

IT-003

## Solar Photovoltaics Technology: No longer an Outlier

Lawrence L. Kazmerski

National Renewable Energy Laboratory

The prospects of current and coming solar-photovoltaic (PV) technologies are envisioned, arguing this solar-electricity source is beyond a tipping point in the complex worldwide energy outlook. Truly, a revolution in both the technological advancements of solar PV and the deployment of this energy technology is underway; PV is no longer an outlier. The birth of modern photovoltaics (PV) traces only to the mid-1950s, with the Bell Telephone Laboratories' development of an efficient, single-crystal Si solar cell. Since then, Si has dominated the technology and the markets, from space through terrestrial applications. Recently, some significant shift toward technology diversity have taken place. Some focus of this presentation will be directed toward PV R&D and technology advances, with indications of the limitations and relative strengths of crystalline (Si and GaAs) and thin-film (a-Si:H, Si, Cu(In,Ga)(Se,S)<sub>2</sub>, CdTe). Recent advances, contributions, industry growth, and technological pathways for transformational now and near-term technologies (Si and primarily thin films) and status and forecasts for next-generation PV (nanotechnologies and non-conventional and "new-physics" approaches) are evaluated. The need for R&D accelerating the now and imminent (evolutionary) technologies balanced with work in mid-term (disruptive) approaches is highlighted. Moreover, technology progress and ownership for next generation solar PV mandates a balanced investment in research on longer-term (the revolution needs revolutionary approaches to sustain itself) technologies (quantum dots, multi-multijunctions, intermediate-band concepts, nanotubes, bio-inspired, thermophotonics, . . . and solar hydrogen) having high-risk, but extremely high performance and cost returns for our next generations of energy consumers. This presentation provides insights to the reasons for PV technology emergence, how these technologies have to be developed (an appreciation of the history of solar PV)—and where we can expect to be by this mid-21st century.