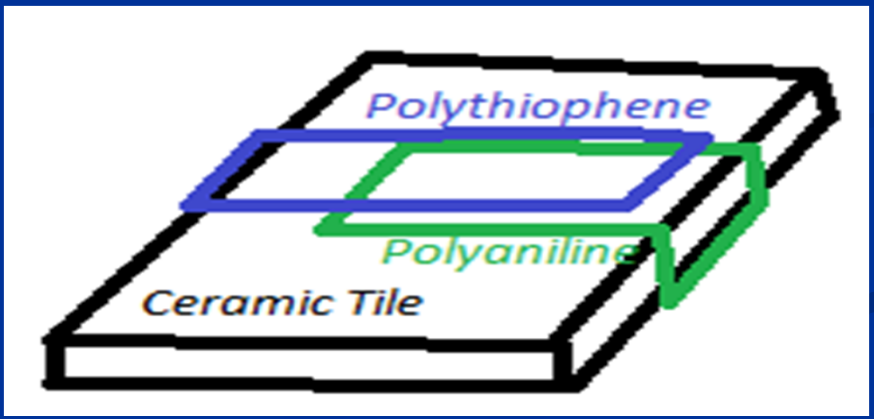
Conjugated Polymers

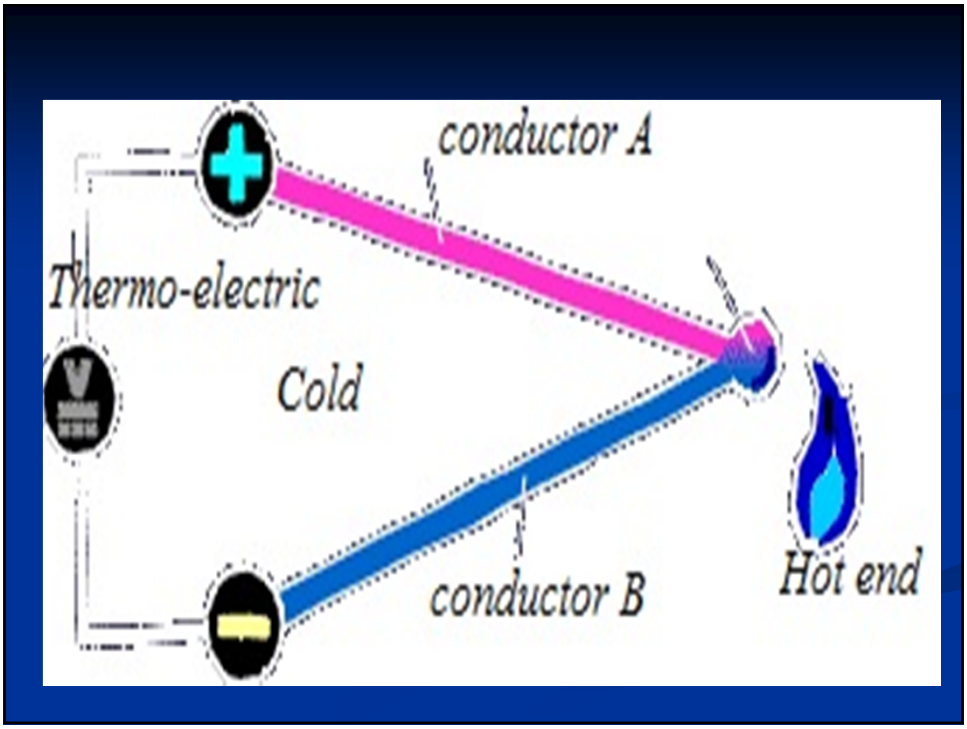


Thermoelectric Material Method

- Organic semiconductor polymers were developed at URI for use as additives in paints for corrosion prevention of metals
- The challenge ahead is the development of multi-layer thin films or composite materials that will function as a thermoelectric device
- Integration of solar energy collected would be a function of the low cost process, where low cost materials must be considered

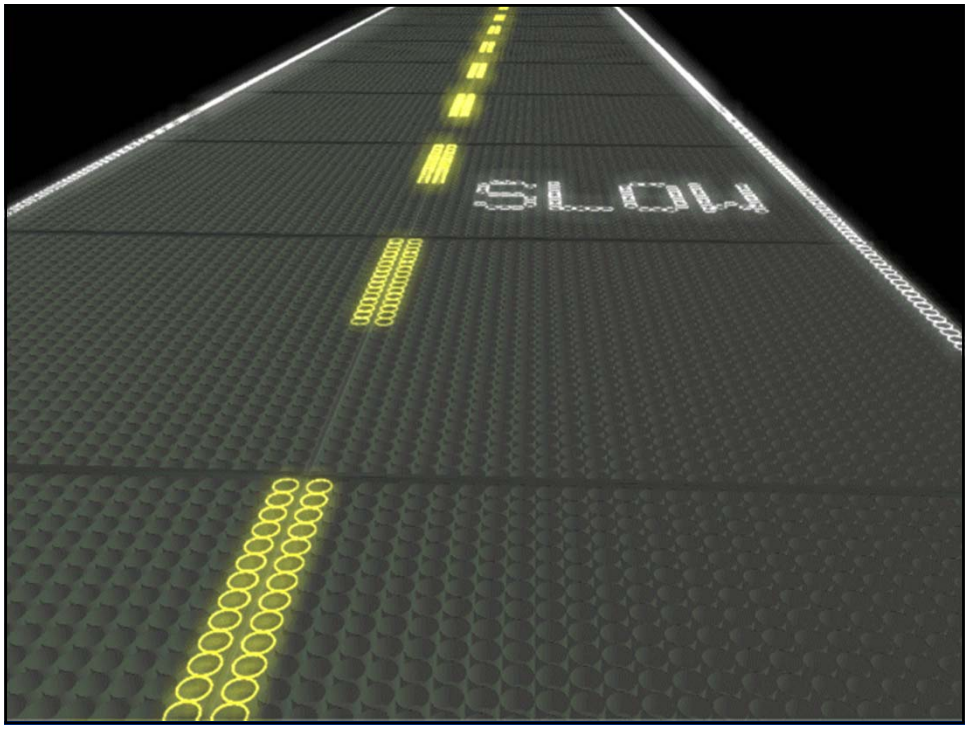
*** To test these organic semiconducting polymers, a polymer film will be created to coat the surface of rooftops and pavements**
*** They can also be used within the building or asphalt materials as a blend: the development of future building materials could have these polymers integrated within them**





(4) Solar Roadway Method

- The ultimate purpose is to develop a solar cell system embedded in a composite material structure that can be used on a road surface under severe loading conditions
- The idea is to replace all current asphalt roads with solar panels that collect and store solar energy or to retrofit older roads with this newer technology
- Each individual panel may consist of at least three sub layers: surface layer, electronics layer, and base plate layer



- The surface layer needs to be translucent and high-strength, but rough enough to provide sufficient traction, yet still capable of receiving sunlight through to the solar collector cells (e.g., colored epoxy etc.)
  - It also needs to be constructed to handle heavy traffics and the worst conditions as well as being weatherproof to protect the electronics layer beneath it.
- The sub layer will contain a large array of cells, the bulk of which will contain solar-collecting cells with LEDs for "painting" the road surface
  - These cells also contain the "Super" or "Ultra" caps that store the sun's energy for later use
- The base sub layer distributes power and data signals, as well as acting as another waterproof layer to encase the entire panel

Thank you
and
Happy New Year!

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or

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