Professor Martin A. Green

The period from 2010 to 2018 has seen dramatic cost reductions in solar photovoltaics (PV), guaranteeing a major and possibly dominant role in future sustainable electricity supply. Although many over several decades have contributed, Professor Martin Green has played a key role in achieving this outcome.

In 1983, the highest silicon solar cell efficiency had stabilised at close to 17% efficiency for close to a decade, after more than 30 years prior development, with 20% thought a practical limit. Informed studies suggested *"achievable module efficiency using silicon cells is probably limited to around 15%"* (EPRI, AP-3176-SR, Sept.1983). Through a series of innovative device developments over the next two decades, Green's research completely revamped expectations of PV's potential by demonstrating 50% relative improvement in cell performance. Along the way, he invented and led the development of the PERC cell (Passivated Emitter and Rear Cell), now becoming the global commercial standard. Through this research, Green developed both the technological platform and the cohort of skilled personnel that helped transform the industry.

Green established the Solar PV Group at the University of New South Wales (UNSW Sydney) in 1974, initially raising cell open-circuit voltage to new levels. This led him to question the validity of the then understood efficiency limits, undertaking a fundamental study of performance-limiting mechanisms. He found the limit arose from Auger recombination, where photo-excited carriers give their energy to neighbors unable to use it effectively. Based on this insight, he predicted that 25% efficiency was a feasible target and specified cell features required to reach such efficiencies (IEEE Trans. ED-31, 671, 1984).

Through the 1980s and 1990s, Green led a UNSW team that worked towards this target, increasing independently confirmed efficiency (by present standards) from 16.5%, through the 20% milestone, to 25% (Prog. PV 17, 183, 2009), holding the record for silicon cell efficiency for over 30 years. During this evolving process of world record efficiency achievements, he invented the PERC cell (SOLMAT 143, 190, 2015). At the end of 2017, PERC accounted for about a third of silicon cell manufacturing capacity (EnergyTrend, 2018) expected, due to rapidly increasing market share, to exceed 50% by the early 2020s.

Key concepts Green pioneered, now standard in high efficiency cell design, include small area contacts to limit detrimental impacts (Appl. Phys. Lett. 27, 287, 1975), thin oxide layers along cell surfaces, culminating in enshrouding virtually the entire surface by oxide in his 25% efficient cells (Solid-State Electron. 17, 551, 1974; 17, 562, 1974), inversion layers under such oxides to reinforce this action (Appl. Phys. Lett. 33, 179, 1978), moderate doping to control Auger impacts (IEEE Trans. ED-31, 671, 1984), non-ergodic geometrical light-trapping using macroscopic surface texture (J. Appl. Phys. 62, 243, 1987), electro-luminescence to monitor cell quality (Nature 412, 805, 2001), as well as invention of successive generations of devices exploiting these features (Prog. In PV 17, 183, 2009).

Recent rapid cost reductions (and future reductions through PERC cell uptake) are a direct consequence. Staff and students developing their expertise conducting this research spearheaded the establishment of the Asian PV manufacturing industry through several Australian joint ventures. Successful capital raising on US exchanges financed the rapid expansion of this manufacturing, dramatically reducing cost (PV Magazine, July 2016, p.96). In related work, Green supplied cells for the first PV system converting sunlight to electricity with 20% efficiency in 1989, with his team boosting to 40% efficiency in 2014.

Green received the Bachelor in Engineering from the University of Queensland in 1970, his PhD from McMaster University, Canada, in 1974 and a Doctor of Engineering from UNSW in 2010. He is a Fellow of the IEEE, the Australian Academy of Science and of the Royal Society, London. His work has been recognised by several major awards including the IEEE J.J. Ebers Award (1995) and the IEEE Wm R. Cherry Award (1991).