Hatch.com

SUPERCRITICAL
WATER SYSTEMS

Updates for Spring 2025

- *Expanded Gambler First Nations Partnership for Clean Fuels Bio-Hydrogen/Bio-Carbon/Syngas*
- *Canadian Engineering Firm Appointed (Hatch.com)*
- *SCWS-sponsored Government-Industry-Academic Forum to Demonstrate Our NASA SCW System*
- *UK Memorandum of Understanding for a 30-ton SCWS Facility*

BIO-HYDROGEN™, BIO-SYNGAS™ & Bio-CARBON

Via Hydrothermal Gasification of Organic Wastes Using Any Water

Zero-Carbon, Energy-Efficient, Low Opex

SUPERCRITICAL WATER SYSTEMS

SUPERCRITICAL WATER SYSTEMS

SuperCritical Water Systems

- Zero-carbon, flexible, scalable platform using any water source with multiple applications and end-products
- Profitably transforms low-value materials and waste into high-value commodities:
  - ***BIO-HYDROGEN*, *BIO-CARBON* & *BIO-SYNGAS***
  - many other chemicals using advanced catalysis
- Provides its own 100% renewable energy (biocarbon)
- Creates a huge impact on advancing the circular economy

SuperCritical Water Systems (SCWS)

SUPERCRITICAL
WATER SYSTEMS

Our Vision

To deploy the world's premier ultra-green hydrogen and biocarbon co-production ZERO-CARBON technology to process virtually ALL solid-liquid-mixed organic wastes and at the cost of grey H_2

Our Mission

To accelerate the worldwide transition to an ESG-focused circular economy through economical, ecological and profitable waste conversion to ZERO-CARBON bio-hydrogen, bio-syngas and bio-carbon.

Net Zero BIO-HYDROGEN Summary

SUPERCRITICAL WATER SYSTEMS

SuperCritical Water Systems (hydrothermal gasification) offers the most efficient, flexible, eco-friendly (no emissions/effluents), profitable, 100% zero-carbon alternative to producing "clean" H_2 via electrolysis (Green H_2), steam-reformed natural gas with CO_2 sequestration (Blue H_2), methane pyrolysis (Turquoise H_2) or "net zero" methods.

Developed over 22 years at leading Canadian universities in collaboration with NASA, our proven SCW-*hydrothermal gasification* and world-class catalytics profitably extract *hydrogen* and *carbon* from ANY organic waste (solid/liquid/mixed) on a small footprint – producing valuable biocarbon instead of undesirable CO_2.

We can produce our own renewable power by using biocarbon to generate all electricity. Our process uses 1/6 of the energy and 1/3 of the water of electrolysis at 50% of the capex. SCW is cheaper, cleaner, and safer than steam reforming and every other commercial scale method we have identified when using waste tires or whole sugar cane as feedstock.

SUPERCRITICAL WATER SYSTEMS

Net Zero

BIO-HYDROGEN, BIO-CARBON & BIO-SYNGAS At Lower Cost Than Green, Grey, Blue or Other Hydrogen Production Methods

SUPERCRITICAL
WATER SYSTEMS

BIO-HYDROGEN Cheaper Than Blue

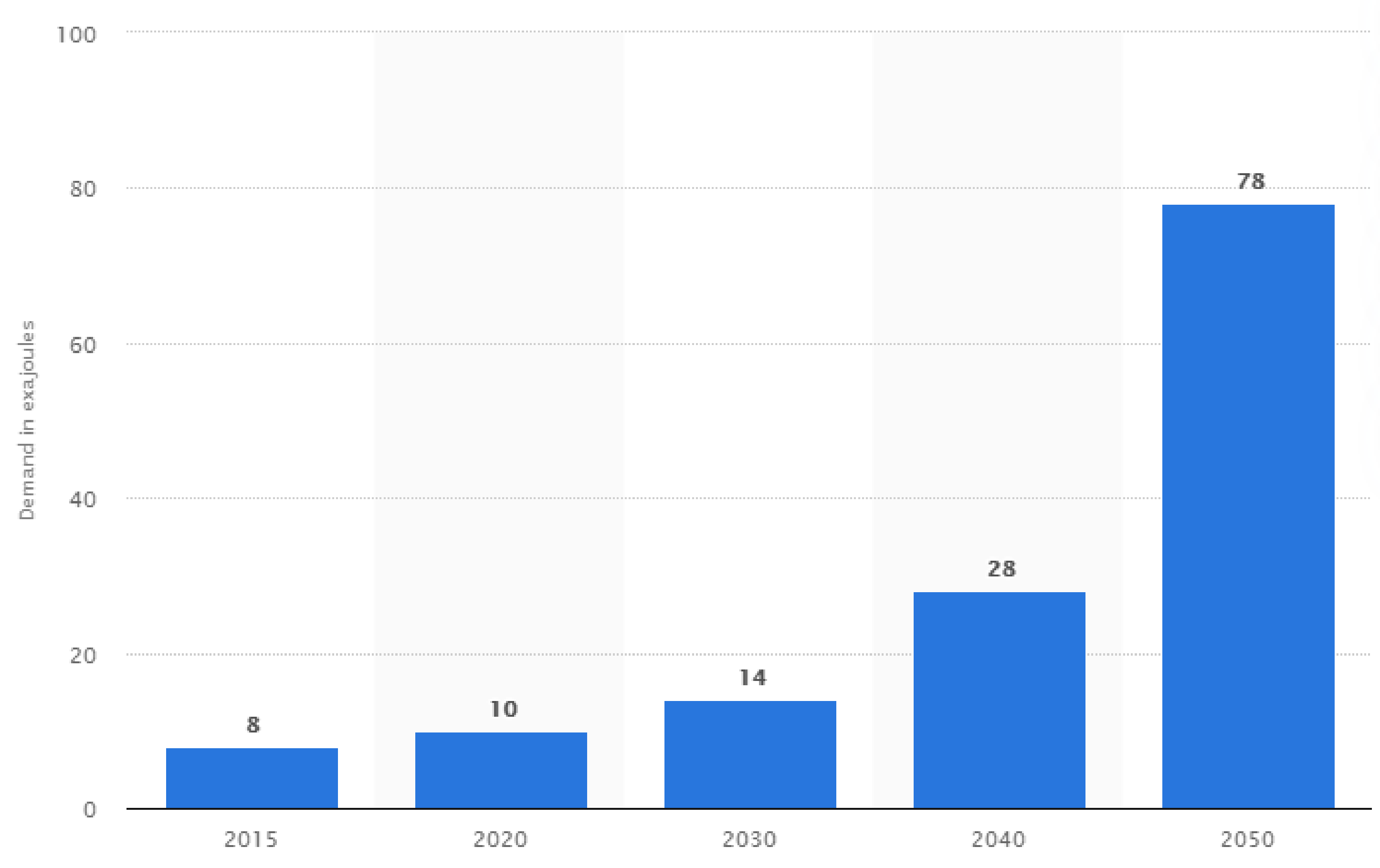
H_2 from supercritical water is ***ULTRA-GREEN*** and carbon neutral/negative:

- ***Converts any carbonaceous waste to 99.2% pure H_2 and C (pure carbon)***
- 30 metric tons per day reactor modules have small footprint and few moving parts
- H_2 produced on-demand or continuously
- Low capex & opex
- Superior mass-energy balance
- Low energy consumption
- Uses far less UNFILTERED water (recycling)
- Uses ANY water – sewage, industrial, etc.
- No effluents or emissions
- Project construction/operation within 7-8 months of permitting
- Simple maintenance takes only 10 days/year

ULTRA-GREEN

Bio-H_2 from supercritical water processing of carbon-hydrogen containing waste with low energy use, low water use/total recycling, pure carbon by-product & virtually no effluents or emissions

Market Opportunity: Projected Global Demand for H_2 to 2050



Assumes +2 C temperature increase by 2050

SUPERCRITICAL WATER SYSTEMS

SuperCritical Water Systems (SCWS) Company Background

- In 2021 SCWS Inc. was formed as a R&D company to commercialize the technology while retaining multiple university ties and qualifying for grants.
- The Company offers the most efficient, flexible, eco-friendly/zero-carbon, and profitable alternative to electrolysis for green hydrogen production using proven, proprietary super critical water *hydro-thermal gasification* to extract hydrogen and biocarbon from ANY organic wastes (solid/liquid/mixed).
- Company R&D is now headquartered in Thunder Bay, Ontario, to take advantage of our state-of-the-art facilities at the Lakehead University Department of Engineering and Computer Science where Professor Kozinski is Dean of the Faculty.

SUPERCRITICAL WATER SYSTEMS

Near-term SCWS Activities

- We are applying for a Canadian Government FEED grant under the Clean Fuels initiative to cover 75% of the engineering PDP costs for our next-gen 30-mton per day CDU (Commercial Demonstration Unit) currently being engineered by Hatch Engineering (Calgary) based on our 2-mton per day reactor (TRL = 7) and our NASA commercial product (TRL-9) .
- Following completion of the engineering work, a second grant application for CDN$60M to cover 75% of costs will be made to Clean Fuels for a building-operating a 30-tpd CDU to produce biocarbon, H_2 and syngas from waste tires in partnership with ***Gambler First Nations*** (Manitoba, Canada.
- Our prior experience and advanced modeling predict no issues with scaling the CDU to 30-tpd modules.

SuperCritical Water Systems Leadership Team

Dr Janusz Kozinski
Co-Founder and Chairman of the Board
Dean, Faculty of Engineering, Lakehead University

Dr Richard C. Newbold, III
Co-Founder, Interim President
and Science Advisor

Dr Mary A. Parenti
SCWS Executive Marketing Consultant

Paul Roach
Director and Waste Management Expert

Joseph R. Mallon, JD
Director and Corporate Counsel (USA)

Jim Smutnik, MS (Taxation)
Financial Director and Comptroller

SUPERCRITICAL
WATER SYSTEMS

SuperCritical Water Systems Consultants & Scientific Advisory Board

Dr Ben Lashkari
Technology and Climate Expert

Kenneth Hamilton
Biocarbon Agricultural Applications & Soil Amendment Expert

Jere S. Hull
Project Development and Management

Liz Grieco, JD
Business Development Consultant

SUPERCRITICAL WATER SYSTEMS

SCWS Scientific & Technical Team

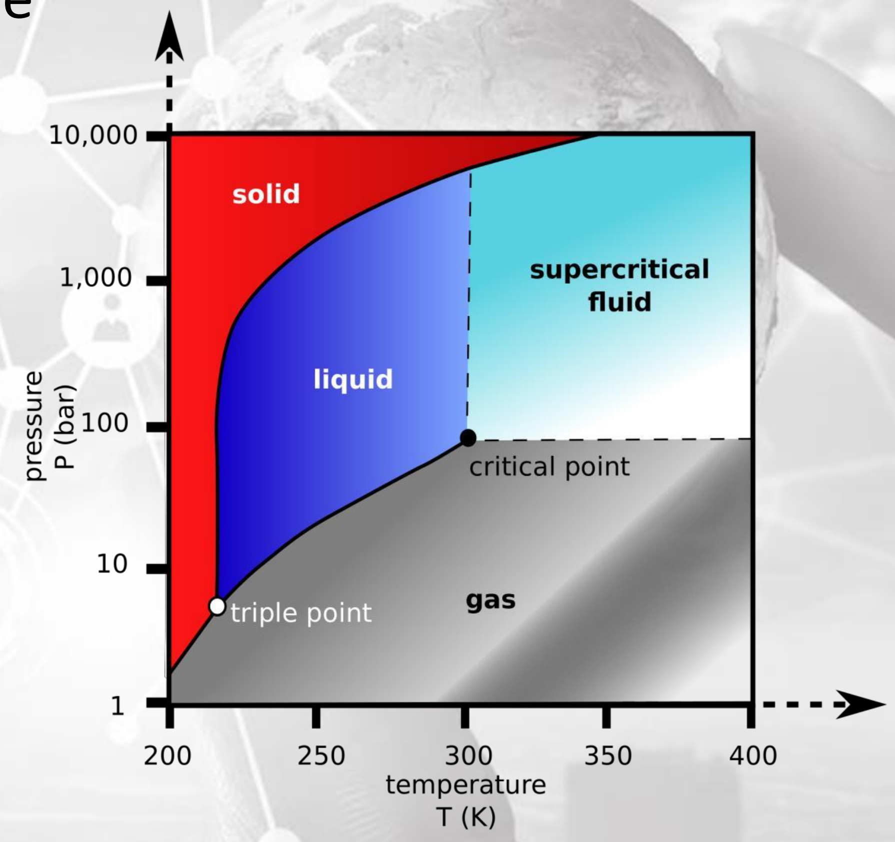
Prof. Ajay K. Dalai
Senior Scientist - Catalysis
Distinguished Professor and Canada Research Chair,
Chemical and Biological Engineering
University of Saskatchewan,
Saskatoon, SK, Canada

Prof. Sonil Nanda
Senior Technologist - Biocarbon
Assistant Professor of Engineering (Agricultural Campus)
Dalhousie University, Halifax, Nova Scotia, Canada

Prof. Baris Yilmaz
Senior Engineering Scientist - Catalysis
Assoc. Prof. of Engineering, Marmara University (Turkey)
Visiting Associate Professor, Lakehead University, Faculty of Engineering

SCWS Process Description 1

- Supercritical water (SCW) is water heated to a temperature > 374°C and pressure > 22.1MPa. The ionic product, fluid density, dielectric constant and viscosity of SCW are different from extreme states of the gas phase or liquid phase of water.
- In its supercritical state, water forces the dissolution of every biomass material (including hydrocarbons) into H_2 rich syngas with negligible toxic by-products, no effluents, and ultra-low emissions/ waste residues.
- It uses water from any source (even sewage) and compared to electrolysis, requires a fraction of the water and renewable energy by employing very efficient water and gas recycling processes.

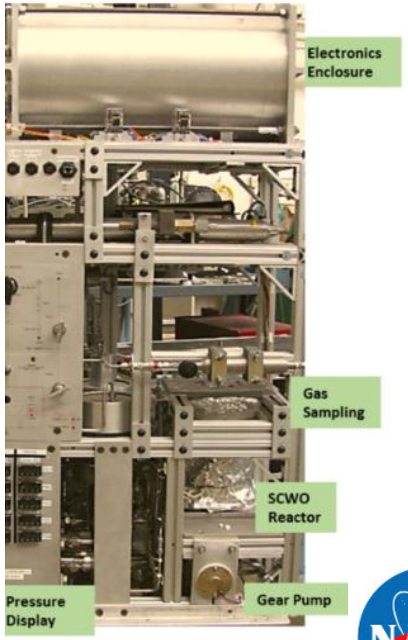


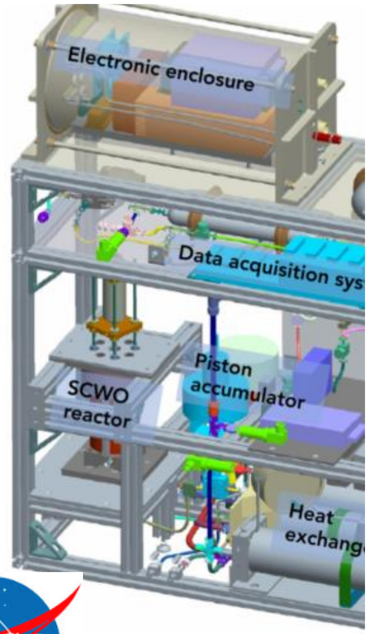
SCWS Process Description 2

- Our 8th generation, 2-mtpd reactor was located at the University of Saskatchewan Engineering Department.
- Our 30-mt Commercial Pilot Unit (CPU) will incorporate the latest advances to generate profits in a tire-to-energy project to produce pure H_2 and biocarbon.
- If pure syngas is desired (H_2-CO), we produce our own pure CO by heating biocarbon or by processing waste plastics in a 3 to 1 ratio of CO to CO_2.
- CO is then membrane-separated from CO_2 and precisely mixed with H_2 to create syngas whilst the CO2 is sold for carbonating beverages.
- Our intellectual property includes trade secrets, a process patent (provisional), and selected component patents.

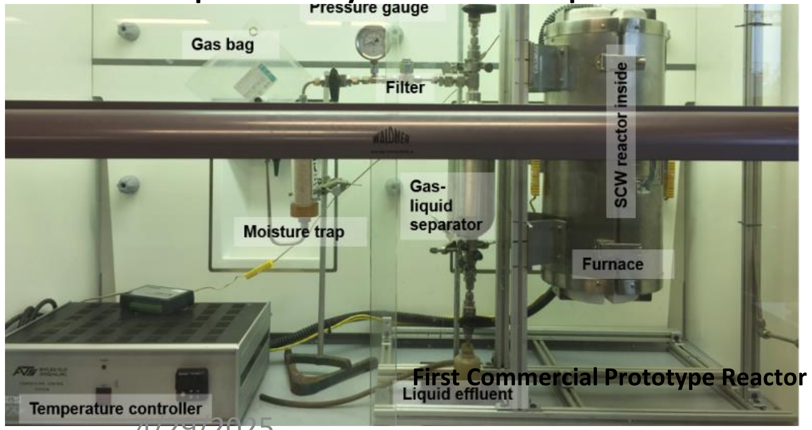
2-Metric Ton Per Day Reactor USask (2015-2019)

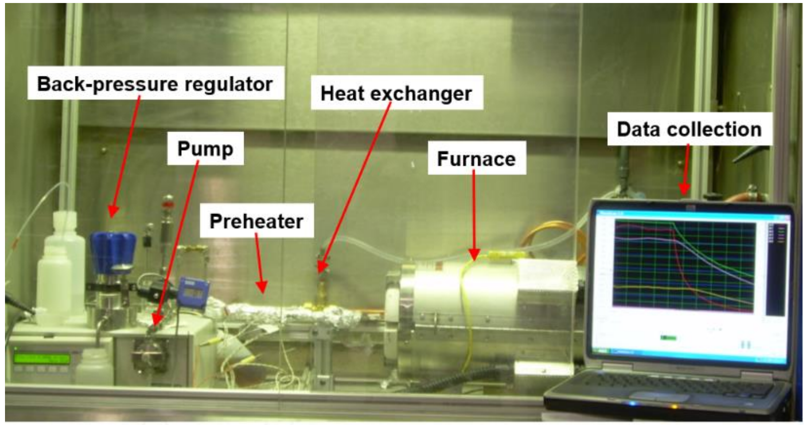
Evolution of our SuperCritical Water Reactor over 20+ Years

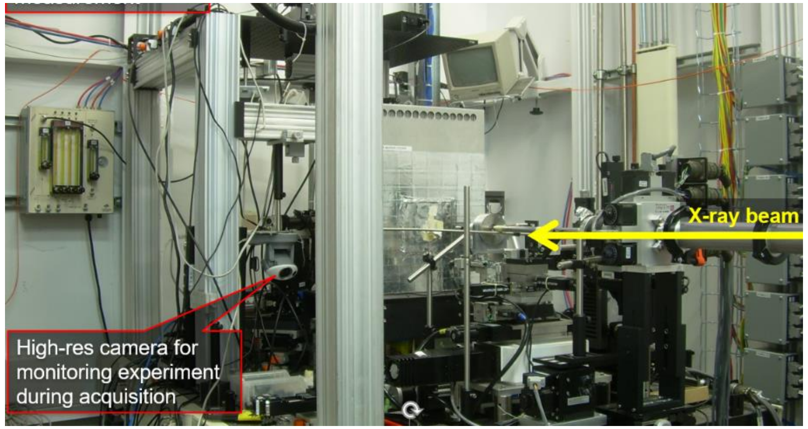




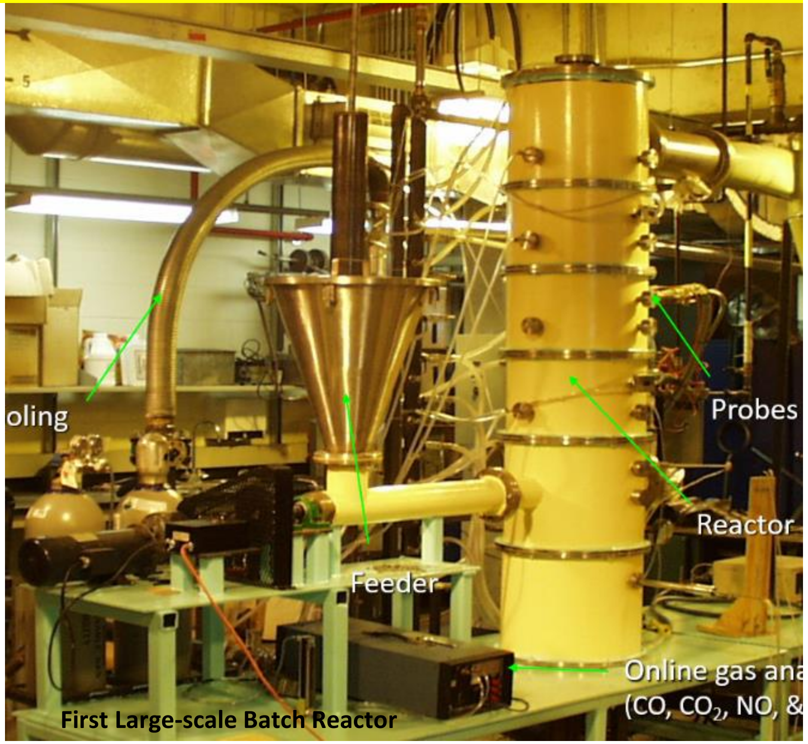
Research sponsored by NASA for the Space Shuttle







2 mton/24 hrs unit



After Two Decades of SCW Scientific Research, Many Peer Journal Publications & Development of Multiple Prototypes, our SCW Reactor is Ready for Commercial Development beginning with a 30-ton commercial pilot unit (30-ton CPU)

Competitive Advantages of SCWS vs PEM Electrolysis 1

The SCW Process:

- Has greatly superior mass-energy balance to electrolysis
- Uses 1/6 of the renewable energy needed for electrolysis
  - Powerful exergonic reactions reduce external energy needs
- Uses 1/7 of the water needed for electrolysis
  - Water is recycled
  - Processes ANY water without filtration (sewage-storm-industrial process)
- Can provide its own self-sustaining, 100% renewable energy from produced biocarbon

Competitive Advantages of SCWS vs PEM Electrolysis 2

The SCW Process:

- Along with Hydrogen, co-produces profitable Biocarbon
  - nanocarbon – high grade, suitable for industry or agricultural use
  - biochar - high grade for agricultural use & water filtration
- Has far lower costs of construction-installation
- Allows much faster project completion – 1/3 as long as electrolysis
  - full operation within 7-8 months of permitting
- Lower cost operation/maintenance – few moving parts/no membranes or electrodes to replace

Competing Waste to H_2 Conversion Methods

COMPARATIVE H_2 MASS-ENERGY BALANCE SCORES (10 = SCWS Process)

SUPERCRITICAL WATER SYSTEMS

S.NO.	PROCESS	CONVERSION PATHWAYS	
		CHEMICAL	
1	**HYDROTHERMAL UPGRADING (HTU)**	Biomass feed stock is treated with water at 300-350^0 C and 100-180 bars for 5-20 minutes to remove almost 85% of O_2 in equal parts of CO_2 and H_2O. The final product is a **liquid fuel** that can be converted into a high quality diesel fuel	*4.5 / 10*
2	**HIGH PRESSURE LIQUEFACTION (HPL)**	Solid cellulosic biomass materials or lignin are converted to **oil**	*4.5 / 10*
		BIOCHEMICAL	
1	**ANAEROBIC DIGESTION**	Organic material in the absence of oxygen is converted into **biogas** (a mixture of CH_4 and CO_2)	*2.5 / 10*
2	**FERMENTATION**	Production of **ethanol** from starchy and cellulosic biomass	*1.5 / 10*
3	**ACID/ENZYMATIC HYDROLYSIS**	Lignocellulosic biomass such as wood and grasses are treated with strong acids to convert the biomass to **sugars**	*2.5 / 10*
		THERMOCHEMICAL	
1	**COMBUSTION**	Thermal decomposition of biomass at elevated temperatures in excess amounts of oxygen to produce **energy**	*1.5 / 10*
2	**GASIFICATION**	Decomposition of biomass at high temperatures with a controlled amount of oxygen and/or steam to produce **syngas** (a mixture of hydrogen and CO)	*3.5 / 10*
3	**PYROLYSIS**	Biomass is decomposed at moderate temperatures in the absence of oxygen to produce **bio-oil**	*1.0 / 10*

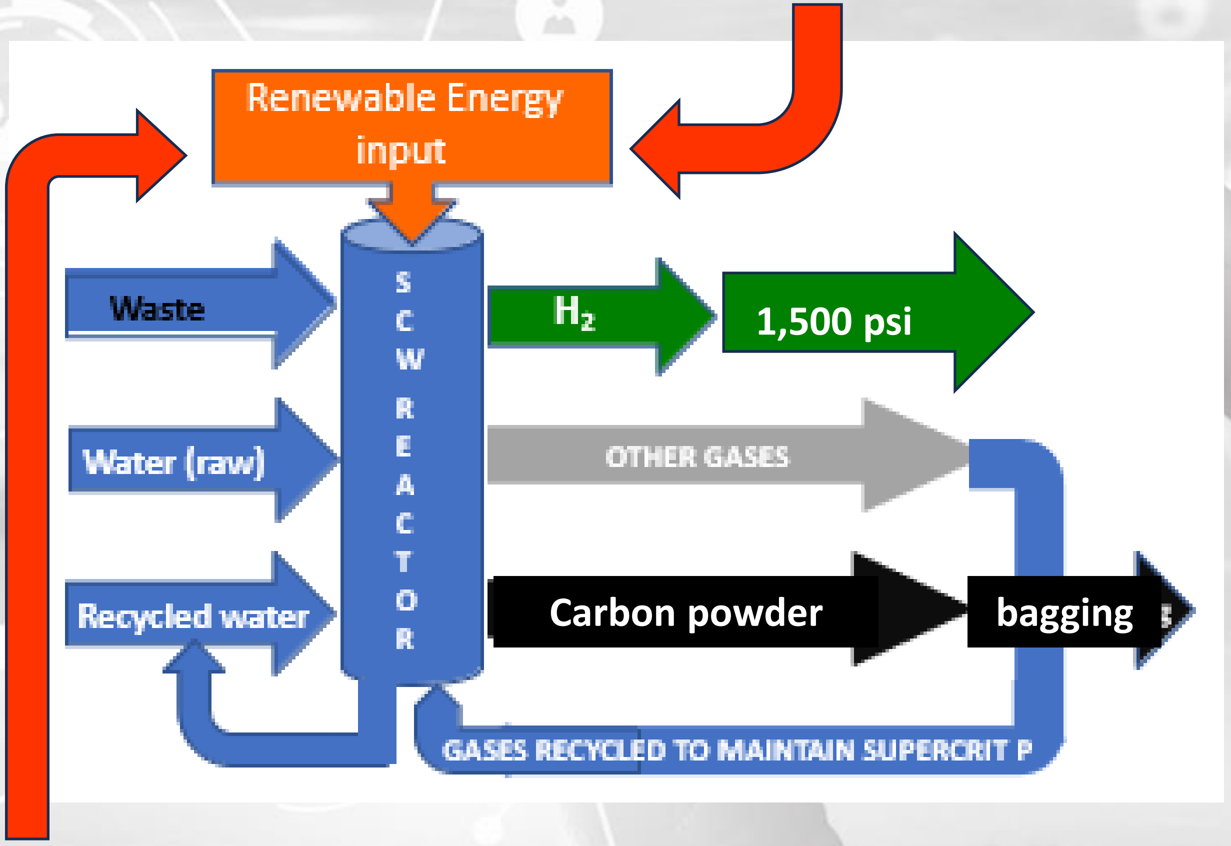
SCWS Advantages Over Other Waste to H_2 Gasification Methods

The SCW Process:

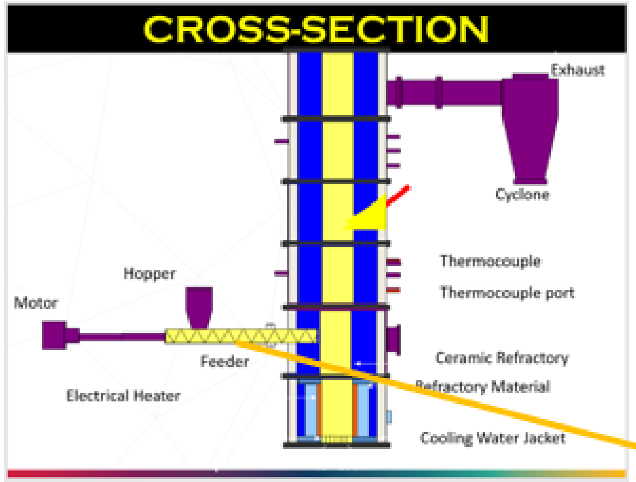
- Is far superior in mass-energy balance to any other waste-to-H_2 process
- Is available in cost-effective modules that are sized to process from 3 to 60 metric tons of feedstock per day with very small footprints (1/6 acre for 60-mton unit)
- Yields H_2 gas of 99.2% purity exiting reactor at 1,500 psi/103.4 bar
- Allows reactor modules to operate intermittently, making them practical for filling stations for example
- Prevents corrosion of any part of the reactor:
    - SCWS uses liquid catalysts – there are no catalyst deactivation or collection/reuse issues
    - High reaction rates and use of any unfiltered water source (even sewage)
    - Hot gases recycling, powerfully exergonic (energy-producing), enhanced reaction kinetics, and far fewer complex intermediate reactions compared to other super critical or gasification methods
- Has on-line monitoring, a proven safety record, long intervals between maintenance needs
- Yields biocarbon which generates profits and carbon sequestration credits

SCWS Reactor Dimensions, Renewable Energy and Process Flow

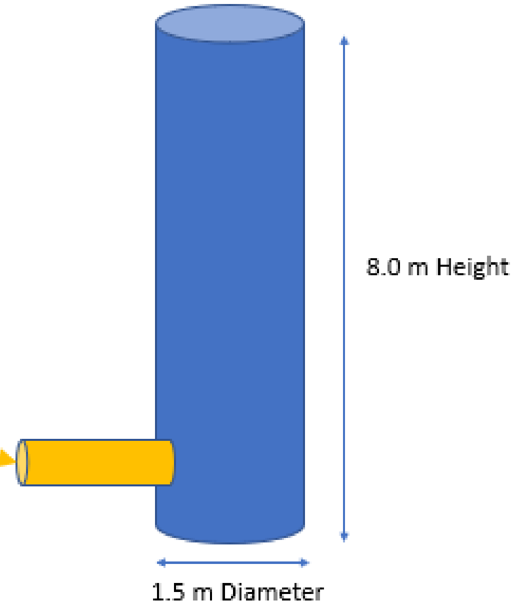
Super critical water dissolves virtually all chemical bonds thereby releasing huge exergonic reaction energy that dramatically lowers renewable energy requirements.



Biocarbon produced contains 34MJ/kg of energy minimum. A small percentage can provide climate neutral, renewable energy for ALL reactor electricity needs. No solar or wind required, eliminates energy supply uncertainty!



Principal Components – Reactor Scaled to Accept 20 mtons of Waste Feedstock Per 12-hour Continuous Batch Cycle = 40 mtons total daily



Summary M-E Balance (30 metric tons of waste tires/day)

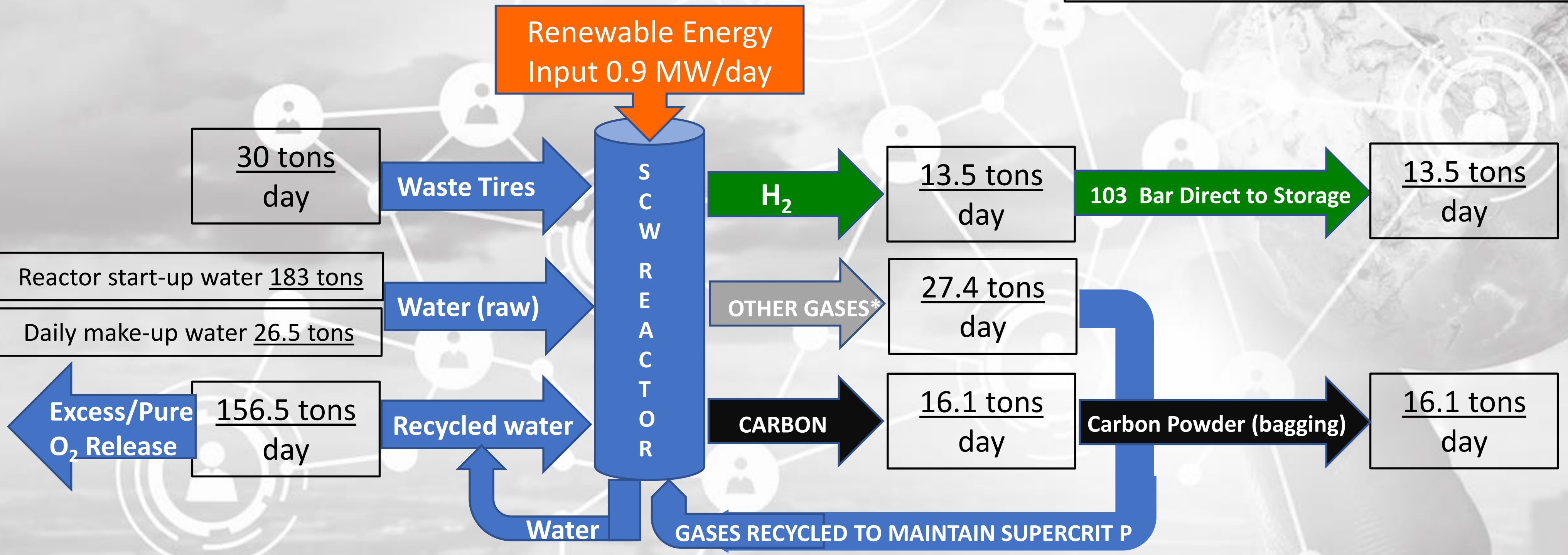
SUPERCRITICAL WATER SYSTEMS

Waste Tire Energy Content
54 MJ/kg

Total Energy Content Per Day
300 MW

Carbon Content
1% carbon steel = 0.91 kg
28% carbon black = 2.45 kg

Waste Tire Dewired Shreds by % Weight
- Natural & Synthetic Rubber 41%
- Carbon Black 28%
- Steel 15%
- Fabric-fillers-other 17%



***Other gases include CO, CO_2, CH_4 and C_2 – C_4 hydrocarbons; gas mix optimized for H2 production – some clients might want to offtake some gases for their own use**

SCWS Technology Advantages 1

SCWS Technology:

- Uses modular design with modules capable of processing from 3-30 metric tons daily of any/every wet or dry waste feedstock – facility capacity can be increased by adding modules
- Can provide its own renewable energy using a fraction of the biocarbon produced
- Directly produces H_2 without electrolyzer or traditional gasifiers
- Reactor design and construction are robust with few moving parts and great longevity, resulting in the lowest Lifetime Operating Cost (LOC) of any existing technology
- Refractory brick lining will last for a minimum of 5 years while the reactor core minimum life is 25 years

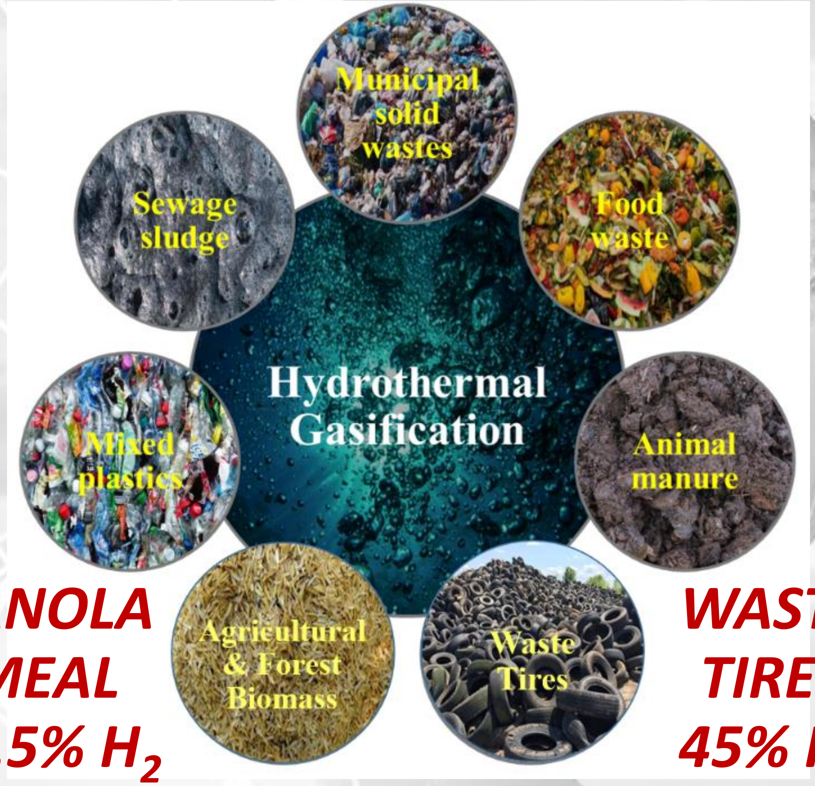
SCWS Technology Advantages 2

SCWS Technology:

- Allows 355 full production days per year
- Our company has deep scientific and engineering resources to ensure continuing R&D, software/firmware updates, 24-7-365 remote performance monitoring/data collection via embedded sensors, worker operational/safety training, on-site maintenance and technical support
- Requires only a small footprint (30 mtpd reactor column is 1.5 meters wide x 5 meters high)
- Provides rigorous quality control of construction, installation & operation

Variety of Feedstock Candidates for Conversion to H_2 and C

- Most plastics, agricultural-forest residues, and other widely available organic & biomass waste feedstocks like railroad ties are suitable to make ***ultra-green hydrogen and biocarbon.***
- The large amounts of pure carbon can be used as biochar for soil amendment, water purification, and many other uses.
- SCW reactors can process any mix of wet-dry waste which can be infinitely varied/mixed.
- Pure H_2 production yields vary from a high of 45% of feedstock weight (waste tires) to 12.5% (wet canola meal and wheat straw).
- All of these feedstocks are plentiful.
- Only feedstocks SCWS cannot process are those with large amounts of chloride (PVC).



CANOLA MEAL 12.5% H_2

WASTE TIRES 45% H_2

CREOSOTED RAILROAD TIES 25% H_2

WHOLE SUGAR CANE 42% H_2

Uses for Bio-Carbon from SCWS Gasification of Biomass

(including 100% carbon-neutral, self-powering of SCWS installations)

SUPERCRITICAL WATER SYSTEMS

Area	*Applications*
Tire Manufacturing	High quality "tunable" carbon black
Agriculture	Soil fertility
	Removal of heavy metals
	Sheltering beneficial soil microorganisms and organic matter
	Preventing soil erosion by forming a complex with plant roots and soil-biochar mixture
	Maintains an optimal pH level, water holding capacity, salinity, cation exchange capacity in the soil
Environment	Carbon capture
	Wastewater treatment
	Adsorption of particulate matter from flu gases
Fuel	Solid fuel pellets
	Co-firing and co-gasification with coal
Cosmetics	Face masks, toothpastes, soaps
Pharmaceuticals	Adsorption of toxins from digestive tract
Electrical	Material for electrodes, capacitors and conductors
Material	Biocomposite materials, Fillers

SUPERCRITICAL WATER SYSTEMS

Our Technology is Supported by Over 235 Scientific Journal, Peer-reviewed Articles and Books From Our Team

Contents lists available at ScienceDirect

Chemical Engineering Science

ELSEVIER

journal homepage: www.elsevier.com/locate/ces

Hydrothermal catalytic processing of waste cooking oil for hydrogen-rich syngas production

Sonil Nanda [a], Rachita Rana [b], Howard N. Hunter [c], Zhen Fang [d], Ajay K. Dalai [b], Janusz A. Kozinski [e,*]

[a] Department of Chemical and Biochemical Engineering, University of Western Ontario, London, Ontario, Canada
[b] Department of Chemical and Biological Engineering, University of Saskatchewan, Saskatoon, Saskatchewan, Canada
[c] Department of Chemistry, York University, Toronto, Ontario, Canada
[d] College of Engineering, Nanjing Agricultural University, Nanjing, Jiangsu, China
[e] Department of Chemical Engineering, University of Waterloo, Waterloo, Ontario, Canada

Contents lists available at ScienceDirect

The Journal of Supercritical Fluids

ELSEVIER

journal homepage: www.elsevier.com/locate/supflu

Catalytic subcritical and supercritical water gasification as a resource recovery approach from waste tires for hydrogen-rich syngas production

Sonil Nanda [a], Sivamohan N. Reddy [b], Howard N. Hunter [c], Dai-Viet N. Vo [d], Janusz A. Kozinski [e,*], Iskender Gökalp [f]

[a] Department of Chemical and Biochemical Engineering, University of Western Ontario, London, Ontario, Canada
[b] Department of Chemical Engineering, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, India
[c] Department of Chemistry, York University, Toronto, Ontario, Canada
[d] Center of Excellence for Green Energy and Environmental Nanomaterials, Nguyễn Tất Thành University, Hồ Chí Minh City, Vietnam
[e] Department of Chemical Engineering, University of Waterloo, Waterloo, Ontario, Canada
[f] Institut de Combustion, Aérothermique, Réactivité et Environnement (ICARE), Centre National de la Recherche Scientifique (CNRS), Orléans, France

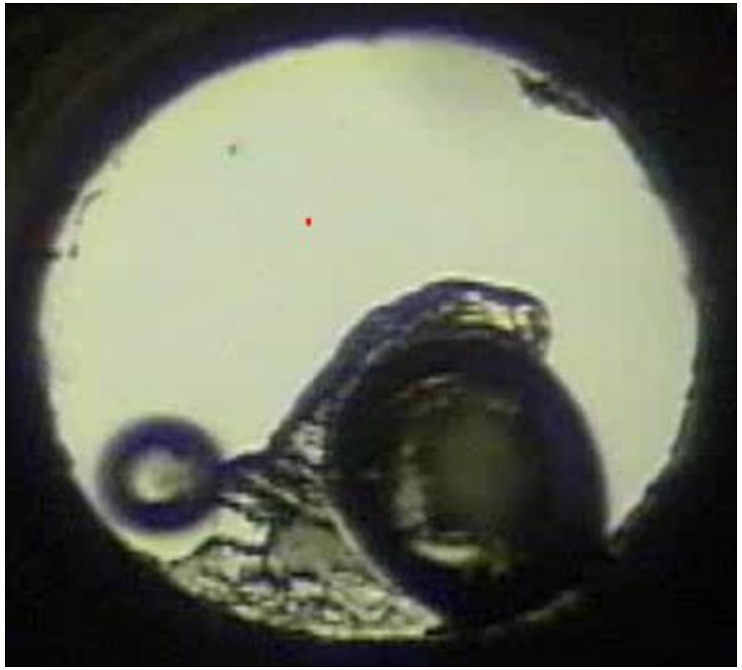
CHAPTER 19

Hydrothermal Events Occurring During Gasification in Supercritical Water

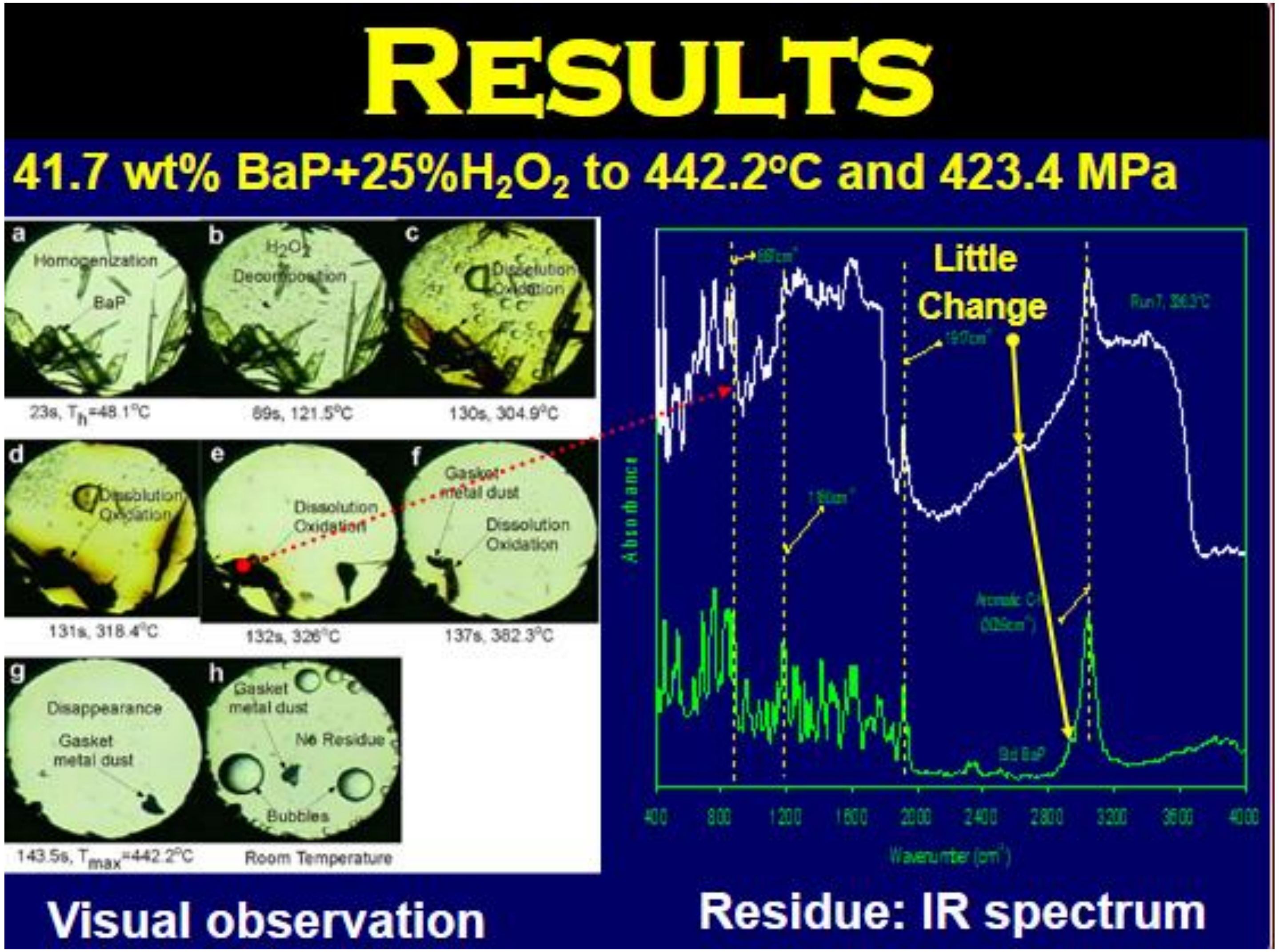
SONIL NANDA[a], SIVAMOHAN N. REDDY[b], ZHEN FANG[c], AJAY K. DALAI[d] AND JANUSZ A. KOZINSKI*[e]

[a]Department of Chemical and Biochemical Engineering, University of Western Ontario, London, Ontario, Canada; [b]Department of Chemical Engineering, Indian Institute of Technology Roorkee, Uttarakhand, India; [c]College of Engineering, Nanjing Agricultural University, Nanjing, Jiangsu, China; [d]Department of Chemical and Biological Engineering, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; [e]New Model in Technology & Engineering (NMiTE), Hereford, Herefordshire, UK
*E-mail: janusz.kozinski@nmite.org.uk

SCWS Has Library of Super Critical Water Real-time Video Evidence of Many Feedstock Conversions



Polystyrene dissolved and catalytically reconstituted as targeted end-product within 100 msecs as mini-reactor goes from sub- to super-critical conditions



Hatch.com

SUPERCRITICAL WATER SYSTEMS

Updates for Spring 2025

- *Expanded Gambler First Nations Partnership for Clean Fuels Bio-Hydrogen/Bio-Carbon/Syngas*
- *Canadian Engineering Firm Appointed (Hatch.com)*
- *SCWS-sponsored Government-Industry-Academic Forum to Demonstrate Our NASA SCW System*
- *UK Memorandum of Understanding for a 30-ton SCWS Facility*

ZERO-CARBON

HYDROTHERMAL GASIFICATION

ANY ORGANIC WASTE

ANY WATER

BIO-HYDROGEN

BIO-SYNGAS

BIO-CARBON

SUPERCRITICAL WATER SYSTEMS

Dr. Richard C. Newbold, III - President
Mobile: +1 267-337-3010 ▪ Email: Richard@supercritical-h2o.com