ReductionTech^{tm}

What Does Globally Scaled GHG Removal Look Like and Cost With "Doublet" Hydroxyl Dispersal Technology?

Introduction

At ReductionTech we have created a proprietary ceramic that can split gases when heated, and have successfully achieved and standardized the splitting of a combined flow of pure CO_2 and oxygen to produce atomic oxygen radicals. We received nomination for a Nobel Prize in Physics for this discovery in 2012. **We** Have since established the production of doublet aqueous hydroxyl radicals (OH*), which are the key to safe and effective open-air purification and greenhouse gas (GHG) removal. This document will introduce you to the technology that we can share with potential implementers and with the public.

Nature has historically relied upon hydroxyl radicals (OH*) as a principal air cleanser/metabolizer in both natural and urban settings. The dangerous, toxic build up of a well-mixed atmospheric brew of chemicals, smog, and heat trapping gases (GHGs) on local, regional and continental scales has now become a serious hazard to health and well-being, both human and of the biosphere in general. It threatens lives and property as seen with the increasingly frequent and severe fires, floods, and droughts spanning the globe, affecting every community. We have the loss of Arctic Ice, a meandering jet stream with chaotic Rossby wave related dangerous high and low pressure weather systems, collapsing ocean circulations, lost permafrost, excessive methane emissions, and an impending loss of latent planetary scale cooling and albedo because of Arctic and polar glacial ice losses. Humanity is already experiencing a lot of pain at the 1.5'C/500ppm CO2e warming level because of these gases at the root of the problem. These gases can be removed relatively quickly with our technology, as hydroxyl reacts promiscuously and in seconds, and persists in the air until it gets reacted! It's a PAC MAN, chemical transformer, and magic bullet all rolled into one. It has the power to reset the atmosphere back to a preindustrial state without unwanted chemical residues or any hazards.

Technical ceramics are in a class of synthetic materials known for their engineered properties, like fracture toughness, strength, purity, hardness, density, thermal, gaseous and electrical conductivity, and for their use as 'molecular sieves.' They are also fundamental to ***ReductionTech***^{tm} proprietary technology.

We are currently offering this technology to national and international governments and clients that are already aware of the need for a solution to mitigate a) the health impacts of globalized air pollution, b) a fundamental cause of climate change, the overloading of Earth's atmosphere with greenhouse gases (GHGs) like CO_2, methane, and extremely heat-trapping synthetic halogenated greenhouse gases, and c) damage to above- ground municipal infrastructure over time due the destructive climate properties of GHGs.

Common Urban Problems Addressed by *ReductionTech*^{tm}

Reduce levels of toxic urban and rural air pollution

Reduce the growing impacts of climate change

Reduce Infrastructure Stresses

The Challenge

At present for nearly all major cities and municipalities of appreciable size, in addition to climate damages, air quality has become a multi-dimensional problem. Poor air quality affects the health of citizens, pets, farm animals, wildlife, as well as trees, forests and crops. Low birth weight
babies and dementia in seniors have both been traced to air pollution, as just two of the many known health problems. Climate change is well known to stem from the overloading of the atmospheric 'sink' for the common greenhouse gases:
carbon dioxide, methane and halogenated carbon molecules used in refrigeration and industrial processes. The lesser known, but just as common urban problem is the stressing of infrastructure due to the thermochemical activity of various components of air pollution. All three problems are reduced by introducing our proprietary ReductionTechtm.

The atmosphere is a critical infrastructure. Due to current hazardous atmospheric loading, there is an imperative need for improving the removal of criteria air pollutants like PM 2.5, ozone, and carbon monoxide. Table 1 to the right indicates the most common sources and sinks for a several atmospheric radicals, including *OH and RO2 (peroxy or HOO radicals). The challenge that has arrived is that human civilization produces far more of these radicals than the natural OH* recuperative processes can handle. Hence we have overwhelmed the natural pollution sinks that have been operative for millennia.

		median rate, 10^5 molecule cm^{-3} s^{-1}		
		daily	noon	midnight
	net OH sources			
1	$HONO + h\nu \rightarrow OH + NO$	14.2	21.8	4.7
2	$H_2O_2 + h\nu \rightarrow OH + OH$	0.9	2.1	0.1
3	$O_3 + h\nu \rightarrow O(^1D) \rightarrow OH + OH$	0.3	1.7	0.0
4	$CH_3OOH + h\nu \rightarrow HO_2 + OH$	0.2	0.4	0.0
	recycling $RO_2 \rightarrow OH$			
5	$HO_2 + NO \rightarrow OH + NO_2$	8.3	11.6	2.2
6	$HO_2 + O_3 \rightarrow OH + 2O_2$	0.4	0.6	0.1
	net RO_2 sources			
7	$HCHO + h\nu \rightarrow 2HO_2 + CO$	2.1	3.7	0.4
8	$CH_3CHO + h\nu \rightarrow HO_2 + CH_3O_2 + CO$	0.9	2.1	0.2
9	$CH_3OOH + h\nu \rightarrow HO_2 + OH$	0.2	0.4	0.03
	recycling $OH \rightarrow RO_2$			
10	$CO + OH \rightarrow HO_2 + CO_2$	5.9	7.8	1.9
11	$CH_4 + OH \rightarrow CH_3O_2 + H_2O$	2.3	3.3	0.7
12	$HCHO + OH \rightarrow HO_2 + CO$	1.0	1.1	0.3
13	$CH_3CHO + OH \rightarrow CH_3CO_3$	0.8	1.1	0.3
14	$O_3 + OH \rightarrow HO_2 + O_2$	0.6	0.7	0.2
15	$H_2 + OH \rightarrow HO_2 + H_2O$	0.5	0.8	0.2
16	$CH_3OOH + OH \rightarrow CH_3O_2 + H_2O$	0.3	0.5	0.1
17	$H_2O_2 + OH \rightarrow HO_2 + H_2O$	0.1	0.3	0.0
	net radical losses			
18	$OH + NO_2 \rightarrow HNO_3$	1.9	2.2	1.1
19	$OH + NO \rightarrow HONO$	0.5	0.6	0.2
20	$OH + RO_2 \rightarrow$ products	0.4	1.0	0.0
21	$OH + RO_2NO_2 \rightarrow$ products	0.4	0.5	0.1
22	$OH + HONO \rightarrow H_2O + NO_2$	0.1	0.2	0.1
23	$OH + HNO_3 \rightarrow H_2O + NO_3$ [a]	0.0	0.0	0.0
24	$RO_2 + NO_2 \rightarrow RO_2NO_2 \rightarrow$ products	1.9	2.4	1.2
25	$RO_2 + RO_2 \rightarrow$ products	0.7	2.1	0.1
26	$RO_2 + OH \rightarrow$ products	0.4	1.0	0.0
	$\sum$ OH sources	24.2 ± 2.1 [b]	38.3 ± 3.2	7.1 ± 0.7
	$\sum$ OH losses	14.8 ± 4.6	20.3 ± 3.6	5.1 ± 1.2
	Δ	9.4 ± 5.0	17.9 ± 4.8	2.1 ± 1.4
	Δ/ OH Losses	0.6 ± 0.4	0.9 ± 0.3	0.4 ± 0.3
	$\sum RO_2$ sources	14.6 ± 1.8	21.9 ± 2.3	4.2 ± 0.9
	$\sum RO_2$ losses	11.7 ± 4.6	17.7 ± 7.2	3.5 ± 1.6
	Δ	2.9 ± 5.0	4.2 ± 7.6	0.7 ± 1.9
	Δ/ RO_2 Losses	0.25 ± 0.4	0.24 ± 0.4	0.19 ± 0.5
	$\sum RO_2$ and OH net sources	18.7 ± 0.6	32.3 ± 0.9	5.5 ± 0.1
	$\sum RO_2$ and OH net losses	6.4 ± 5.9	10.1 ± 7.1	2.7 ± 1.7
	Δ	12.3 ± 6.0	22.2 ± 7.2	2.7 ± 1.7
	Δ/net losses	1.9 ± 2	2.2 ± 1.7	1.0 ± 0.9
	$P_{pr}^{net}(OH) = \sum$netOHsources $- \sum$netOHlosses	12.2 ± 4.2	21.4 ± 3.0	3.4 ± 0.8
	$R_{net}(OH \rightarrow RO_2) = \sum(OH \rightarrow RO_2) - \sum(RO_2 \rightarrow OH)$	2.8 ± 2.7	3.5 ± 3.8	1.4 ± 1.1
	$P_{pr}^{net}(RO_2) = \sum$net$RO_2$sources $- \sum$netRO_2losses	0.15 ± 4.2	0.74 ± 6.6	−0.7 ± 1.5

Table 1: Global tropospheric hydroxyl distribution, budget and reactivity - Jos Lelieveld, Sergey Gromov, Andrea Pozzer, and Domenico Taraborrelli

The ReductionTech^{tm} Remedy

For every 1 ppm (part per million) increase in OH* radicals, the following reductions (Table A) are achieved where 50% treats criteria air pollutants and 50% treats GHGs: 20% of the OH* released will recycle and go on to remove more pollution so dispersing it creates a 125% enhanced steady volume, or 131 CO_2e/tonne secondary effect over 5 days. Each tonne of OH* directly offsets 530 CO_2 equivalents of atmospheric warming in addition to indicated air quality improvements, and

Table A translates to reduction of 861 tonnes of CO_2e per tonne of OH* emitted in a concentrated stream without losses, plus an estimated 27 saved lives/100,000.

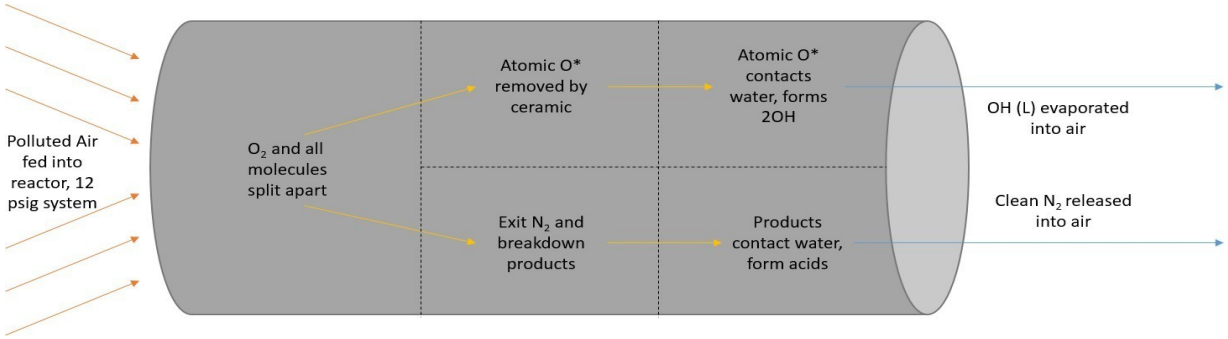
Gas or Species	Molality used	Wt % of species removed by 1 ppm OH* release	Wt % removed by thermal destruction in 20 T/Day ReductionTech System Feed Air = 200 CO2e/tonne
PM 2.5	1:1	12.5	100
O3	1:1	12.5	100
Carbon Monoxide	1:1	12.5	100
Methane	3:1	4	100
NOx	1:1	12.5	100
CO_2 buffered & removed	1:1	12.5-10 CO_2e/day	100
VOC	2:1	6.25	100
Synthetic GHGS	4:1	3	99

ReductionTech^{tm} Processing Facility

GIGA Factories are
Just larger...

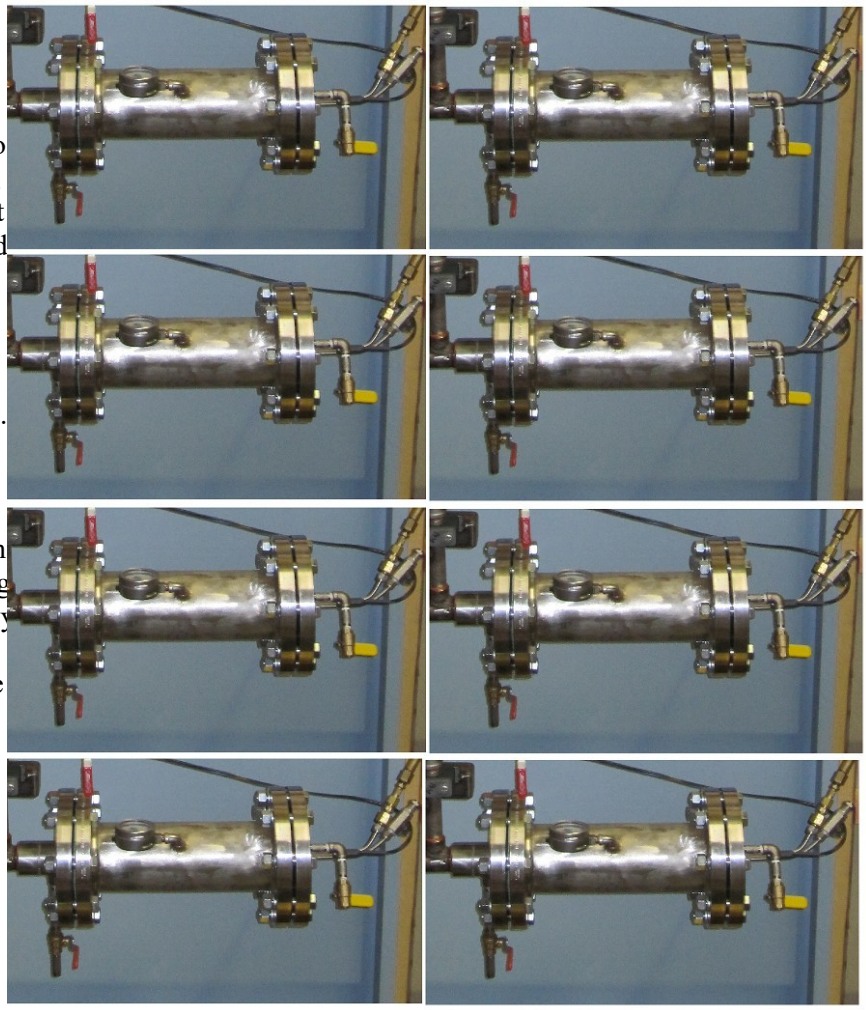
Process Flow

(Facility footprint)



Operation & Maintenance

The ceramic systems are housed heavy-duty stainless steel, mounted on steel skids, piped together and controlled by computer. The ceramic tubes clamp into the reactors with the removal of 8 bolts, the adjustment of 4 screws, replacement of three graphite gaskets in a turnaround time of approximately 20 minutes. The reactors weigh just less than 90 lbs. each, are serviceable in place. The tube warranty for replacement averages one year, the heaters warranty every 3 years. This system is 8 times more cost efficient than generating OH* radicals using UV light bulbs in ambient air and produces highly concentrated streams th can remove CO_2 by enhanced weathering The technology does not involve a heavy engineering burden like some others. Each ceramic will remove 40,000 CO2e in its lifetime.
These are the actual cells shown right.



Unmounted ReductionTech reactor cells

The sustainability of this technology includes recycling and reusing the ceramic material, so costs and the environment benefit. The tubular heaters' nichrome wiring can be scrapped and replaced as well. Each reactor uses approximately 700 watts of 30 amp, 110 V electricity from a green source. We suggest a combination of smaller nuclear power systems and solar energy.
Water is used conservatively to make hydroxyl dispersant, which is safely misted to the environment.

Air Shed Specifications and ReductionTech[tm] Value Proposition to 100,000 Urban Residents of an 8 TPD Hydroxyl Radical Air-Quality-Climate and GHG Mitigation Infrastructure

Air shed treatment volume Km^3 1% volume (300)	3
Tonnes of Air	3,900,000
OH dispersal/day Tonnes	8
Added ppm of OH to area	2.2
Total ppm of Kamloops 3 year average PM 2.5	5
Provincial goal: 6 ppm Kamloops at 11ppm (5+6=11)	
PM 10 3 year average	6
Kamloops Deaths per year per 2.5 ppm of PM 2.5 level	22
Deaths/yr 1% with <50ppb O3/10ppb+ avg 30ppb (Cardiopulmonary Death)	30
Total empirically attributable AQ premature deaths in Kamloops/year	52
Disability adjusted Lost years attributable to air pollution	50
Monetary value of a human life USD (per US EPA)	$7,000,000
Annual cost of loss of human life value for Kamloops USD	$574,000,000
Minimum human savings for OH* dispersal per year to Kamloops USD	$57,400,000
Kamloops Methane emission cost to society at 180 kT/yr, $2900/T	$522,000,000
Value of 6% Methane footprint reduction work by 8 TPD OH*	$32,625,000
Total Annual cost of noted Criteria Pollutants to Kamloops	$1,128,625,000
Total recouped annual costs from dispersing 8TPD OH*	$90,025,000
Value of recoup in human lives: a mass casualty incident = 6 lost lives	30
Annual cost Average of a cost shared 8TPD OH* dispersal over 10 years	$10,000,000
CO2e offset impact for one year. 8T x 350 days steady flux effect included	2,410,800 Tonnes
Annual cost of OH* technology investment as % of annual 8% Recoup	11.1%
Annual cost of OH* technology investment as % of annual total losses	1.24%
Return on annual investment against annual losses	112x

Data Sources: Kamloops BCMOE, Stern Report, EPA, WHO, Schindell et. al., Physicians for the Environment Kamloops

Time Estimates

The process of scaling up to a total of 1200 ***ReductionTech[tm]*** reactors would require an estimated 2-year lead time, at a cost of $500,000.

units wanted	1200
cost for them	$18,118,525
Land 20 acres	$3,000,000
total cost/unit	$22,648
total system	$27,177,788
POWER	$9,700,000
TOTLCAPEX	**$39,877,788**

An estimated additional three years would be required to build and commission the plant and power supply. A global scale up will take ten years.

Global Scaling and Solving the Root of the Problem Involves:

7-8 acres of the buildings shown, supported by 175MW of DE-carbonized solar/small nuclear/pressurized nitrogen electricity. With this process in place for 60–80 years, the whole volume of our planetary atmosphere can be treated with hydroxyl to oxidize and weather out CO_2 by releasing over 170MT of Hydroxl in concentrated pH 10 streams that can buffer out the CO2 as well as remove all other GHGs.

The resulting cooling will address atmospheric warming fully, and start allowing the oceans to cool!

Potential Project Funding Structure- for Global Mitigation

This gives a view of the cost per 100,000 urban residents wishing to continuously upgrade and treat their air system with 1200 cells.

Price of OH release program per citizen	
Grams/day	80
Kg per year	28
@$2.45/Kg/ye	$96.60

Offsets 2x the annual carbon footprint

News &Views

HUMAN AQ STATISTICS FOR 100,00 Urban People-ANNUAL

COPD/100,000 Canadian Government	1.,137
Asthma/100,000 Canadian Government	9,604
AQ Deaths WHO	50
AQ Disability WHO	52
All Cause mortality (Lancet)	301
TOTAL PER 100,000	23,094

Federal Government of Canada estimates that climate damages per capita will range from $636-$1,194/person per year. Our global scaling cost per Tonne of CO2e is $3-4 USD.

remove methane.

Unfortunately, the Air Quality story includes a badly deteriorating situation where Arctic methane is releasing from the terrestrial and sub sea permafrost caps into the Earth's atmosphere. Methane from this and fracking can in turn trigger a self-amplifying feedback of Arctic warming throughout the Arctic. Natural hydroxyl is extremely low in the Arctic, which means that Methane will persist there dangerously. Scientists estimate that there are 1000 billion tonnes of methane and CO_2 at risk of leaking over the coming decades with an estimated 50 Gt release already in process. This will cause additional increased global warming of at least 2.1 °C if the entire leak happens and the methane is commercially exploited.

Table 3. Scenario B: atmospheric methane inventory (Gt), corresponding mixing ratio (ppm), radiative forcing (Wm^{-2}), and corresponding temperature increase (°C) for 2040, 2060, and 2100.

Year	Emission rate ($Tg\ yr^{-1}$)	Methane mass m CH_4 (Gt)	Mixing ratio (ppm)	Additional CH_4 radiative forcing (Wm^{-2})	Additional increase (°C)
2040	580 (2010–2040)	14.1[a]	4.9	+0.96	+0.77
2060	765 (2040–2060)	10.5	3.7	+0.64	+0.51
2100	1190 (2060–2100)	14.7	5.1	+1.01	+0.80

Source: Arctic methane, Elena Dyupina & Andre van Amstel - Journal of integrative environmental sciences.

Direct air capture of CO_2, methane removal, and synthetic greenhouse gas removal can all be done with new technologies. As governments move to protect community infrastructure, they are forced to look at mitigating climate damages including opportunities to remove the GHG root cause of climate damages -or never maximally secure their assets or meet Paris and 1.5'C goals, which frankly are being breached right now during 2020 in the Northern Hemishpere and the poles because of Arctic amplification. Green infrastructure that can remove GHGs, protect and restore the atmosphere, provide lifesaving local and global air quality, begin reducing chaotic infrastructure stressing are now a critical public good. Hydroxyl radicals are the best methane removal and air quality tool we have so we need reliable technology that can potentially deliver them to the atmospheric infrastructure on a global scale while reducing damages.

The total warming that municipalities are confronting is 3.1'C, we have already warmed 1.5'C (Arctic Methane Emergency Group). If methane and reactive GHGs are removed with technology, a 2'-3'C cooling over the next century is critical. CO_2 caused warming and other GHGs are now a combined impact. If we remove the potent GHGs we can restore the climate about 2'C over the next century and significantly reduce property damage and loss of life. The climate emergency is decadal in scale, but very large damages are already happening. The municipal damages are changing/shortening amortization schedules for infrastructure, forcing them to think about more frequent and bigger public works expenses. Through carbon pricing, the emitter will begin to offset their impact and give emissions removal technologies at least a partial business case. Historical emissions and their role in damages have yet to be fully addressed and we can help.

As of September 7, 2020, 1400 Local Government bodies covering over 820 million people have declared a climate emergency. https://climateemergencydeclaration.org/climate-emergency-declarations-cover- 15-million-citizens/

IPCC scientists advise that we have at most 9 years to establish a forceful and sweeping combined emissions reduction protocol to get to net zero carbon emissions. If we fail, the average temperature of Earth will warm at least 2 °C over pre-industrial times, with catastrophic results. We are already at a warming of approximately 1.5°C and the results in weather anomalies, drought and deluge, are bankrupting farmers and causing massive population migrations. ***ReductionTech***™ production of hydroxyl radicals is an extremely fast and powerful intervention in this time-sensitive effort. The only delay in our cooling proposition is the oceans.

The more methane in the atmosphere, the fewer *OH are present to ensure air quality from other pollution sources in urban air which kills an average of 52 people per 100,000 population in Canada. Cities that are removing GHGs are also protecting themselves from the advance of climate damages by going to the root cause: the emissions themselves.

*OH is naturally variable, which means that lowered levels of it because of our excessive pollution activity slows the removal of both pollutant groups, GHG and criteria air pollutants. At this time, communities need assurances that GHGs are being removed from the atmosphere in order to gain protection of assets and people. The way to achieve protection is with ***fast acting easy to adopt, low tech technology*** such as ***ReductionTech*** [tm]. Guaranteeing a steady oxidative capacity will speed the reduction of climate damages.

Governments can organize to secure a working ***ReductionTech*** [tm] facility, including using our previous experience, to build a pilot plant demonstration, and then to help secure assets and reduce the carbon footprint that causes climate damages by maintaining safe elevated oxidation to the environment. This chemistry has a track record of 2.4 Billion years!

More information about the methane threat can be found at Prof. Paul Beckwith's web site, from Dr. Peter Wadhams, IPCC, Arctic Council technical reports, peer reviewed journals and numerous public media sources.

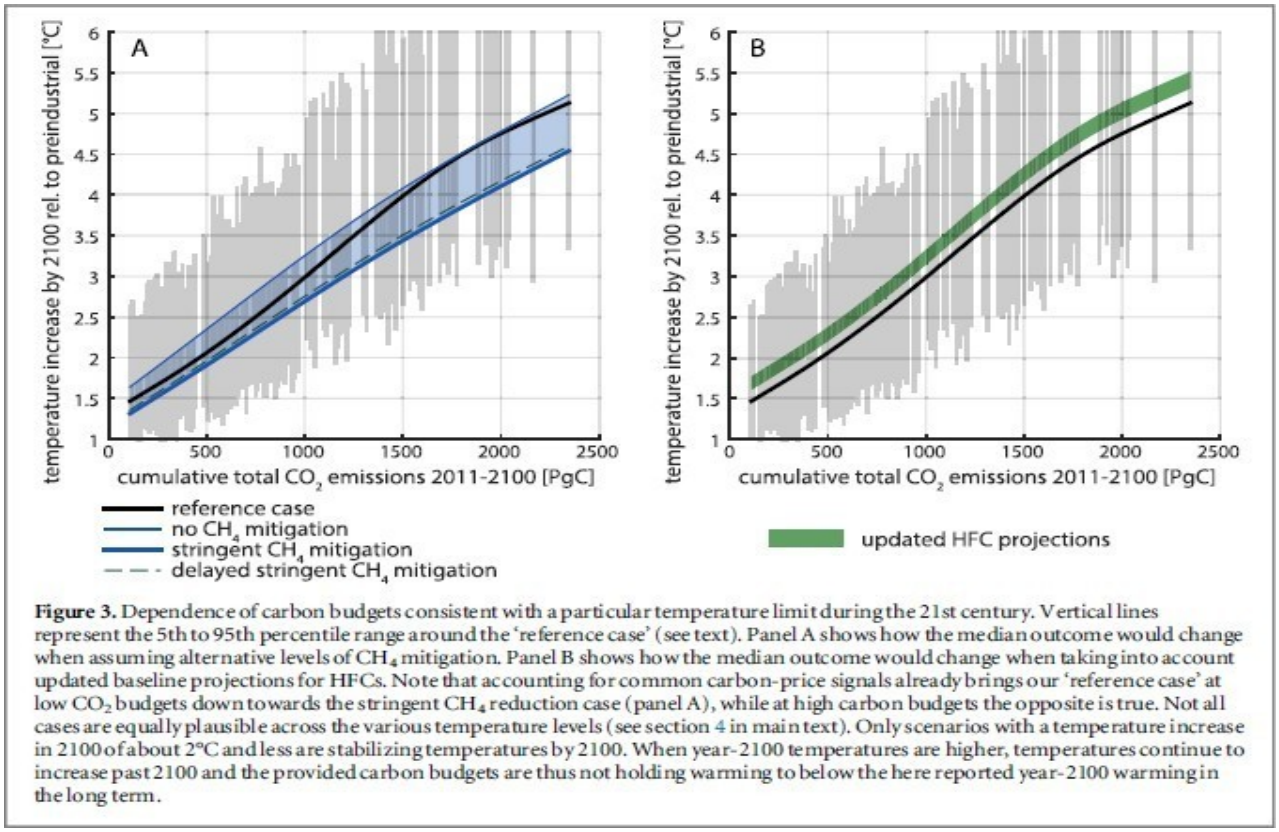


Figure 3. Dependence of carbon budgets consistent with a particular temperature limit during the 21st century. Vertical lines represent the 5th to 95th percentile range around the 'reference case' (see text). Panel A shows how the median outcome would change when assuming alternative levels of CH_4 mitigation. Panel B shows how the median outcome would change when taking into account updated baseline projections for HFCs. Note that accounting for common carbon-price signals already brings our 'reference case' at low CO_2 budgets down towards the stringent CH_4 reduction case (panel A), while at high carbon budgets the opposite is true. Not all cases are equally plausible across the various temperature levels (see section 4 in main text). Only scenarios with a temperature increase in 2100 of about 2°C and less are stabilizing temperatures by 2100. When year-2100 temperatures are higher, temperatures continue to increase past 2100 and the provided carbon budgets are thus not holding warming to below the here reported year-2100 warming in the long term.

Source: Impact of short-lived non-CO2 mitigation on carbon budgets for stabilizing global warming - Joeri Rogelj[1,2], Malte Meinshausen[3,4], Michiel Schaeffer[5,6], Reto Knutti[2] and Keywan Riahi[1,7]

Endorsements of ReductionTech Technology

Dr. Kingsley

Donkor, Professor, Thompson Rivers University, who said "the science merits inclusion in more text books", "Relevant", Stephen Brydon, Climate Change Strategy Branch, Province of BC.

Lead Contact

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Hydroxyls are nature's silver bullet
12 million preventable AQ deaths and disabilities/yr
3'C of global food and climate change reversal security

ReductionTech^{tm}

Frequently Asked Questions

1. Does this method really assist with outdoor air quality and greenhouse gases?

Yes. The hydroxyl radical is relied upon in nature as the #1 air quality and greenhouse gas removal compound. Its secret is that it persists in the atmosphere until it does react, meaning any enhancement of it will have an additive effect and minimal waste.

2. Is the hydroxyl radical *really* overwhelmed by modern pollutants?

The highest average amount of hydroxyl is 3 ppm and about 20% recycles in the area overnight. This means that total pollutant counts above 8.60 ppm are overwhelming it and are creating a tipping point where the polluted area is now contributing to a build up of greenhouse gases and pollutants that is being exported out of the local area into neighboring regions, and contributing to accelerated global warming and climate damages.

3. Isn't the atmosphere an unlimited container?

Definitely not and only coordinated removal processes will ensure that we lower pollutant levels and protect infrastructure and lives in the mid and long term.

4. Isn't the average pollution count still acceptable in urban air?

Our statistics are based on Canadian monitoring that must include particulates and if possible, aerosol counts. The aggregate pollution count is used because hydroxyl attaches to, or breaks up aerosols and PM, so these constituents use it up just as much as the other pollutants. When they are included in urban air, even Canada's standards allow too much for the natural hydroxyl level.

5. With smart cities, can't we lower our emission levels?

It's a long journey and plant stress and plant metabolism from increased CO_2, warming and drought alone is increasing aerosol levels even in green cities and with COVID-19. Atmospheric brown carbon and black carbon are a global issue and use up the hydroxyl reservoir and are exported to neighboring countries of developing countries that have asserted that they will peak their emissions before considering cutting down. Global emissions rose over 2% in 2018 while 18 single countries lowered emissions and viable direct removal methods like this one at *ReductionTech*^{tm} are being scaled up because the global average temperature is still rising, drought, floods and fires are projected to progress by scientists.

6. What is the individual's value proposition to personally assess this technology?
   Per Person Pollution Reductions

PM 2.5	25%
Ozone	90%
CO	50%
CO2	6%
NO	50%
aerosols	20%
CH4	200%
SGHGs	200%
reduced deaths	30-50%
Cost Per Person Per year	
Per Person $US	8
Up to	16
OH per day grams	80-160

Based on an average Canadian Citizen's emissions profile. Other countries like the US and Asia emit more. As the hydroxyl system is outpaced, emissions are exported to other regions in an increasing cycle of inundation leading to incalculable climate damages.

Reduction Tech^{tm}: Offering a way that governments and other authorities can act scientifically and effectively for their constituents, for the air, their health, and for the Earth.
Canada is officially warming at twice the pace of other countries, with the Arctic warming amplification at three times the pace. Canada could be the home of this global remediation and act for the benefit of all.