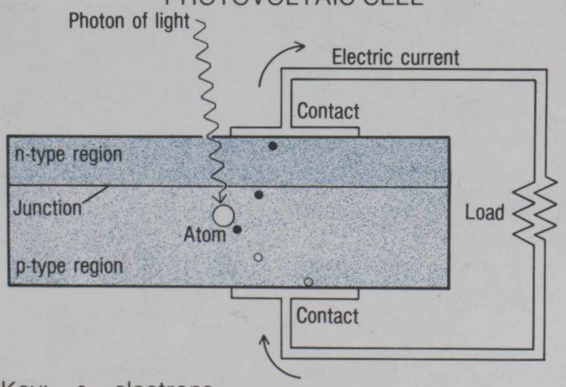
The Design and Operation of a Photovoltaic Cell

When sunlight falls on a silicon crystal, it knocks an electron out of its fixed position in the crystal structure. Negatively charged electrons thus freed to move produce a current, but under normal circumstances they quickly fall back into the positively charged "holes" they have vacated.

In order to get useful work from a solar cell, an electrical barrier must be set up which stops the free electrons from simply dropping into the nearest hole. The barrier separates the electrons and holes (negative and positive charges) and drives them in different directions. It is created by adding minute quantities of impurities to the silicon, making it a semiconductor. If phosphorus, for example, is added, an excess of electrons over holes is created and one has an "n-type" semiconductor in which some electrons remain free to move. But, to have an electrical current, a positive charge is also required; thus an element like boron is added to another silicon crystal, creating additional holes or a positively charged "p-type" semiconductor. In a solar cell an n-type and a p-type semiconductor are joined together and their outer faces connected by an electrical wire, as illustrated in below.

Figure 6-32: SCHEMATIC DRAWING OF A PHOTOVOLTAIC CELL



Key: • electrons
o holes

Source: After "The Sun on a Semiconductor", 1978, p. 23.

When a photovoltaic cell is exposed to sunlight, the electrons knocked loose do not fall into holes but instead follow the line of least resistance out of the n-type layer and through the external circuit to re-enter the p-type layer. This flow of electrons constitutes an electrical current and the flow continues as long as sunlight falls on the cell.

and air navigational aids (fixed-site hazard/warning lights, buoys) and environmental monitors and sensors. Thereafter, domestic markets will be developed for telecommunications applications, outdoor lighting and the replacement of small diesel/gas generators in remote areas. The development of a sufficiently large market to make mass production feasible will hopefully reduce the cost of solar cells.

In an evolving electricity/hydrogen economy, electricity generated directly from sunlight may become increasingly important in replacing electricity from other sources. As R&D continues over the next few years the potential for photovoltaic electricity production in Canada will become better established. Certainly for environmental reasons it is a preferred method for the generation of electricity.

If Canadian industry can develop these systems, a substantial Third World export market exists as photovoltaics can be used for running water pumps, for communications facilities and for supplying electricity to small villages. With a view to developing an industry capable of producing low-cost photovoltaic devices, the Federal Government is presently funding RD&D at $600,000 under the NRC's solar program, and at $250,000 for university research through the National Scientific and Engineering Research Council. A further $200,000 is assigned to applicable laboratory work at NRC and $100,000 is earmarked for joint federal/provincial programs. The NRC has proposed a five-year RD&D program, with funding increasing yearly from the present level of just over $1 million, to over $4 million by 1984-85.

CONCLUSION

It is essential that the most promising photovoltaic systems developed during the RD&D program be commercialized as early as possible. Only then will Canada be able to capture part of the export market and develop a viable domestic industry.

RECOMMENDATION

In light of both the domestic and export potential for photovoltaic systems, the Committee recommends that Canada's RD&D efforts in photovoltaics be accelerated beyond the levels currently planned.

5. SOLAR ENERGY: AN APPROPRIATE TECHNOLOGY

The term "appropriate technology" has come into use in recent years in discussions of technology transfer