

Acronyms, Abbreviations, and Definitions

ΔK	driving force	ATM-PP	benzyltrimethylammonium functionalized Diels-Alder poly(phenylene)
ΔS	entropy change		
2-D	two-dimensional	ATO	antimony-doped tin oxide
3-D	three-dimensional	AVT	A. V. Tchouvelev & Associates, Inc.
A	ampere		
AB	acetylene black	AWARE-US	Available water remaining for the United States
ABS	American Bureau of Shipping		
AC	activated carbon	AWSM	advanced water splitting materials
ACI	ACI Services, Inc.	B	magnetic induction
(AD)Fe-N-C	atomically dispersed iron-nitrogen-carbon	BAPDA	Bay Area Planning Directors Association
		BaSce	Baseline Scenario analysis
AEM	anion exchange membrane	BCM	$BaCe_{0.25}Mn_{0.75}O_3$
AEMEl	alkaline exchange membrane electrolyzer	BESS	battery energy storage system
AEMFC	anion exchange membrane fuel cell	BET	Brunauer-Emmett-Teller
AEO	Annual Energy Outlook	BEV	battery electric vehicle
AEP	amino ethyl piperazine	BMO	$BaMnO_3$
AFCB	American Fuel Cell Bus	BOC	best of class
AFDC	Alternative Fuels Data Center	BOL	beginning of life
AFM	atomic force microscopy	BOP	balance of plant
AHJ	authority having jurisdiction	BOS	balance of system
AHMF	advanced hydrogen mobile fueler	BP	budget period
AIChE	American Institute of Chemical Engineers	BP-Ar(F _x)	perfluoroalkylsulfonate polymer(s)
		BPN	alkyl ammonium functionalized poly(biphenylene); biphenylene
ALD	atomic layer deposition		
AMFC	alkaline membrane fuel cell	BPN1	quaternary ammonium functionalized biphenyl-based polymer
AMM	Advanced Materials Manufacturing		
AMR	active magnetic regenerator; Annual Merit Review	BPSH	biphenylsulfonic acid
ANL	Argonne National Laboratory	BTMAOH	benzyltrimethylammonium hydroxide
ANSI	American National Standards Institute		
API	application program interface	BUT	butanediol
APS	Advanced Photon Source	BYZ	barium yttrium zirconate
APU	auxiliary power unit	C&S	codes and standards
ASME	American Society of Mechanical Engineers	C5	five-carbon sugar (hemicellulose)
		C6	six-carbon sugar (cellulose)
ASR	area specific resistance	CaFCP	California Fuel Cell Partnership
AST	accelerated stability test; accelerated stress test	CARB	California Air Resources Board
ASTM	ASTM International	CBM	conduction band minimum
atmA	atmospheres pressure, absolute	CcH ₂	cryo-compressed hydrogen
		CCL	cathode catalyst layer
		CCM	catalyst-coated membrane

CCSI	continuous codes and standards improvement	dge	diesel gallon equivalent
CDO	code development organization	DGEBA	diglycidyl ether of bisphenol A
CDP	composite data product	DGEBF	diglycidyl ether of bisphenol F
CEC	California Energy Commission	DH	dehydrogenation
CF	carbon fiber; characterization factor	DIC	digital image correlation
CFD	computational fluid dynamics	DMA	dynamic mechanical analysis
CH	chemical hydrogen storage	DMAc	dimethylacetamide
cH ₂	compressed hydrogen	DME	dimethyl ether
CHS	Center for Hydrogen Safety	DMF	dimethylformamide
CL	catalyst layer	DMFC	direct methanol fuel cell
cm ²	square centimeters	DMIm	1,2-dimethylimidazole
CMU	Carnegie Mellon University	DMR	de-acetylated and mechanically refined
CNG	compressed natural gas	DMSO	dimethylsulfoxide
CO	carbon monoxide	DOE	U.S. Department of Energy
Co	cobalt	DOT	U.S. Department of Transportation
CO ₂	carbon dioxide	DR	demand response
COD	chemical oxygen demand	DRIFTS	diffuse reflectance infrared Fourier transform spectroscopy
CoF	coefficient of friction	DRTS	digital real-time simulator
COF	covalent organic framework	DSM	dimensionally stable membrane
Cold-cH ₂	cold-compressed hydrogen	DSM 1313	Deutsche Sammlung von Mikroorganismen 1313
COPV	composite overwrapped pressure vessel	DSRC	dedicated short-range communication
CPM	cycles per minute	EASIUR	Estimating Air pollution Social Impact Using Regression
CRC	cyclic redundancy check	ECSA	electrochemical surface area
CS	carbon steel	ED	electroless deposition
CSA	compact SOEC architecture	ED	Entner–Doudoroff pathway
CSA	Canadian Standards Association	EDC	Energy Dispatch Controller
CSM	Ce _x Sr _{2-x} MnO ₄	EDS	energy dispersive X-ray spectroscopy
CTE	coefficient of thermal expansion	EDXS	energy dispersive X-ray spectroscopy
CTE	Center for Transportation and the Environment	EERE	Office of Energy Efficiency and Renewable Energy
CY	calendar year	EG	ethylene glycol; expanded graphite
D-A	Dubinin-Astakhov	EHC	electrochemical hydrogen compressor/compression
DAPP	Diels-Alder poly(phenylene)	EIS	electrochemical impedance spectroscopy
DC	direct current	EMN	Energy Materials Network
DDCA	durability descriptor calculation automation	EMP	Embden-Meyerhof-Parnas pathway
DDS	dodecyl succinic anhydride	EMTA-NLA	Eshelby-Mori-Tanaka–Nonlinear Analysis
DETA	diethylene triamine		
DETAIL	Dynamic Energy Transport and Integration Laboratory		
DFMA	Design for Manufacture and Assembly		
DFT	density functional theory		

ENG	expanded natural graphite	FMEA	failure mode and effects analysis
EOD	electro-osmotic drag	F-MEC	fermentation and microbial electrolysis cell
EOL	end of life		
EOT	end of test	FMVSS	Federal Motor Vehicle Safety Standard
EPDM	ethylene propylenediamene		
ePTFE	expanded polytetrafluoroethylene	FNR	false-negative rate
eREV/EREV	extended range electric vehicle	FOA	funding opportunity announcement
ETFE	ethylene tetrafluoro ethylene polymer	FOM	figure of merit
		FPGA	field-programmable gate array
ETFECS	extended thin film electrocatalyst structures	FPR	false-positive rate
		FTA	Federal Transit Administration
EV	electric vehicle	FTIR	Fourier transform infrared spectroscopy
EW	equivalent weight		
F ⁻	fluoride ion	FTO	fluorine-doped tin oxide
FASTSim	Future Automotive Systems Technology Simulator	FY	fiscal year
		FZ	fusion zone
FC	fuel cell	g	grams
FCEB	fuel cell electric bus	g/s	grams per second
FCET	fuel cell electric truck	GCMS	gas chromatography-mass spectrometry
FCEV	fuel cell electric vehicle		
FCGR	fatigue crack growth rate	GDC	Gd _{0.1} Ce _{0.9} O _{1.95}
FCH JU	Fuel Cell and Hydrogen Joint Undertaking	GDE	gas diffusion electrode
		GDL	gas diffusion layer
FC-PAD	Fuel Cell Performance and Durability	Gen	generation
		GEN-II	second generation active magnetic regenerative refrigerator prototype
FCPP	fuel cell power plant	gge	gasoline gallon equivalent
FCS	fuel cell system	GH2	gaseous hydrogen
FCTO	Fuel Cell Technologies Office	GISAXS	grazing-incidence small-angle X-ray scattering
FCTT	Fuel Cell Tech Team		
FCV	fuel cell vehicles	GN2	gaseous nitrogen
FE	finite element; Office of Fossil Energy	GNG	go/no-go
FEA	finite element analysis	GPC	gel permeation chromatography
FEC	front end controller	GREET	Greenhouse gases, Regulated Emissions, and Energy use in Transportation model
FEMP	Federal Energy Management Program		
FeN ₄	iron atom coordinated to four nitrogen atoms	GSE	ground support equipment
FeN _x	iron atom coordinated to “x” nitrogen atoms	GT	graphene tube
		GTR	Global Technical Regulation
Fe _x N _y	iron-nitrogen species with “x” iron atoms coordinated to “y” nitrogen atoms	GUI	graphical user interface
		GWE	Greenway Energy, LLC
Fe-Zn-ZIF	zinc and iron zeolitic imidazolate framework	GWR	groundwater recharge
		H	magnetic field induced by circulating current in a superconducting magnet
FHWA	Federal Highway Administration	H ₂	hydrogen

H2A	Hydrogen Analysis model	HSC	high-surface-area carbon; high-surface carbon
H ₂ btdd	bis(1 <i>H</i> -1,2,3-triazolo[4,5- <i>b</i>],[4',5'- <i>i</i>])dibenzo[1,4]dioxin]	HSECoE	Hydrogen Storage Engineering Center of Excellence
H2FIRST	Hydrogen Fueling Infrastructure Research and Station Technology project	HSP	Hydrogen Safety Panel
H ₂ PhOHpydc	6-(4-carboxy-2-hydroxyphenyl)nicotinic acid	HT	high throughput
H ₂ S	hydrogen sulfide	HTAE	high-temperature alkaline electrolysis
H2VGI	hydrogen vehicle to grid integration	HTE	high-temperature electrolysis
H70	hydrogen service at 70 bar or 70 MPa	HTF	heat transfer fluid
HAADF	high angle annular dark field	HT-PEMFC	high-temperature polymer electrolyte membrane fuel cell
HA-FCG	hydrogen accelerated fatigue crack growth	HTT	hydrogen transport trailer
HAVO	Hawaii Volcanoes National Park	HX	heat exchanger
HAZ	heat affected zone	HyLine	high-pressure hydrogen pipeline for intra-urban distribution
HCD	hydrogen contaminant detector	HyMARC	Hydrogen Materials Advanced Research Consortium
HCD	high current density	HyRAM	Hydrogen Risk Assessment Models
HDPE	high-density polyethylene	HyReS	Hydrogen Regional Sustainability Framework
HDSAM	Hydrogen Delivery Scenario Analysis Model	HyS	hybrid sulfur
HDV	heavy-duty vehicle	HySCORE	Hydrogen Storage Characterization and Optimization Research Effort
HER	hydrogen evolution reaction	HyWAM	hydrogen wide area monitoring
HES	hydrogen energy system	Hz	Hertz
HEV	hybrid electric vehicle	I/C	ionomer-to-carbon ratio
HFC Nexus	Hydrogen Fuel Cell Nexus for the United States	I:C	ionomer-to-carbon ratio
HFR	high-frequency resistance	ICEV	internal combustion engine vehicle
HGV	hydrogen gas vehicle	ICHS	International Conference on Hydrogen Safety
HHC	Hawaii Hydrogen Carriers	ICP-MS	inductively coupled plasma mass spectrometry
Highway	EPA drive cycle representing highway type driving	IEC	ion exchange capacity
HIL	hardware-in-the-loop	IEEE	Institute of Electrical and Electronics Engineers
HiPoD	high power density cell	IFC	International Fire Code
HITRF	Hydrogen Infrastructure Testing and Research Facility	IJHE	International Journal of Hydrogen Energy
HNEI	Hawaii Natural Energy Institute	im	mass activity
HOR	hydrogen oxidation reaction	IMM	inverted metamorphic multijunction
HP	high pressure metal hydride candidate materials	INL	Idaho National Laboratory
HRS	hydrogen refueling station	IPA	isopropanol / 2-propanol
HR-TEM	high-resolution transmission electron microscopy	IR	infrared
HSAC	high-surface-area carbon		

<i>iR</i> -corrected	voltage/potential corrected for cell resistance	LSCF	(La,Sr)(Co,Fe)O ₃
<i>iR</i> -free	voltage/potential corrected for cell resistance	LTE	low-temperature electrolysis
IRIG	Inter-Laboratory Research Integration Group	mA	milliampere
IRS	ionomer-rich-surface	MA	mass activity
is	specific activity	MARAD	Maritime Administration
ISO	International Organization for Standardization	MarFC	maritime fuel cell
ITC	Investment Tax Credit	MAS NMR	magic angle spinning nuclear magnetic resonance
J-M	Johnson-Matthey	MASC	multi-acid side chain
JRC	(European) Joint Research Centre	MATI	modular adsorbent tank insert
K	Kelvin	MAWP	maximum allowable working pressure
KB	Ketjen black	max	maximum
kg	kilogram	MBE	molecular beam epitaxy
kMC	kinetic Monte Carlo	MBRC	miles between roadcall
kPaA	kiloPascals pressure, absolute	MCE	magnetocaloric effect
kW	kilowatt	m-CFDE	multi-electrode channel flow double electrode
kWh	kilowatt-hour	MCH	methyl cyclohexane
kW _{net}	net kilowatt electric	MCHL	magnetocaloric hydrogen liquefier
L	liter	MDHD	medium duty and heavy duty (vehicles)
L/D	length-to-diameter ratio	<i>m</i> -dobdc	4,6-dioxido-1,3-benzenedicarboxylate
LANL	Los Alamos National Laboratory	MDV	medium-duty vehicle
lbf	pound force	MEA	membrane electrode assembly
LBNL	Lawrence Berkeley National Laboratory	MEC	microbial electrolysis cell
lb	pounds mass	MeOH	methanol
LCD	low current density	MgB ₂ -THF	magnesium boride reacted with tetrahydrofuran
LDPE	low density polyethylene	MH	metal hydride
LDV	light-duty vehicle	MHC	metal hydride compressor
LH2	liquid hydrogen	Micro CT	micro computed tomography
LHC	liquid hydrogen carrier	MLVSI	multi-layer vacuum insulation
LHV	lower heating value	MMT	million metric tonnes
LI	laboratory instruction	MO	metal oxide
LLNL	Lawrence Livermore National Laboratory	MOCVD	metal organic chemical vapor deposition
LMRC	linear motor reciprocating compressor	MOF	metal organic framework
LN2	liquid nitrogen	MoP	molybdenum phosphide
LP	low pressure	MPa	megaPascal
LP@PF	low Pt@PGM-free	mph	miles per hour
LP@PFNF	low Pt@PGM-free nanofiber	MPL	microporous layer
LPHC	liquid phase hydrogen carrier	MSC	medium-surface-area carbon
LSAC	low-surface-area carbon		

MTA	County of Hawaii Mass Transit Agency	NTCNA	Nissan Technical Center North America
mV	millivolt	NTO	niobium-doped titanium oxide
MW	megawatt	NU	Northwestern University
MWh	megawatt-hour	O ₂	oxygen
MY	model year	OBU	onboard unit
MYRDD	Multi-Year Research, Development, and Demonstration	OCTA	Orange County Transportation Authority
NA	not applicable	OCV	open circuit voltage
NADH	nicotinamide adenine dinucleotide	OEM	original equipment manufacturer
NADPH	nicotinamide adenine dinucleotide phosphate	OER	oxygen evolution reaction
nano-CT	nanoscale X-ray computed tomography	OH	hydroxide
NaOH	sodium hydroxide	ORNL	Oak Ridge National Laboratory
NASA	National Aeronautics and Space Administration	ORR	oxygen reduction reaction
NBR	nitrile butyl rubber	OVC	ordered-vacancy compound
NC	nanocomposite	P	pressure
NDA	nondisclosure agreement	P&ID	pipng and instrumentation diagram
NE	Office of Nuclear Energy	PA	phosphoric acid
NELHA	Natural Energy Laboratory Hawaii Authority	PAA	poly(acrylic acid)
NFCTEC	National Fuel Cell Technology Evaluation Center	PAN	polyacrylonitrile
NFPA	National Fire Protection Association	PAP-TP-Me	poly(aryl piperidine) triphenyl methyl
NH ₃	ammonia	PAP-TP-MQN	poly(aryl piperidine) triphenyl mono quaternary ammonium
NHE	normal hydrogen electrode	PBI	polybenzimidazole
NHTSA	National Highway Traffic Safety Administration	PBI-PA	polybenzimidazole phosphoric acid
NIST	National Institute of Standards and Technology	PCE	proton conducting membrane
nm	nanometer	PCT	pressure, composition, temperature
NMP	N-methylpyrrolidone	Pd	palladium
NMR	nuclear magnetic resonance	PE	polyethylene
nPA	1-propanol l	PEC	photoelectrochemical
NPTF	nanoporous thin film	PEEK	polyetheretherketone
NPV	net present value	PEFC	polymer electrolyte fuel cell
NREL	National Renewable Energy Laboratory	PEM	polymer electrolyte membrane; proton exchange membrane
NSF DMREF	National Science Foundation Designing Materials to Revolutionize and Engineer our Future	PEMFC	polymer electrolyte membrane fuel cell; proton exchange membrane fuel cell
NSTF	nanostructured thin film	PEN	pentanediol
		PET	polyethylene terephthalate
		PF	perfluoro
		PFD	process flow diagram
		PFIA	perfluoro imide-acid
		PFSA	perfluorosulfonic acid
		PF-SFP	fluoride precursor

PG&E	Pacific Gas and Electric	QRA	quantitative risk assessment; quantitative risk analysis
PGM	platinum group metal		
PHA	preliminary hazard analysis; preliminary hazard assessment	R	load ratio
PI	principal investigator	R&D	research and development
Pip	piperidine	R2R	roll-to-roll
PL	photoluminescence	RCS	regulations, codes, and standards
PLL	potential loss of life	RD&D	research, development, and demonstration
PNNL	Pacific Northwest National Laboratory	RDE	rotating disk electrode
ppb	parts per billion	REF	Renewable Electricity Futures study
PPS	polyphenylene sulfide	RFP	request for proposals
PPS-40GF	polyphenylene sulfide with 40% glass fiber filler	RGA	residual gas analysis
PPSU	polyphenylsulfone	RH	rehydrogenation; relative humidity
PSD	particle size distribution	RHE	reversible hydrogen electrode
psi	pounds per square inch	RIF	infrared/reactive impinging flow
psig	pounds per square inch gage	RMSE	root mean square error
PSIS	powder sputter and implant system	RO ₂	local oxygen transport resistance
PSM	post-synthetic modification	ROI	record of invention
PSU	Pennsylvania State University	RPI	Rensselaer Polytechnic Institute
Pt	platinum	RPN	risk priority number
Pt/C	carbon-supported platinum	RRDE	rotating ring-disk electrode
PtCo	platinum-cobalt	RSDT	reactive spray deposition technology
PtCo/HSC	platinum and cobalt on high- surface-area carbon	RSU	roadside unit
PTFE	polytetrafluoroethylene	RT	room temperature
PTL	porous transport layer	RTO	ruthenium dioxide-titanium dioxide
PtNi	platinum-nickel	RTS	real-time simulation
PtNiNW	platinum-nickel nanowire	S&T	shell and tube (heat exchanger)
PtNW	platinum nanowire	SA	Strategic Analysis Inc.
PtRu	platinum-ruthenium	SAE	SAE International
Pt-TF	platinum-thin-film	SARTA	Stark Area Regional Transit Authority
PUD	pick-up and delivery (vehicles)	SASB	Sustainability Accounting Standards Board
PV	pressure volume	SBIR	Small Business Innovation Research
PVD	physical vapor deposition	SBV	Small Business Voucher
PWN	phosphonated poly(pentafluorosytrene)	SCAN	strongly constrained appropriately normed
PXRD	powder X-ray diffraction		
Pyr	pyridine	sccm	standard cubic centimeters per minute
Q	heat	SDE	SO ₂ depolarized electrolyzer
QA	quatarnary ammonium	SDO	standards development organization
QAP	quatarnary ammonium polymer		
QC	quality control		
QE	quantum efficiency		

SEBS	poly(styrene- <i>b</i> -(ethylene- <i>co</i> -butylene)- <i>b</i> -styrene)	TEM-EELS	transmission electron microscopy with electron energy loss spectroscopy
SED	strong electrostatic deposition	TETA	triethylene tetramine
SEM	scanning electron microscopy	Tg	glass transition temperature
SERA	Scenario Evaluation and Regionalization Analysis model	TGA	thermogravimetric analysis
SES	poly(styrene- <i>b</i> -ethylene- <i>b</i> -styrene)	THF	tetrahydrofuran
SFR	stagnation flow reactor	TIR	(SAE) Technical Information Report
SIO	Scripps Institution of Oceanography	TJ	tunnel junction
SISSO	sure independence screening and sparsifying operator	TKK	Tanaka Kikinzoku Kogyo K. K.
SLPM	standard liters per minute	TM	transition metal
SMR	steam methane reforming	TMA	trimethylamine
SMSI	strong metal support interaction	TMAC6PP	hexamethyl ammonium functionalized Diels-Alder poly(phenylene)
SMYS	specified minimum yield strength	TPD	thermally programmed desorption
SNL	Sandia National Laboratories	TPN	alkyl ammonium functionalized poly(terphenylene)
SOA	state of the art	TPRE	through-plane reactive excitation
SOEC	solid oxide electrolysis cell	tribo-	tribology
SOFC	solid oxide fuel cell	TRU	transport refrigeration unit
SPS	suspension plasma spray	TS	Technical Standard
SRNL	Savannah River National Laboratory	TTA	technology transfer agreement
SS	stainless steel	U.S.	United States
STC	solar thermochemical	UALR	University of Arkansas at Little Rock
STCH	solar thermochemical hydrogen	UCI	University of California, Irvine
STEM	scanning transmission electron microscopy	UConn	University of Connecticut
STF	$\text{Sr}(\text{Ti}_{0.3}\text{Fe}_{0.7})\text{O}_3$	UDDS	EPA drive cycle representing city type driving
STFC	$\text{Sr}(\text{Ti}_{0.3}\text{Fe}_{0.63}\text{Co}_{0.07})\text{O}_3$	UES	Unique Electric Solutions
STH	solar-to-hydrogen	UK CAER	University of Kentucky Center for Applied Energy Research
STWS	solar thermochemical water splitting	ULCL	ultra-low catalyst loading
SUNY	State University of New York	UN	United Nations
SWIFT	structured what-if analysis	UPS	United Parcel Service
SwRI	Southwest Research Institute	US06	EPA drive cycle with aggressive accelerations and some high-speed sections
sys/yr	systems per year	USAXS	ultra-small-angle X-ray scattering
T	temperature	USC	University of South Carolina
TBD	to be determined	USCAR	United States Council for Automotive Research
TC	technical committee	USCG	United States Coast Guard
Tc	Curie temperature	USGS	United States Geological Survey
TCO	total cost of ownership		
TEA	techno-economic analysis		
TEDS	thermal energy distribution system		
TEM	transmission electron microscopy		

UT-CEM	The University of Texas–Center for Electromechanics
UTF	ultrathin film
UTRC	United Technologies Research Center
UUV	unmanned underwater vehicle
UV	ultraviolet
V DC	voltage DC
VAC	volts alternating current
VACD	variable area control device
VBM	valence band maximum
VTIR	variable-temperature infrared
W/m ²	Watts per square meter
WaMM	water management membrane
WAVE	Wireless Access in Vehicular Environments
XAFS	X-ray absorption fine structure
XANES	X-ray absorption near-edge structure
XAS	X-ray absorption spectroscopy
XCT	X-ray computed tomography
XES	X-ray emission spectroscopy
XPS	X-ray photoelectron spectroscopy
XRD	X-ray diffraction
XRF	X-ray fluorescence
YSZ	(ZrO ₂) _{0.92} (Y ₂ O ₃) _{0.08}
ZANZEFF	Zero- and Near Zero-Emission Freight and Facilities
ZEBA	Zero Emission Bay Area
ZIF	zeolitic imidazolate framework
(Zn _{1-x} Fe _x)ZIF-F	zinc and iron zeolitic imidazolate framework fiber