

## XI. Acronyms and Abbreviations

°C	Degrees Celsius	ACR	Autothermal cyclic reforming
°F	Degrees Fahrenheit	ACS	American Chemical Society
1-D, 1D	One-dimensional	AC-Transit	Alameda Contra Costa Transit
2-D, 2D	Two-dimensional	AE	Alkaline earth
3-D, 3D	Three-dimensional	AEET	Alternative Energy Engineering Technician
1Q	First quarter of the fiscal year	AEO	Annual Energy Outlook
2Q	Second quarter of the fiscal year	AES	Auger electron spectroscopy
3Q	Third quarter of the fiscal year	AFM	Atomic force microscopy
4Q	Fourth quarter of the fiscal year	Ag	Silver
6F	Hexafluorinated (biphenol A) sulfonated poly(arylene ether sulfone)	AgCl	Silver chloride
6FCN-x	HexaFluoro bisphenol A based disulfonated polybenzoxirle (H <sup>+</sup> form) (x denotes degree of sulfonation)	AHCHG	Ad Hoc Committee for Hydrogen Gas
6F-x	HexaFluoro bisphenol A based disulfonated polySulfone (H <sup>+</sup> form) (x denotes degree of sulfonation)	AIBN	Azobisisobutyl nitrile
ΔH	Enthalpy; heat of reaction	AIChE	American Institute of Chemical Engineers
ΔH <sub>f</sub> <sup>o</sup>	Standard heat of formation	AirCred	Air Quality Credits calculation software tool developed by ANL
ΔP	Pressure drop, pressure change	AK	Alkali
λ	Lambda, hydration number	Al	Aluminum
μA	Micro ampere(s)	AlCl <sub>3</sub>	Aluminum chloride
μA/cm <sup>2</sup>	Micro ampere(s) per square centimeter	ALD	Atomic layer deposition
μg	Microgram(s)	AlH <sub>3</sub>	Aluminum hydride; alane
μm	Micrometer(s); micron(s)	Al <sub>2</sub> O <sub>3</sub>	Aluminum oxide
μM	Micromolar	Alt-G1	Alternative dendron generation-one
μmol	Micromole(s)	AM	Air mass
μΩ-cm <sup>2</sup>	Micro-ohm(s) - square centimeter	AM 1.5	Air Mass 1.5 solar illumination
μV	Micro volt(s)	ANL	Argonne National Laboratory
Ω	Ohm(s)	ANS	American Nuclear Society
Ω-cm <sup>2</sup>	Ohm-square centimeter	ANSI	American National Standards Institute
ρ <sub>a</sub>	Apparent density of activated carbon	ANT	Albany Nano Tech, SUNY
ρ <sub>ad.H<sub>2</sub></sub>	Adsorbate hydrogen density in micropores	APCI, APCi	Air Products and Chemicals, Inc.
A	Ampere, amp	APR	Aqueous-phase reforming
Å	Angstrom	APS	Arizona Public Service
AB	Ammonia borane	APS	American Physical Society
ABI	Automated Ball Indentation, Agent-Based Investment	APU	Auxiliary power unit
ABM	Agent-based modeling	AR	Adsorption reactor
ABMS	Agent-based modeling and simulation	a.u., A.U.	Arbitrary Units
ABPBI	Poly(2,5-benzimidazole)	Ar	Argon
A/cm <sup>2</sup>	Amps per square centimeter	ARC	Accelerated reaction calorimetry
AC	Alternating current	As	Arsenic
AC	Activated carbon	a-Si	Amorphous silicon
		a-SiGe	Amorphous silicon germanium
		ASM	American Society of Metals
		ASCM	Automotive Systems Cost Model

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ASME	American Society of Mechanical Engineers	BOP, BoP	Balance-of-plant
ASMSS	Anode side membrane support structure	<sup>11</sup> B-NMR	Boron 11 Nuclear Magnetic Resonance
ASPEN	Modeling software	BP	British Petroleum
ASR	Area-specific resistance	BPM	Brushless permanent magnet
ASTM	American Society for Testing and Materials	BPS	Ballard Power Systems
AT	Ammonia triborane	BPSH	Biphenyl sulfone H form; aromatic polysulfone
at%, at.%	Atomic percent	BPSH-x	BiPhenyl based disulfonated polySulfone (H+ form) (x denotes degree of sulfonation)
ATG	Adenine,Thymine,Guanine, the 3 base combinations that indicate the first translatable amino acid on the DNA molecule	BPSH-30	Biphenyl sulfone H form, 30% molar fraction of disulfonic acid unit (30% level of sulfonation)
atm	Atmosphere	BPV	Boiler and Pressure Vessel
ATP	Adenosine triphosphate	Br	Bromine
ATR	Autothermal reformer; autothermal reforming	Br <sub>2</sub>	Diatomic bromine
ATS	Adsorption test stand	BSE	Back scattered electron
Au	Gold	BSS	Bootstrap start
AuS	Gold sulfide	BTU, Btu	British thermal unit(s)
AuSnO <sub>x</sub>	gold supported on hydrous tin oxide	C	Carbon
AuTiO <sub>x</sub>	gold supported on titanium oxide	C	Coulomb
Avg	Average	Ca	Calcium
AVR	Ford's Agent-Based Hydrogen Vehicle Owner and Fuel Retailer model	CA	Carbon aerogel
B	Boron	CaBr <sub>2</sub>	Calcium bromide
Ba	Barium	CaCO <sub>3</sub>	Calcium carbonate
barg	Bar gauge	CAD	Computer-aided design
bcc	Body-centered cubic	CAE	Computer-aided engineering
Be	Beryllium	CAER	Center for Applied Energy Research
BEOS	Bender equation of state	CaFCP	California Fuel Cell Partnership
BES	Basic Energy Sciences office within the DOE Office of Science	Calphad	Calculation of phase diagrams
BESR	Bio-ethanol steam reforming	CAN	Controller area network
BET	Bruner-Emmett-Teller surface area analysis method	CaO	Calcium oxide
B-H	Boron/hydrogen bond	CaS	Calcium sulfide
BH <sub>4</sub>	Borohydride	CbHS	Carbon-based Hydrogen Storage
Bi	Bismuth	CBS	Casa Bonita strain
BM	Ball-milled	cc	Cubic centimeter(s)
BMPFFP	1-butyl-1-methyl-pyrrolidinium tris(pentafluoroethyl)trifluorophosphate	CCD	Charge-coupled device
BN	Boron nitride	cc/g cat/hr	Cubic centimeter(s) per gram catalyst per hour
BNHx	Dehydrogenated ammonia-borane	CCHSS	Complex Compound Hydrogen Storage System
BNL	Brookhaven National Laboratory	CCM	Catalyst-coated membrane
B-O	Boron/oxygen bond	CCT	Continuous cooling transformation
B <sub>2</sub> O <sub>3</sub>	Boron oxide; diboron trioxide	Cd	Cadmium
BOM	Bill of materials	CDC	Carbide-derived carbon
		CDO	Code development organization
		Ce	Cerium

CEA	Commissariat a Energie Atomique	Cr	Chromium
CEC	California Energy Commission	CRBJT	Combined reverse-Brayton Joule-Thompson
CeO <sub>2</sub>	Ceric oxide	CS	Chemically stable
Cermet	Combination of ceramic and metal	CS	Ceramic support
CERT	Committee on Energy Research and Technology	Cs	Cesium
CFC	Chlorofluorocarbon	CSA	Canadian Standards Association
CFD	Computational fluid dynamics	CSA	Cell stack assembly
cfm	Cubic feet per minute	CSMP	Cabot Superior MicroPowders
CGA	Compressed Gas Association	CSR	Catalytic steam reforming
CGO	Cerium gadolinium oxide	CSTT	Codes and Standards Tech Team
CH <sub>2</sub>	Compressed hydrogen gas	CTE	Coefficient of thermal expansion
CH <sub>4</sub>	Methane	CTO	Conductive transparent oxide
C <sub>2</sub> H <sub>4</sub>	Ethylene	CTV	Chevron Technology Ventures LLC
C <sub>2</sub> H <sub>6</sub>	Ethane	Cu	Copper
C <sub>3</sub> H <sub>8</sub>	Propane	CU	University of Colorado
CHARGEH2	GTI hydrogen cylinder filling model	cu.yd.	Cubic yard(s)
CHARM	Cost-effective High-efficiency Advanced Reforming Module	CuO	Cupric oxide, copper(II) oxide
CS	Chemically stabilized	Cu <sub>2</sub> O	Cuprous oxide
Chl	Chlorophyll	CUTE	Clean Urban Transport for Europe
CHP	Combined heat and power	CV	Cyclic voltammetry; cyclic voltammogram
CIS	CuInSe (alloy of copper, indium, and selenium)	CVD	Chemical vapor deposition
Cl	Chlorine	CVS	Chemical vapor synthesis
Cl-Bcat	Catechol chloroborane where boron is bound to catecholate dianion and chlorine (B-Cl)	CWRU	Case Western Reserve University
CLV	City of Las Vegas	CY	Calendar year
cm	Centimeter	CZO	Ceria-zirconia
cm <sup>2</sup>	Square centimeter	d	Day(s)
CMU	Carnegie Mellon University	d <sub>DR</sub>	Dubini-Radushkevich average micropore diameter
CNG	Compressed natural gas	DADB	Diammoniate of diborane
CNT	Carbon nanotube	dB(A)	Decibel(s) A scale
CO	Carbon monoxide	DC	Direct current
Co	Cobalt	DCEC	Delaware County Electric Cooperative, Inc.
CO <sub>2</sub>	Carbon dioxide	DCHX	Direct contact heat exchanger
CoE	Center of Excellence	DDOT	District of Columbia Dept. of Transportation
COF <sub>2</sub>	Carbonyl fluoride	DDT	Deflagration-to-detonation transition
COPV	Composite Overwrapped Pressure Vessel	DFC	Direct fuel cell
COS	Carbon oxysulfide; carbonyl sulfide	DFM	Design for manufacture
CoTPP	Cobalt tetraphenyl porphyrin	DFMA <sup>®</sup>	Design for Manufacture and Assembly
COx	Oxides of carbon	DFSS	Design for six sigma
cp	Commercial purity	DFT	Density functional theory
c.p.s.	Counts per second	DH-RH	Dehydrogenation and rehydrogenation
CPSS	Combinatorial powder synthesis system	DI	Deionized
		dL/g	Deciliters per gram

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DMA	Dynamic mechanical analysis	EGR	Exhaust gas recirculation
DMAc	Dimethyl acetamide	EIA	Energy Information Administration of the U.S. Department of Energy
DME	Dimethyl ether	EIGA IGC	European Industrial Gases Association/Industrial Gases Council
DMFC	Direct methanol fuel cell	EIS	Electrochemical impedance spectroscopy
DNA	Deoxyribonucleic acid	ELAT <sup>®</sup>	Registered Trademark of De Nora North America, Inc., covers GDLs and GDEs
DOD	Depth of discharge	EM	Electromagnetic
DOD	U.S. Department of Defense	EMC	Electromagnetic compatibility
DOE	U.S. Department of Energy	EMF	Enterprise modeling framework
DOT	U.S. Department of Transportation	EMI	Electro magnetic interference
DPAU	Differential pressure adsorption unit	EMTEC	Edison Materials Technology Center
DRIFTS	Diffuse reflectance infrared Fourier transform spectroscopy	eNMR	Electrochemical NMR
DS	Dielectric spectroscopy	EPA	U.S. Environmental Protection Agency
DSC	Differential scanning calorimetry	EPR	Electron paramagnetic resonance
DSM <sup>™</sup>	Dimensionally stable membrane (trademark of Giner Electrochemical Systems, LLC)	EPRI	Electric Power Research Institute
DTA	Differential thermal analysis	ER	Emergency responder
DV	Diesel vehicle	eRAM	Enterprise remote access monitoring
e <sup>-</sup>	Electron	ESEM	Environmental scanning electron microscopy
E	Potential	eV	Electron volt
Ea	Activation energy	EW	Enthalpy wheel
EAN	Ethylammonium nitrate	EW	Equivalent weight
EASA	Electrochemically active surface area	EXAFS	Extended x-ray absorption fine structure analysis
EC	European Community; electro-chemical	F	Fluorine
ECA	Electrochemical area	F	Faraday constant, the amount of electric charge in one mole of electrons (96,485.3383 coulomb/mole)
ECE	Economic Commission for Europe	F <sup>-</sup>	Fluorine ion
ECE-WP29/GRPE	United Nations Economic Commission for Europe, World Forum for Harmonization of Vehicle Regulations, and Working Party on Pollution and Energy Program	FANS	Filter analyzer neutron spectroscopy
ECS	Electrochemical Society	FAT	Fleet Analysis Toolkit
ECSA	Electrochemical surface area	FBMR	Fluidized bed membrane reactor
ECTOS	Ecological City Transport System (Iceland)	FC	Fuel cell
EDAX	Manufacturer of energy dispersive X-ray hardware and software	FCB	Fuel cell bus
EDM	Electrical discharge machining	fcc	Face-centered cubic
EDS	Energy dispersive x-ray spectroscopy; Energy dispersive spectrum	FCC	Federal Communications Commission
EDX	Energy dispersive x-ray	FCCP	Carbonyl cyanide m-chlorophenylhydrazone
EEA	Energy & Environmental Analysis, Inc.	FCE	FuelCell Energy
EELS	Electron energy loss spectroscopy	FCFP	FreedomCAR and Fuel Partnership
EERE	U.S. DOE Office of Energy Efficiency and Renewable Energy	FCPP	Fuel cell power plant
E <sub>0</sub> xE <sub>1</sub>	Utilization efficiency of incident solar light energy	FCS	Fuel cell system
		FCT	Fuel Cell Technologies
		FCTES <sup>QA</sup>	Fuel Cell Testing, Safety and Quality Assurance (an international effort to harmonize fuel cell testing procedures)

FCV	Fuel cell vehicle	gal	Gallon
Fd	Ferredoxin	GAMS	Generalized Algebraic Modeling System, a commercially available software designed for linear and non-linear optimization
FDA	Fleet Data Acquisition		
FE	U.S. DOE Office of Fossil Energy		
Fe	Iron	GaP	Gallium phosphide
Fe <sub>2</sub> O <sub>3</sub>	Ferric oxide	GAS-PASS/H	Simulation code for gas-cooled nuclear reactors
FEA	Finite element analysis	GC	Gas chromatograph
FMEA	Failure mode effects analysis	GC	Glassy, or vitreous carbon; a pure carbon that is amorphous (non- crystalline)
FEP	Fluorinated ethylene propylene; Teflon <sup>®</sup>	GC/MS	Gas chromatograph/Mass spectroscopy
FER	Fluoride emission rate	GCtool	Software package developed at ANL for analysis of fuel cells and other power systems
FERC	Federal Energy Regulatory Commission	Gd	Gadolinium
FET	Field effect transistor	GDC	Gadolinium-doped ceria
FFT	Fast fourier transform	GDE	Gas diffusion electrode
FGHA	Forming gas hydrogen electrode	GDL	Gas diffusion layer
FMEA	Failure modes and effects analysis	GDM	Gas diffusion media
<sup>19</sup> FNMR	<sup>19</sup> Fluorine nuclear magnetic resonance	Ge	Germanium
FOM	Federated object modeling	GE	General Electric
FP	Fuel processor	Gen I	First generation
fpm	Feet per minute	GES	Giner Electrochemical Systems, LLC
FPS	Fuel processing system	GF	Glass fiber
FR	Froude	GGA	Gradient generalized approximation
Fr <sub>den</sub>	densimetric Froude	GGE, gge	Gasoline gallon equivalent
FRP	Fiber-reinforced polymer	GH <sub>2</sub>	Gaseous hydrogen
FSEC	Florida Solar Energy Center	GHG	Greenhouse gas
F-SPEEK	Fluorosulfonic acid of polyetheretherketone	GHSV	Gas hourly space velocity
FST	FuelSell Technologies	GIS	Geographic information system
ft	Feet	GJ	Gigajoule(s)
ft <sup>2</sup>	Square feet	g/kW	Gram(s) per kilowatt
ft <sup>3</sup>	Cubic feet	GM	General Motors
FTA	Federal Transit Administration	gm	Gram(s)
FT-IR, FTIR	Fourier transform infrared	gm/day	Gram(s) per day
FTIR-ATR	Fourier transform infrared attenuated total reflection	g/min	Gram(s) per minute
FTP	Federal Test Procedure	GNF	Graphite nanofiber
FWHM	Full width at half maximum	GPa	Gigapascal(s)
FY	Fiscal year	GPS	Global positioning system
G	Graphite	GREET	Greenhouse Gas Energy and Emissions in Transportation model
G2	Generation-two	GRPE	Working Party on Pollution and Energy
g	Gram; acceleration of gravity	GRSP	Working Party on Passive Safety
g/cc	Grams per cubic centimeter	GTI	Gas Technology Institute
g/kW	Gram(s) per kilowatt	GTR	Global Technical Regulations
g/min	Grams per minute	GV	Gasoline vehicle
g/s	Grams per second		
Ga	Gallium		
GaAs	Gallium arsenic		

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GW	Product of the Green's function, G, and the energy, W	HFCIT	Hydrogen, Fuel Cells and Infrastructure Technologies
GWe	Gigawatt(s) electric	HFCV	Hydrogen fuel cell vehicle
h	Hour(s)	HFI	Hydrogen Fuel Initiative
H	Hydrogen	HFR	High-frequency impedance; high-frequency resistance
H+	Proton	HFS	Hydrogen filling station
$\Delta H$	Enthalpy; heat of reaction	HGM	Hydrogen Generation Module
$\Delta H_f^\circ$	Standard heat of formation	HGMs	Hollow glass microspheres
H <sub>2</sub>	Diatomic hydrogen	HGV4	Hydrogen Gas Powered Vehicle – 4
H <sub>2</sub> A	Hydrogen Analysis project sponsored by DOE	HHV	Higher heating value
H <sub>2</sub> cat	Catechol, 1,2 dihydroxybenzene	HI	Hydrogen iodide
H <sub>2</sub> Lib	Library of H <sub>2</sub> component models in Simulink	HIA	Hydrogen Implementing Agreement
HAD	Hydrogen adsorption/desorption	H <sub>2</sub> ICE	Hydrogen-fueled internal combustion engine
HAMMER	Hazardous Materials Management and Emergency Response	HiPCO HiPCo	High-pressure carbon monoxide
HARI	Hydrogen and Renewables Integration (UK)	HIPOC	Hydrogen Industry Panel on Codes
HATCI	Hyundai-KIA America Technical Center Inc.	HIx	Blend of hydrogen iodide, iodine, and water
HAZ	Heat affected zone	HLA	High level architecture
HAZID	Hazard Identification Analysis	HMC	Hyundai Motor Company
HAZOP	Hazards and Operational Safety Analysis; Hazards and Operability Analysis	HMM	Hidden Markov Model
H-Bcat	Catecholborane where boron is bound to catecholate dianion and a hydride (B-H)	HNEI	Hawaii Natural Energy Institute
HBr	Hydrogen bromide	HNO <sub>3</sub>	Nitric acid
HBU	Hydrogen Based Unit	H <sub>2</sub> O	Water
HCCI	Homogeneous charge compression ignition	H <sub>2</sub> O <sub>2</sub>	Hydrogen peroxide
HCl	Hydrochloric acid	HOMO	Highest occupied molecular orbital
HClO <sub>4</sub>	Perchloric acid	HOR	Hydrogen oxidation reaction
HCNG	Hydrogen-compressed natural gas	HP	High-pressure
HCO <sub>3</sub> <sup>-</sup>	Bicarbonate	hp	Horsepower
hcp	Hexagonal close-packed	HPA	Heteropolyacid
HDPE	High-density polyethylene	HPC	Highly porous carbon
HDSAM	Hydrogen Delivery Scenario Analysis Model	HPE	Hybrid photoelectrode
He	Helium	HPFC	Hydrogen polymer electrolyte membrane fuel cell
HER	Hydrogen evolution reaction	HPLC	High performance liquid chromatograph
HEV	Hybrid electric vehicle	H <sub>3</sub> PO <sub>4</sub>	Phosphoric acid
Hf	Hafnium	hr	Hour(s)
HF	Hydrogen Fueler	HRL	HRL Laboratories, LLC
HF	Hydrofluorhydric acid; hydrogen fluoride	HRTEM	High-resolution transmission electron microscopy
		H <sub>2</sub> S	Hydrogen sulfide
		HSC	Database name derived from the letters for enthalpy, entropy and heat capacity
		HSDC	Hydrogen Secure Data Center
		HSE	health, safety and environmental
		HSO <sub>4</sub>	Bisulfate anion

H <sub>2</sub> SO <sub>4</sub>	Sulfuric acid	IEC	Ion exchange capacity
HSRP	Hydrogen Safety Review Panel	IEEE	Institute of Electrical and Electronics Engineers, Inc.
HT	High-temperature	IGCC	Integrated gasification combined cycle
HTE	High-temperature electrolysis	IGS	Industrial gas supplier
HTF	Heat transfer fluid	IGT	Institute of Gas Technology
HTFC	High-temperature fuel cell	In	Indium
HTGR	High-temperature gas-cooled reactor	In., in	Inch
HTHX	High-temperature heat exchanger	in <sup>2</sup>	Square inch
HTM	High-temperature membrane	INERI	International Nuclear Energy Research Initiative
HTM	Hydrogen transport membrane	INL	Idaho National Laboratory
HTMWG	High Temperature Membrane Working Group	InP	Indium phosphorus
HTS	High-temperature shift; high-throughput screening	IP	Intellectual property
HVAC	Heating, ventilation and cooling	IPE	Integrated photovoltaic electrolysis
HWFET	Highway Fuel Economy Test	IPHE	International Partnership for the Hydrogen Economy
HX	Heat exchanger	IPNS	Intense Pulse Neutron Scattering Facility at Argonne National Laboratory
HyARC	Hydrogen Analysis Resource Center	IR	Infrared
Hydrofill™	GTI hydrogen dispenser filling control algorithm	Ir	Iridium
HyDS model	Hydrogen deployment system model	iR	Internal resistance; voltage loss due to resistance
HyDS ME	HyDS modeling environment	IRMOF	Isorecticular metal organic framework
HYSYS®	Process simulation software by AspenTech	IRR	Internal rate of return
Hythane	Compressed hydrogen natural gas blend	ISO	International Organization for Standardization; International Standards Organization
Hz	Hertz	ISS	Ion scattering spectroscopy
i	Current density (mA/cm <sup>2</sup> )	ITM	Ion transport membrane
I	Current	ITO	Indium tin oxide
I <sub>2</sub>	Diatomic iodine	I-V	Current-voltage
IBAD	Ion beam assisted deposition	J	Current
IBS	Ion beam sputtering	J	Joule(s)
IC	Internal combustion	JM	Johnson Matthey
ICC	International Code Council	JMFC	Johnson-Matthey Fuel Cells
ICE	Internal combustion engine	JPL	Jet Propulsion Laboratory
ICEV	Internal combustion engine vehicle	Jsc	Short circuit current density
ICM	Idealized city model	K	Kelvin
ICMS	Integrated ceramic membrane system	K	Potassium
ICP	Inductively coupled plasma	K <sub>TH</sub>	Hydrogen-assisted crack growth threshold
ICP-MS	Inductively coupled plasma mass spectrometry	kÅ	1000 angstroms
ICR	Interfacial contact resistance	KAERI	Korea Atomic Energy Research Institute
ICSD	Inorganic Crystal Structure Database	kA/m <sup>2</sup>	Kilo-ampere(s) per square meter
ICU	Isotherm characterization unit	kb	Kilo-base pair, a unit of measurement used in genetics equal to 1,000 nucleotides
ID, i.d.	Internal diameter		
IEA	International Energy Agency		
IEC	International Electrotechnical Commission		

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KBr	Potassium bromide	LECO	Instrument for fixed oxygen determination
kcal	Kilocalorie(s)	LEED	Low-energy electron diffraction
kcal/mol	Kilocalorie(s) per mole	LEEM	Low-energy electron microscopy
KeV	Kilo electron volt(s)	LEIS	Low-energy ion scattering
kg	Kilogram(s)	LEL	Lower explosion limit
kg/day	Kilogram(s) per day	LEMSYS	Local Energy Management System
kg/hr	Kilogram(s) per hour	LFL	Lower flammability limit
kg/m <sup>3</sup>	Kilogram(s) per cubic meter	L/h, l/h	Liter(s) per hour
KH	Potassium hydride	LH <sub>2</sub>	Liquid hydrogen
kHz	Kilohertz	LHC	Light-harvesting chlorophyll
kJ	Kilojoule(s)	LHSV	Liquid hourly space velocity
kJ/mol	Kilojoule(s) per mole	LHV	Lower heating value
km	Kilometer(s)	Li	Lithium
KMC	Kia Motors Corporation	LiBH <sub>4</sub>	Lithium borohydride
KOH	Potassium hydroxide	LiH	Lithium hydride
kPa	Kilopascal(s)	Li <sub>3</sub> N	Lithium nitride
kph	Kilometer(s) per hour	LLC	Limited Liability Company
ksi	1,000 pound-force per square inch	LLNL	Lawrence Livermore National Laboratory
kT/y	Kiloton(s) per year	LMDS	Laser modulation differential spectroscopy
kW	Kilowatt(s)	L/min, l/min	Liter(s) per minute
kWe	Kilowatt(s) electric	LNG	Liquefied natural gas
kWh	Kilowatt-hour(s)	LOPA	Layer of protection analysis
kWh/kg	Kilowatt-hour(s) per kilogram	LP	Lattice parameter
kWh/L	Kilowatt-hour(s) per liter	LPG	Liquefied petroleum gas
kW/kg	Kilowatt(s) per kilogram	LPM	Liters per minute
kWt	Kilowatt(s) thermal	LSC	Lanthanum strontium cobalt oxide, (La, Sr)CoO <sub>3</sub>
L, l	Liter(s)	LSCM	Lanthanum strontium chromium manganese oxide, (La, Sr)(Cr, Mn)O <sub>3</sub>
La	Lanthanum	LSCr	Lanthanum strontium chromium oxide, (La, Sr)CrO <sub>3</sub>
λ	Lambda, hydration number	LSM	Lanthanum strontium manganese oxide, (La, Sr)MnO <sub>3</sub>
LANL	Los Alamos National Laboratory	LTU	Lawrence Technological University
LAO	Lanthanum-modified alumina	LWR	Light water reactor
LAX	Los Angeles International Airport	LUMO	Lowest unoccupied molecular orbital
lb	Pound(s)	LVVWD	Las Vegas Valley Water District
lbmol	Pound-mole(s)	m	Meter(s)
LBNL	Lawrence Berkeley National Laboratory	M	Molar
LCA	Life cycle assessment	m <sup>2</sup>	Square meter(s)
LCC	Lansing Community College	m <sup>3</sup>	Cubic meter(s)
LCC	La <sub>0.7</sub> Ca <sub>0.5</sub> CrO <sub>3-δ</sub>	m <sup>2</sup> /g	Square meter(s) per gram
LCHPP	Low Cost Hydrogen Production Platform (DOE Program Title)	m <sup>2</sup> /s	Square meter(s) per second
LCI	Life cycle inventory	M31	Arkema's First-Generation Membrane Candidate
L/D ratio	Ratio of length to diameter		
LDC	Local Distribution Company		
LDMS	Laser modulated differential spectroscopy		
LDV	Light-duty vehicle		

M40	Arkema's Second-Generation Membrane Candidate	mil	Millimeter(s)
mA	MilliAmps	min	Minute(s)
$\mu\text{A}$	Micro ampere(s)	MIT	Massachusetts Institute of Technology
$\text{mA}/\text{cm}^2$	Milliamp(s) per square centimeter	MJ	Megajoule(s)
$\mu\text{A}/\text{cm}^2$	Micro ampere(s) per square centimeter	ML	Monolayer
MACRS	Modified Accelerated Cost Recovery Schedule	mL, ml	Milliliter(s)
MARKAL	Market Allocation Model - A generic, multi-sector energy model developed by the Energy Technology Systems Analysis Program of the International Energy Agency	$\mu\text{m}$	Micrometer(s); micron(s)
MAS	Magic angle spinning	$\mu\text{M}$	Micromolar
MAS-NMR	Magic angle spinning nuclear magnetic resonance	mM	Millimolar
MBE	Molecular beam epitaxy	mm	Millimeter(s)
MBMS	Molecular beam mass spectrometry	MMBtu	Million British thermal units
MC	Monte Carlo	mmol	Millimole(s)
$\text{mC}\cdot\text{cm}^{-2}$	MilliCoulomb(s) per square centimeter	MMOM	Microporous metal organic materials
MCEL	Millenium Cell, Inc.	$\mu\text{mol}$	Micromole(s)
MCFC	Molten carbonate fuel cell	Mn	Manganese
MD	Molecular dynamics	MnO	Manganese oxide
MDCA	Metal-doped carbon aerogels	$\text{Mn}_2\text{O}_3$	Manganese oxide
MEA	Membrane-electrode assembly	$\text{M}\Omega$	Mega-ohm(s)
MEMS	Micro-electro-mechanical systems	$\text{m}\Omega$	Milli-ohm(s)
MEMSYS	Micro-grid Energy Management System	$\mu\Omega\cdot\text{cm}^2$	Micro-ohm(s) - square centimeter
MeOH	Methanol	$\text{m}\Omega/\text{cm}^2$	Milli-ohm(s) per square centimeter
meq	Milliequivalents	MOF	Metal-organic framework
meq/g	Milliequivalents/gram	Mo	Molybdenum
MetCars	Metal-carbon systems	mol	Mole(s)
MeV	Mega electron volt	mol%	Mole percent
Mg	Magnesium	mol/min	Mole(s) per minute
Mg	Megagram(s)	MoPc	Molybdenum phthalocyanine
$\mu\text{g}$	Microgram(s)	MOVES	Motor Vehicle Emission Simulator
mg	Milligram(s)	MPa	Megapascal
$\text{Mg}(\text{OH})_2$	Magnesium hydroxide	MPG, mpg	Mile(s) per gallon
$\text{mg}/\text{cm}^2$	Milligram(s) per square centimeter	mph	Mile(s) per hour
$\text{MgCl}_2$	Magnesium chloride	MPL	Microporous layer
$\text{MgH}_2$	Magnesium hydride	MR	Membrane reactor
MH	Metal hydride	MRI	Magnetic resonance imaging
MHC	Metal hydride compressor	mRNA	message RNA
MHCoE	Metal Hydride Center of Excellence	MRS	Materials Research Society
MHz	Megahertz	ms	Millisecond(s)
MI	Melt infiltration	$\text{mS}/\text{cm}$	Milli-Siemen(s) per centimeter
mi	Mile(s)	MS	Mass spectrometer
mi/kg	Mile(s) per kilogram	MS-EVB	Multi-state empirical valence bond
		MSHA	Mine Safety and Health Administration
		MSM	Macro-System Model
		MSP	Molten state processing
		MSRI	Materials and Systems Research, Inc.
		MSU	Montana State University
		MSW	Municipal solid waste

## XI. Acronyms and Abbreviations

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MT	Mass transport	Nb	Niobium
MTO	Mass transport overpotential	nc-Si:H	Nanocrystalline silicon
$\mu\text{V}$	Micro volt(s)	NCMS	National Center for Manufacturing Sciences
mV	Millivolt(s)	NCNR	NIST Center for Neutron Research
mW	Milliwatt(s)	ND	Not determined at this time
MW	Megawatt(s)	ND	Nitrogen donor
MW	Molecular weight	NDA	Non-disclosure agreement
$\text{mW}/\text{cm}^2$	Milliwatt(s) per square centimeter	NDC	New Delivery Concept
MWe	Megawatt(s) electric	NE	U.S. DOE Office of Nuclear Energy, Science and Technology
MWh	Megawatt-hour(s)	NEBS	Network Equipment Building Standards
MWNT	Multi-wall carbon nanotubes	NEC	NextEnergy Center
MWOE	Midwest Optoelectronics, LLC	NEC	National Electrical Code
MWth	Megawatt(s) thermal	NEED	National Energy Education Development Project
MYPP	Multi-Year Program Plan (the HFCIT Program's Multi-Year Research, Development and Demonstration Plan)	NEMS	National Energy Modeling System
MYRDDP	Multi-Year Research, Development and Demonstration Plan	NEPA	National Environmental Policy Act
N	Normal (e.g., 1N $\text{H}_3\text{PO}_4$ is 1 normal solution of phosphoric acid)	NERI	Nuclear Energy Research Initiative
N	Nitrogen atom	NETL	National Energy Technology Laboratory
N	Newton (unit of force)	NFCRC	National Fuel Cell Research Center
$\text{N}/\text{cm}^2$	Newton(s) per square centimeter	NFPA	National Fire Protection Association
N112	Nafion <sup>®</sup> 1100 equivalent weight, 2 millimeter thick membrane	NG	Natural gas
$\text{N}_2$	Diatomic nitrogen	ng	Nanogram
Na	Sodium	NGCC	Natural gas combined cycle
NA	North American	NGNP	Next Generation Nuclear Plant
$\text{Na}_3\text{AlH}_6$	Trisodium hexahydroaluminate	$\text{NH}_3$	Ammonia
$\text{NaAlH}_4$	Sodium aluminum hydride; sodium tetrahydroaluminate; sodium alanate	NHA	National Hydrogen Association
$\text{NaBH}_4$	Sodium borohydride	NHE	Normal hydrogen electrode
$\text{NaBO}_2$	Sodium borate	NHFC4	National Hydrogen and Fuel Cells Codes and Standards Coordinating Committee
NACE	National Association of Corrosion Engineers	NHI	Nuclear Hydrogen Initiative
NaCl	Sodium chloride	NHTSA	National Highway Traffic Safety Administration of the U.S. Department of Transportation
NACS	North American Catalysis Society	Ni	Nickel
Nafion <sup>®</sup>	Registered Trademark of E.I. DuPont de Nemours	NILS	Normal interstitial lattice sites
NaH	Sodium hydride	NiMH	Nickel metal hydride
NA NG	North American natural gas	NIST	National Institute of Standards and Technology
NaOH	Sodium hydroxide	NL	Normal liter(s)
$\text{Na}_2\text{S}$	Sodium sulfide	NLDFT	Non-local density functional theory
NAS	National Academy of Sciences	nm	Nanometer(s)
NASA	National Aeronautics and Space Administration	NM	Noble metal
NAU	Northern Arizona University	NMR	Nuclear magnetic resonance
		$\text{Nm}^3/\text{h}$ , $\text{nm}^3/\text{hr}$	Normal cubic meter(s) per hour

nmol	Nanomole(s)	OSHA	U.S. Occupational Safety and Health Administration
NNA	Non-North American		
NNA NG	Non-North American natural gas	OTM	Oxygen transport membrane
NNIF	NIST neutron imaging facility	$\Delta P$	Pressure drop, pressure change
NNSA	National Nuclear Security Administration	P	Phosphorus
		P	Pressure
NMR	Nuclear magnetic resonance	Pa	Pascal(s)
NMSU	New Mexico State University	PA	Phenylacetylene
NMTech	New Mexico Technological University	PADD	Petroleum Administration for Defense District
NO <sub>2</sub>	Nitric oxide		
N <sub>2</sub> O	Nitrous oxide	PAFC	Phosphoric acid fuel cell
NO <sub>x</sub>	Oxides of nitrogen	PANI	Polyaniline
NFPA	National Fire Protection Association	PAS	Photoactive semiconductor
NPC	Nanoporous carbon	PAW	Projector augmented wave
NPD	Neutron powder diffraction	Pb	Lead
NPM	Non-precious metal	PbA	Lead acid
NPT	Normal pressure and temperature	PBI	Polybenzimidazole
NPV	Net present value	PbO	Lead oxide
NRC	National Research Council	P-C	Pressure-composition
NRECA	National Rural Electric Cooperative Association	PC	Polycarbonate
		PC	Personal computer
NREL	National Renewable Energy Laboratory	Pc	Phthalocyanines (e.g., MoPc, FePc)
NSF	National Science Foundation	PCF	Polycarbonate film
NSTF	Nanostructured thin film	PCHD	poly(cyclohexadiene)
NVS	Neutron vibrational spectroscopy	PCI	Pressure-composition isotherm
NYSERDA	New York State Energy Research and Development Authority	PCM	Power control module
		PCR	Polymerase chain reaction
O	Oxygen	PCS	Power conditioning system
O <sub>2</sub>	Diatomic oxygen	PCS	Plasma converter system
O/C	Oxygen-to-carbon atomic ratio	PCT, P-C-T	Pressure concentration temperature
OCP	Open circuit potential	Pd	Palladium
OCV	Open circuit voltage	PDA	Phenyldiacetylene
o.d., OD	Outer diameter	Pd-CR	Palladium-based chemical resistor
OEC	Oxygen evolving complex	Pd-Cu	Palladium-copper
OEM	Original equipment manufacturer	Pd-MIS	Palladium-based metal-insulator-semiconductor
OESR	Oxidative ethanol steam reforming		
OGA	Online gas analyzer	PEC	Photoelectrochemical
$\Omega$	Ohm(s)	PECH	Polyepichlorohydrin
$\Omega\text{-cm}^2$	Ohm-square centimeter	PECVD	Plasma-enhanced chemical vapor deposition
OH <sup>·</sup>	Hydroxyl radical		
O&M	Operation and maintenance	PEEK	Polyether ether ether ketone
OMB	Office of Management and Budget	PEFC	Polymer electrolyte fuel cell
ORF	Opening Reading Frame indicating the occurrence of a protein coding region in the DNA sequence	PEFC	Proton exchange fuel cell
		PEI	Polyetherimide
ORNL	Oak Ridge National Laboratory	PEKK	Poly (ether ketone ketone)
ORR	Oxygen reduction reaction	PEM	Polymer electrolyte membrane

## XI. Acronyms and Abbreviations

PEM	Proton exchange membrane	PSAT	Vehicle simulation software package developed at Argonne National Laboratory - Power-train System Analysis Toolkit
PEMFC	Polymer electrolyte membrane fuel cell		
PEMFC	Proton exchange membrane fuel cell		
PES	Polyether sulfone	PSD	Particle size distribution, pore size distribution
PES	Proton Energy Systems, Inc.	psi, PSI	Pound(s) per square inch
PET	Polyethylene terephthalate	psia	Pound(s) per square inch absolute
PFA	Perfluoroalkoxy (a type of fluoropolymer)	psid	Pound(s) per square inch differential
PFC	Polymer electrolyte membrane fuel cell	psig	Pound(s) per square inch gauge
PFCT	Porvair Fuel Cell Technology, Inc.	PSM	Protic salt membrane
PFD	Process flow diagram	PSU	Pennsylvania State University
PFGSE	pulse field gradient spin echo	PSU OPP	Pennsylvania State University, Office of Physical Plant
PFGSE NMR	Pulsed field gradient spin echo nuclear magnetic resonance	PSU PTI	Pennsylvania State University, Pennsylvania Transportation Institute
PFSA	Perfluorinated sulfonic acid	Pt	Platinum
PFSI	Perfluorosulfonate ionomer	Pt-MM	Platinum mixed metal
PGAA	Prompt gamma activation analysis	P-T	Pressure-temperature
PGAA	Prompt-gamma activation analysis	PTA	Phosphotungstic acid
PGM	Platinum group metal	Pt/C	Platinum on carbon
PHIP	Para-hydrogen induced polarization	Pt <sub>3</sub> Co	Platinum-cobalt alloy
PI	Principal investigator	Pt <sub>3</sub> Fe	Platinum-iron alloy
PILs	Protic ionic liquids	PTFE	Teflon <sup>®</sup> – poly-tetrafluoroethylene
Pl	Platinum	Pt-FePO	Platinum iron phosphate
pK <sub>a</sub>	Acid dissociation constant	Pt-MM	Platinum group mixed metal
PLC	Programmable logic controller	PTM	Proton transport membrane
PM	Precious metal, such as platinum; peroxide mitigation	PtML	Platinum monolayer
PM <sub>10</sub>	Particulate matter with diameters of 10 micrometers or less	Pt <sub>3</sub> Ni	Platinum-nickel alloy
P/M	Powder metallurgy	PTO	Power take-off
PMF	potential mean free energy	PtO <sub>2</sub>	Platinum dioxide
PMG	Glycidyl methacrylate-type copolymer	Pt-TaPO	Platinum tantalum phosphate
PNNL	Pacific Northwest National Laboratory	PTW	Pump-to-wheel
POC	Proof of concept	PUC	Public Utility Commission
POSS	Polyhedral oligomeric silsesquioxane	PV	Photovoltaic
POX	Partial oxidation	PVC	Polyvinyl chloride
ppb	Parts per billion	PVD	Physical vapor deposition
ppbv	Part(s) per billion by volume	PVDF	Polyvinylidene fluoride
PPI	Pore(s) per inch	PVP	Polyvinylpyrrolidone
ppm, PPM	Part(s) per million	PVT, P-V-T	Pressure-Volume-Temperature
ppmv	Part(s) per million by volume	PW91	Perdew-Wang 91
ppmw	Part(s) per million by weight	Q1, Q2, Q3, Q4	Quarters of the fiscal year
PPO	Phenyl phosphine oxide	QC	Quality control
PPS	Polyphenylenesulfide	R	Universal or ideal gas constant, 8.314472 J · K <sup>-1</sup> · mol <sup>-1</sup>
PrOx	Preferential oxidation	Raman	a spectroscopic technique
PSA	Pressure swing adsorption, adsorber		

RBS	Rutherford back scattering	SCPO	Staged catalytic partial oxidation
R&D	Research and development	SCR	Selective catalytic reduction
RD&D, R,D&D	Research, development & demonstration	S/cm	Siemen(s) per centimeter
RDE	Rotating disk electrode	SD	Standard deviation
Re	Rhenium	SDAPP	Sulfonated Diels-Alder polyphenylene
REWP	Renewable Energy Working Party	SDAPPe	Sulfonated Diels-Alder polyphenylene ether
Rf	Generic fluoroalkyl group	SDO	Standards Development Organization
RF	Radio frequency	SDT	Simultaneous differential scanning calorimeter and thermalgravimetric analyzer
RFP	Request for proposals	Se	Selenium
RGA	Residual gas analyzer	sec	Second(s)
RH	Relative humidity	SECA	Solid State Energy Conversion Alliance
Rh	Rhodium	SEM	Scanning electron microscopy
RHE	Reference hydrogen electrode; reversible hydrogen electrode	SEM	Secondary electron microscopy
$\rho_a$	Apparent density of activated carbon	SEMaC	Smart Energy Management Controller
$\rho_{ad.H_2}$	Adsorbate hydrogen density in micropores	SEOS	Simple equation of state
RNA	Ribo nucleic acid	SERC	Schatz Energy Research Center
RPI	Rensselaer Polytechnic Institute	SF <sub>6</sub>	Sulfur hexafluoride
rpm	Revolution(s) per minute	SFA	Sulfonic acid
RRDE	Rotating ring disc electrode	SHE	Standard hydrogen electrode
RT	Room temperature	Si	Silicon
Ru	Ruthenium	S-I	Sulfur-iodine
s	Second(s)	SiC	Silicon carbide
S	Siemen(s)	SIMS	Secondary ion emission spectroscopy
S	Sulfur	SiO <sub>2</sub>	Silicon dioxide
SA	Surface area	SLPM, SLM,	
SAE	Society of Automotive Engineers	sL/min	Standard liter(s) per minute
SAM	Scanning Auger microscopy	SMAE	Solid membrane alkaline electrolyzer
SAXS	Small angle x-ray scattering analysis	SMC	Sheet-molding-compound
S <sub>BET</sub>	BET specific surface area	SME	Mercury sulfate electrode
SBCR	Slurry bubble column reactor	S <sub>min</sub>	Minimum surface area
SBH	Sodium borohydride	SMR	Steam methane reformer; steam methane reforming
SBIR	Small Business Innovative Research	Sn	Tin
SBU	Secondary building unit	SNG	Substitute natural gas
Sc	Scandium	SNL	Sandia National Laboratories
S/C	Steam to carbon ratio	SNLL	Sandia National Laboratory Livermore
SCD	Spinneret-to-collector	SnO	Tin oxide
sccm, SCCM	Standard cubic centimeter(s) per minute	SnO <sub>2</sub>	Tin oxide
SCE	Southern California Edison	SO <sub>2</sub>	Sulfur dioxide
SCE	Saturated calomel electrode	SO <sub>3</sub>	Sulfur trioxide
SCF, scf	Standard cubic feet	SOC	State of charge
scfd	Standard cubic feet per day	SOEC	Solid oxide electrolysis cell; solid oxide electrolyzer cell
SCFH, scfh	Standard cubic feet per hour	SOFC	Solid oxide fuel cell
SCFM	Standard cubic feet per minute		

## XI. Acronyms and Abbreviations

SOFEC	Solid oxide fuel-fed electrolysis cell	TBD	To be determined
SOM	Solid-oxide oxygen-ion-conducting membrane	TBX	Turboexpander
SOO	Statement of Objectives	TC	Thermocouple
SOP	Standard operating procedure	TC	Thermochemical
SORFC	Solid oxide regenerative fuel cell	TCD	Thermal conductivity detector
SO <sub>x</sub>	Oxides of sulfur	TDS	Transitional demand scenario
SPE	Solid phase epitaxial	Te	Tellurium
SPEKK	Sulfonated polyether(ether ketone ketone)	TEA <sub>2</sub> B <sub>12</sub> H <sub>12</sub>	Triethylammonium dodecahydrododecaborate
sPEEK	Sulfonated poly(ether ether ketone)	TEAB	Tetraethyl ammonium borohydride
SPEX	Type of milling machine	TEAH	Tetraethylammonium hydroxide
SPR	Solid particle receiver	TEAMS	Tetraethylammonium methane sulfonic
sq. in.	Square inch(es)	TEM	Transmission electron microscopy
Sr	Strontium	TESI	Teledyne Energy System Inc.
SR	Steam reformer; steam reforming	TFMSA	Trifluoromethane sulfonic acid
SRM	Steam reforming	TFVE	Trifluorovinyl ether
SRNL	Savannah River National Laboratory	tf-Si	Thin film silicon
SS	Stainless steel	Tg	Glass transition temperature
SSA	Specific surface area	TG	Thermogravimetric
SSM	stress strain microprobe	TGA	Thermal gravimetric analysis; thermogravimetric analysis; thermal gravimetric analyzer
SSR™	Stackable Structural Reactor		
SSRL	Stanford Synchrotron Radiation Laboratory	TGC	Tail gas combustor
STA	Silicotungstic acid	THC	Total hydrocarbons
STEM	Scanning transmission electron microscopy	THF	Tetrahydrofuran
STH	Solar-to-hydrogen	Ti	Titanium
STM	Scanning tunneling electron microscopy	TiCl <sub>3</sub>	Titanium trichloride
STP	Standard temperature and pressure	TiF <sub>3</sub>	Titanium trifluoride
STTR	Small Business Technology Transfer	TiH <sub>2</sub>	Titanium hydride
SUNY	State University of New York	TiO <sub>2</sub>	Titanium dioxide (anatase)
SV	Space velocity	Tla	Truncated light-harvesting chlorophyll antenna
SWCNT	Single-walled carbon nanotube	tla1	Mutant of the Tla1 gene (GenBank Assession No. AF534570)
SWNH	Single-walled nanohorn	tlaX	Mutant of unknown gene with a truncated light-harvesting chlorophyll antenna (GenBank Assession No. AF534571)
SWNT	Single-wall nanotube		
SwRI	Southwest Research Institute	TM	Transition metal
T	Temperature	TMB	Trimethylborate
T	Ton	ToF-SIMS	Time-of-flight secondary ion spectroscopy
t	Time	TPD	Tons per day
Ta	Tantalum	TPD	Thermally programmed desorption; Temperature-programmed desorption
TAG	Technical Advisory Group	TPO	Temperature-programmed oxidation
TaPO	Tantalum phosphate	TPP	Tetraphenyl porphyrin
TBA <sub>2</sub> B <sub>12</sub> H <sub>12</sub>	Tetra- <i>n</i> -butylammonium dodecahydrododecaborate	TPR	Temperature-programmed reduction
TBA-PF <sub>6</sub>	Tetra- <i>n</i> -butylammonium hexafluorophosphate		

tr. oz.	Troy ounce	VASP	Vienna Ab-initio Simulation Package
TSSER	Thermal swing sorption enhanced reaction	VaTech	Virginia Polytechnic Institute and State University
UC	University of California	VC	Vulcan carbon
UCI	University of California, Irvine	VDC	Volts direct current
UCLA	University of California, Los Angeles	vdW	van der Waals
UCONN	University of Connecticut	V(H <sub>2</sub> )	Volumetric hydrogen adsorption capacity
UCSB	University of California, Santa Barbara	VHTR	very high temperature gas-cooled nuclear reactor
UDDS	Urban Dynamometer Driving Schedule	VHTS	Virtual high-throughput screening
UH	University of Hawaii	V-I	Voltage – current
UHP	Ultra-high purity	VIM/VAR	Vacuum induction melting/vacuum arc remelting
UHV	Ultra-high vacuum	VIR	Voltage - current - resistance
UIUC	University of Illinois, Urbana-Champaign	VMT	Vehicle miles travelled
UL	Underwriters Laboratory	VNT	Variable nozzle turbine
ULSD	Ultra-low sulfur diesel	VOC	Volatile organic compounds; Voltage open circuit
um	Micrometer(s)	vol	Volume
UNC	University of North Carolina	vol%	Volume percent
UN/ECE	United Nations/Economic Commission for Europe	VT	Virginia Tech
UNLV	University of Nevada Las Vegas	VTA	Valley Transportation Authority
UNLVRF	UNLV Research Foundation	VTGR	Very high temperature gas reactor
UNM	University of New Mexico	W	Tungsten
UNR	University of Nevada, Reno	W	Watt(s)
UPS	Ultraviolet photoelectron spectroscopy	WAXD	Wide-angle x-ray diffraction
US06	Environmental Protection Agency vehicle driving cycle	WBS	Work breakdown schedule
U.S.	United States	W/cm <sup>2</sup>	Watt(s) per square centimeter
USA	United States of America	We	Watt(s) electric
USC	University of South Carolina	WGS	Water-gas-shift
USC	University of Southern California	WGS-MR	Water-gas-shift membrane reactor
USCAR	U.S. Cooperative Automotive Research	Wh	Watt-hour(s)
USFCC	United States Fuel Cell Council	W-h/kg	Watt-hour(s) per kilogram
USM	University of Southern Mississippi	W-h/L, Wh/liter,	
USPP	Ultrasoft pseudopotentials	Wh/L	Watt-hour(s) per liter
UT	University of Toledo	WHSV	Weight hourly space velocity
UTC, UTC FC	United Technologies Corporation Fuel Cells	W/kg	Watt(s) per kilogram
UTC	University of Tennessee, Chattanooga	W/L, W/l	Watt(s) per liter
UTR	Untranslated region	W/m-K, W/m.K,	
UTRC	United Technologies Research Center	W/mK	Watt(s) per meter-Kelvin (unit of thermal conductivity)
UV	Ultraviolet	WO <sub>3</sub>	Tungsten trioxide
UV-vis	Ultraviolet-Visual	WP.29	World Harmonization of Vehicle Regulations
UW	University of Washington	Wt	Watt(s) thermal
V	Vanadium	wt	Weight
V	Volt		
VAC	Volts alternating current		

## XI. Acronyms and Abbreviations

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wt%, wt.%	Weight percent (percent by weight)
WTP	Well-to-pump
WTW	Well-to-wheel
X-	An anionic ligand such as chloride
XANES	X-ray absorption near-edge spectroscopy
XAS	X-ray absorption spectroscopy
XML	Extensible markup language
XPS	X-ray photoelectron spectroscopy
XRD	X-ray diffraction
XRF	X-ray fluorescence
Y	Yttrium
yr, YR	Year
YSZ	Ytria-stablized zirconia
ZEV	Zero emission vehicle
Zn	Zinc
ZnO	Zinc oxide
zpp	Zirconium phenyl phosphonate
Zr	Zirconium
ZrO <sub>2</sub>	Zirconium dioxide