Solar-powered electrochemical production of hydrogen through water electrolysis is an active and important research endeavor. However, technologies and roadmaps for implementation of this process do not exist. In this perspective paper, we describe potential pathways for solar-hydrogen technologies into the marketplace in the form of photoelectrochemical or photovoltaic-driven electrolysis devices and systems. We detail technical approaches for device and system architectures, economic drivers, societal perceptions, political impacts, technological challenges, and research opportunities. Implementation scenarios are broken down into short-term and long-term markets, and a specific technology roadmap is defined. In the short term, the only plausible economical option will be photovoltaic-driven electrolysis systems for niche applications. In the long term, electrochemical solar-hydrogen technologies could be deployed more broadly in energy markets but will require advances in the technology, significant cost reductions, and/or policy changes. Ultimately, a transition to a society that significantly relies on solar-hydrogen technologies will benefit from continued creativity and influence from the scientific community.