

## Explanatory Notes for NREL’s “Best Research-Cell Efficiencies” Chart

The National Renewable Energy Laboratory (NREL) maintains a plot of compiled values of highest confirmed conversion efficiencies for research cells, from 1976 to the present, for a range of photovoltaic technologies.

Devices included in this plot of the current state of the art have efficiencies that are confirmed by independent, recognized test labs (e.g., NREL, AIST, Fraunhofer) and are reported on a standardized basis. The measurements for new entries must be with respect to Standard Test or Reporting Conditions (STC) as defined by the global reference spectrum for flat-plate devices and the direct reference spectrum for concentrator devices as listed in standards IEC 60904-3 edition 2 or ASTM G173. The reference temperature is 25°C and the area is the cell total area or the area defined by an aperture.

Cell efficiency results are provided within different families of semiconductors: (1) multijunction cells, (2) single-junction gallium arsenide cells, (3) crystalline silicon cells, (4) thin-film technologies, and (5) emerging photovoltaics. Some 26 different subcategories are indicated by distinctive colored symbols.

The most recent world record for each technology is highlighted along the right edge in a flag that contains the efficiency and the symbol of the technology. The company or group that fabricated the device for each most-recent record is bolded on the plot.

The information plotted by NREL is provided in good faith, but NREL cannot accept direct responsibility for any errors or omissions. The plot is not copyrighted and may be used in presentations and publications, with a notation included that states: “This plot is courtesy of the National Renewable Energy Laboratory, Golden, CO.”

### Company/Institution Acronyms or Abbreviations used as Labels on the Efficiency Chart

Label	Full name
AIST	National Institute of Advanced Industrial Science and Technology
Alta	
AMETEK	
Amonix	Amonix, Inc.
ARCO	Atlantic Richfield Company
ASU	Arizona State University
Boeing	The Boeing Company
DGIST	Daegu Gyeongbuk Institute of Science and Technology
EMPA	Swiss Federal Laboratories for Materials Science and Technology
EPFL	École polytechnique fédérale de Lausanne

EuroCIS	
FhG-ISE	Fraunhofer Institute for Solar Energy Systems
FirstSolar	First Solar, Inc.
FhG-ISE	Fraunhofer Institute for Solar Energy Systems
GE	
GIT	Georgia Institute of Technology
Heliatek	
HKUST	Hong Kong University of Science and Technology
HZB	Helmholtz-Zentrum Berlin
IBM	International Business Machines
ISCAS	Institute of Chemistry–Chinese Academy of Sciences
IES-UPM	Instituto de Energía Solar–Universidad Politécnica de Madrid
ISCAS	Institute of Semiconductors–Chinese Academy of Sciences
ISFH	Institute for Solar Energy Research Hamelin
JpnEnergy	Japan Energy
Kaneka	Kaneka Solar Energy
Kodak	
Konarka	Konarka Technologies, Inc.
Kopin	Kopin Corporation
KRICT	Korea Research Institute of Chemical Technology
LG	
Matsushita	
Mitsubishi	Mitsubishi Chemical Corporation
Mobil	
Monosolar	Monosolar Company Limited
NIMS	National Institute for Materials Science
NCSU	North Carolina State University
NREL	National Renewable Energy Laboratory
Oxford	
Oxford PV	
Panasonic	
Phil66	
PE	
Plextronics	Plextronics, Inc.
RadboudU	Radboud University
RCA	
SNL	Sandia National Laboratories
Sanyo	Sanyo Electric Company, Ltd.
Sharp	Sharp Solar
Siemens	

Soitec	
SolarFron	Solar Frontier
SolarJunc	Solar Junction Corporation
Solarex	
Solarmer	
Solexel	
Solibro	Solibro GmbH
Spectrolab	Spectrolab, Inc.
Spire	
SpireSemicon	Spire Semiconductor, LLC
Stanford	Stanford University
Sumitomo	Sumitomo Chemical Co., Ltd.
SunPower	SunPower Corporation
Trina	
UDresden	University of Dresden
UGroningen	University of Groningen
ULinz	University of Linz
UMaine	University of Maine
UQueensland	University of Queensland
USF	University of South Florida
UStuttgart	University of Stuttgart
UToronto	University of Toronto
UCLA	University of California, Los Angeles
UNIST	Ulsan National Institute of Science and Technology
UniSolar	
UNSW	University of New South Wales
UNSW/Eurosol	
Varian	Varian Semiconductor
Westinghouse	
ZSW	Zentrum für Sonnenenergie- und Wasserstoff- Forschung Baden-Württemberg (Centre for Solar Energy and Hydrogen Research Baden-Württemberg)