ITER Forum Website update 8/14
B.J.Green (22/8/14)

1. Canberra's costly carbon follies outdo even the danes

http://www.theaustralian.com.au/opinion/canberras-costly-carbon-follies-outdo-even-the-danes/story-e6frg6zo-1227009240918

AUSTRALIANS are learning the hard way that moral vanity comes at a high price. After many years of climate policy chaos, we know that most people want some action on climate change but they don't want to waste money on expens-ive, inefficient schemes.

Yet politicians spruik and implement them, we all wake up to the cost and the policy has to change. It's bad for households, consumers and investment. And the merry-go-round achieves little or nothing for the planet.

Bjorn Lomborg recently exposed on these pages the folly of Copenhagen's plans to be the world's first CO2-neutral city.

Hot on Copenhagen's heels, Canberra has announced a plan to mandate that a dizzying 90 per cent of the ACT's electricity- -supply will come from large-scale -renewables by 2020, with a 50 per cent reduction in

carbon emissions.

Canberra's blueprint suffers from the same overreach as Copen-hagen's. As old-style industry protection has fallen out of favour, rent-seekers are hungrily eyeing green industry subsidies.

The ACT government is hopping on the merry-go-round with a blueprint focused on building masses of wind turbines, and the odd solar farm.

Not content to focus on efficient means to reduce carbon emissions, the proposal props up the troubled wind industry. Yet as the Productivity Commission, last week's Deloitte report and mainstream economists tell us, wind energy — viable only on the back of vast subsidies — is an expensive way to reduce carbon emissions.

The ACT has ignored sensible alternatives. For instance, decentralised solar is economic without, repeat, without subsidies in many rural and remote areas. Farmers know this — many have been using solar for years for a range of purposes.

But the present NSW regulatory regime hurts the economics of solar: electricity distributors increase profits and returns through massive network investments where rooftop solar is a better option. Nor is increasing soil carbon part of the ACT plan, despite the obvious opportunity in the surrounding agricultural regions.

On the ACT government's own numbers (which are

questionable), the 90 per cent renewables plan will cost an additional $370 million between now and 2020. These costs will be passed on to ACT households in their electricity bills, hurting the poor, and the government tries to downplay the impact by assuming offsetting efficiencies.

In many countries, renewable energy targets are growing rapidly because today's huge investment costs are hidden in tomorrow's electricity bills.

The ACT plan expects wind power to cost about $100 per megawatt hour, roughly three times the market price. This is consistent with Deloitte's recent finding that the federal large-scale renewable energy target is costing $103 per tonne of carbon abated — four times the cost of our inflated carbon tax.

Ironically, in a recent effort to reduce costs, the ACT government itself has pulled back on the use of green power — renewable energy use in the government's nine directorates plunged by 83 per cent in 2012-13.

It is unclear how the ACT plan may fit with a revised federal RET. The present federal target is intended to include all renewable generation, and ACT efforts should ordinarily be taken into account. This will be a decision for the federal government following the RET review, but there is a real prospect that the ACT's expensive efforts will have no impact at all on Australia's emissions.

The ACT blueprint also does not include the extra

costs of full-scale back-up from another electricity source. Wind blows only some of the time, so Canberra will need to call on coal-fired electricity. In practice, this means that when the wind blows, ACT-sponsored wind farms will send their electricity into the NSW grid, yet the ACT will demand a reliable and constant supply in return. The NSW grid also will need to address large fluctuations in supply, causing unprecedented operational pressures and additional costs.

The most extraordinary part of the blueprint is the assertion that communities outside the ACT, where the turbines will be built, actually want them. This wind-industr-y-inspired propaganda is simply untrue.

I represent a large swath of NSW where there are turbines and where many, many more are planned. I know that a growing majority of people in these quiet, beautiful, unique, windswept communities do not want them.

Wind farms nearly always cause deep community fractures and risk serious downward pressure on the value of adjacent land. Typical wind-farm victims are tree-changers from Canberra who have put their life savings into their dream block, only to find it virtually unsaleable. Wind developers have been known to tell these people they should simply “take one for the planet”.

Middle Australia is willing to support sensible carbon emission-reduction efforts, but it will not tolerate big

economic hits to achieve it, which is why Australia rejected the world's biggest carbon tax.

Experience abroad (witness the 2009 Copenhagen Summit) and here tells us that overreach will thwart well-intended initiatives. We need efficient, careful and well-timed emission-reduc-tion policies. The ACT renewables blueprint fails on every front.

Angus Taylor is the federal member for Hume. He was a partner at McKinsey & Co and director of Port Jackson partners, where his work included carbon and energy strategy and policy development.

2. Renewables in the doldrums

THE AUSTRALIAN
AUGUST 02, 2014 12:00AM

http://www.theaustralian.com.au/news/features/renewables-in-the-doldrums/story-e6frg6z6-1227010634767

FOR Australia's multi-billion-dollar renewable energy industry, marooned in the doldrums of -investment uncertainty, the big calm before the renewable energy target review storm came last week. For two consecutive days a high-pressure system becalmed southeastern Australia, stranding the nation's entire fleet of wind turbines.

Figures provided by the Australian Electricity Market Operator show that on July 21 registered wind generation in the National Electricity Market fell to a

low of 23 megawatts. The minimum average for any two-hour period was 24MW. That is the power production figure for all wind turbines in South Australia, Victoria, NSW and Tasmania, which have a combined capacity of 3300MW.

The crash in supply from wind was repeated the following day.

There are two ways to look at last week's collapse of electricity supply from wind. AEMO said there was no generation "shortfall" from the perspective of the National Energy Market because there was more than 36,000MW of electricity available from other sources of generation to pump into the system when wind dropped.

But for others the forced withdrawal of wind energy highlights a fundamental weakness of renewable technology. In oversupplied electricity markets, such as Australia's, the shortfall may be easy to absorb. But as the penetration of renewables grows the impact of when it goes missing multiplies.

While political attention has been on rising domestic electricity prices there are much bigger issues at play in the federal government's review of the MRET. Behind the intense ideological and self-interested lobbying for zero-carbon technology, the government ultimately must balance the same competing environmental and economic conflicts bedevilling policymakers worldwide.

Is an MRET the best and most cost-effective way to make the transition to a carbon-constrained world? Can it deliver? Will affordable storage technology evolve quickly enough to beat intermittency issues? What role is there for gas as a transitional fuel and economic game-changer, as it has been in the US? Put simply, is there a better way?

Despite strong support, there have been warnings on the pitfalls of forcing renewables into the system, most notably from Germany. But a discussion paper prepared for the Energy Supply Association of Australia says, like Europe, industrial competitiveness is a major policy topic for Australia, with cheap US shale gas on the one hand, and cheap Asian labour on the other, making competitive energy prices vital to the future wellbeing of the Australian economy.

A new paper prepared for the US electricity industry by Swiss consultancy Finadvice provides some valuable insights.

The Finadvice paper concludes: “The lessons learned in Europe prove that the large-scale integration of renewable power does not provide net savings to consumers, but rather a net increase in costs to consumer and other stakeholders.”

Sound familiar? And this: “Overgenerous and unsustainable subsidy programs resulted in numerous redesigns of the renewable support schemes, which increased regulatory uncertainty and financial risk for all stakeholders in the renewable energy industry.’’

More significant for Australia's current RET inquiry, due this month, is confirmation of the problems posed by "intermittency" of renewables. Renewable energy operators, including Infigen Energy, claim the German comparison is unfair because of the different regulations and poorer quality wind and solar resources in Europe compared with Australia.

But last week's wind drought in southeastern Australia shows there will always be a need for power generation equal to entire demand for times that there is no contribution from wind. In Australia, this can be compensated to some extent by interconnection of the national market and the addition of quick-response peaking gas-fired turbines.

But electricity industry experts warn there is a hidden long-term cost. The Finadvice paper documents the financial and technological squeeze that market transformation is imposing in -Europe. Fossil and nuclear plants are "now facing stresses to their operational systems as they are operating under less stable conditions and are required to cycle more often to help balance renewables' variability", the Finadvice report says.

As renewable penetration grows and the wholesale market is crunched by oversupply, new subsidies are required in the form of "capacity payments" to keep -fossil-fuel generation available on demand. Engineer Paul Miskelly claims the report justifies concerns he raised in a 2012 paper in the journal *Energy and Environment*. "Not only does intermittent, and highly

subsidised wind completely ruin the financial returns on the still essential coal and gas-fired generation, thus decreasing incentives to replace this essential generation as required, it causes actual mechanical damage to the existing plant, resulting at the very least in a significant reduction in both plant reliability and operational lifetime," Miskelly says.

"Perversely, the (Finadvice) report also shows too clearly coal and gas-fired generation remain essential to back up wind.''

For Australia, the issue will become greater as the percentage of renewables in the system inc-reases. It is one of the core arguments towards reducing the 2020 RET to a "true" 20 per cent rather than the existing set figure of 41,000 gigawatt hours by 2020, which on present estimates would equal closer to 30 per cent.

Energy company GE says gas has an important role to play, telling the RET review the relationship between gas and renewables will evolve to complement each other rather than compete. "The partnership between gas and renewables is build on supporting each others' weaknesses,'' GE says.

"The variability of renewable sources can be complemented with flexibility of gas-fired power.

"At the same time, the zero fuel cost associated with renewable generation can provide a valuable hedge against potential gas price volatility.'' The gas

industry, however, has argued the RET is an economically inefficient policy that should be discontinued.

A report by BAEconomics for gas industry lobby group APPEA found the RET forced higher-cost renewable energy into the electricity generation mix at the expense of lower-cost emissions abatement opportunities from gas generation and elsewhere.

Renewable energy companies have tried to turn the cost argument on its head, claiming low cost wind generation has pushed -prices down overall in the wholesale market. Infigen Energy told the RET review the low marginal cost of renewable energy was reducing wholesale electricity prices to the benefit of consumers.

But the consumer benefits of the low running cost of renewables is hotly contested. A discussion paper on wind power in South Australia for ESAA says wind farms are able to bid into the National Electricity Market at low prices in part because they receive payments (in the form of renewable energy certificates) from outside the market.

“This distorts the otherwise efficient operation of the NEM,’’ the paper says. In effect the savings on the wholesale market are a mirage because of the high subsidy built into power purchase agreements and RECs through the RET ultim-ately is passed on to consumers.

Outspoken West Australian Liberal senator Chris Back has told parliament power purchase agreements, which are needed to finance renewable projects, lock in prices of up to $120 a megawatt hour compared with the average wholesale price of between $30 and $40 a MWh.

“The price set by the PPA is paid by the retailer irrespective of the wholesale price and passed on to retail customers along with retail margin over the life of the PPA, which is usually 15 and up to 25 years,’’ Back says. He also takes issue with industry claims of sovereign risk, which has been widely cited as a reason not to wind back the RET, saying the RET system was always subject to review that might result in a decrease in value.

Renewable industry lobby group the Clean Energy Council says a reduction of the RET would affect $10 billion of existing investment and imperil $15bn worth of projects now in planning.

Nonetheless, when the federal government finally makes a decision on what to do about the RET, it is expected to be sympathetic to existing renewable energy -projects. The likeliest outcome would be to scale back the RET to a “true” 20 per cent and exempt “special” cases such as Tasmania’s aluminium industry.

Despite pleas for investment certainty, the review is unlikely to solve the issue for the long term. A clue to the future is contained in the RET review submission

lodged by the Australian Energy Market Commission, which makes and amends the rules for the National Electricity Market and elements of the gas markets.

The AEMC says energy and environmental policies have different objectives and it is important they are developed in a manner where any efficiency trade-offs and costs are well understood. The AEMC says it does not consider the present policy of a fixed 2020 target sustainable. It has recommended moving to a floating 20 per cent target to shift the allocation of demand risk from consumers to investors.

AEMC's alternative suggestion is more radical but ultimately may prove more durable. It is to move the RET to an emissions intensity-based scheme under which generators below a defined emissions intensity level are able to create certificates that generators above the level are liable to purchase.

AEMC says this type of approach will encourage all lower emissions technology options, not only renewable energy, and therefore is likely to meet any emissions reduction target at a lower cost. It is an approach that avoids picking technology winners and AEMC hopes it may contribute to the policy certainty necessary to provide industry with confidence to continue to invest in the energy sector.

3. Electricity by intermittent

sources: An analysis based on the German situation 2012

Friedrich Wagner

http://link.springer.com/article/10.1140%2Fepjp%2Fi2014-14020-8

Abstract.

The 2012 data of the German load, the on- and offshore and the photo-voltaic energy production are used and scaled to the limit of supplying the annual demand (100% case). The reference mix of the renewable energy (RE) forms is selected such that the remaining back-up energy is minimised. For the 100% case, the RE power installation has to be about 3 times the present peak load. The back-up system can be reduced by 12% in this case. The surplus energy corresponds to 26% of the demand. The back-up system and more so the grid must be able to cope with large power excursions. All components of the electricity supply system operate at low capacity factors. Large-scale storage can hardly be motivated by the effort to further reduce CO_2 emission. Demand-side management will intensify the present periods of high economic activities. Its rigorous implementation will expand the economic activities into the weekends. On the basis of a simple criterion, the increase of periods with negative electricity prices in Germany is assessed. It will be difficult with RE to meet the low CO_2 emission factors which characterise those European Countries which produce electricity mostly by nuclear and hydro power.

4. We’re ill-prepared if the

iceman cometh

MAURICE NEWMAN
THE AUSTRALIAN
AUGUST 14, 2014 12:00AM
http://www.theaustralian.com.au/opinion/were-illprepared-if-the-iceman-cometh/story-e6frg6zo-1227023489894

WHAT if David Archibald's book *The Twilight of Abundance: Why Life in the 21st Century Will Be Nasty, Brutish, and Short* turns out to be right? What if the past 50 years of peace, cheap energy, abundant food, global economic growth and population explosion have been due to a temporary climate phenomenon?

What if the warmth the world has enjoyed for the past 50 years is the result of solar activity, not man-made CO2?

In a letter to the editor of *Astronomy & Astrophysics*, IG Usoskin et al produced the "first fully -adjustment-free physical reconstruction of solar activity". They found that during the past 3000 years the modern grand maxima, which occurred between 1959 and 2009, was a rare event both in magnitude and duration. This research adds to growing evidence that climate change is determined by the sun, not humans.

Yet during the past 20 years the US alone has poured about $US80 billion into climate change research on the presumption that humans are the primary cause. The effect has been to largely preordain scientific conclusions. It set in train a virtuous cycle where the more scientists pointed to human causes, the more

governments funded their research.

At the same time, like primitive civilisations offering up sacrifices to appease the gods, many governments, including Australia's former Labor government, used the biased research to pursue "green" gesture politics. This has inflicted serious damage on economies and diminished the West's standing and effectiveness in world -affairs.

University of Pennsylvania professor of psychology Philip Tetlock explains: "When journal reviewers, editors and funding agencies feel the same way about a course, they are less likely to detect and correct potential logical or methodological bias." How true. The Intergovernmental Panel on Climate Change and its acolytes pay scant attention to any science, however strong the empirical evidence, that may relegate human causes to a lesser status.

This mindset sought to bury the results of Danish physicist Henrik Svensmark's experiments using the Large Hadron Collider, the world's most powerful particle accelerator. For the first time in controlled conditions, Svensmark's hypothesis that the sun alters the climate by influencing cosmic ray influx and cloud formation was validated. The head of CERN, which runs the laboratory, obviously afraid of how this heretical conclusion would be received within the global warming establishment, urged caution be used in interpreting the results "in this highly political area of climate change debate". And the media obliged.

But Svensmark is not alone. For example, Russian scientists at the Pulkovo Observatory are convinced the world is in for a cooling period that will last for 200-250 years. Respected Norwegian solar physicist Pal Brekke warns temperatures may actually fall for the next 50 years. Leading British climate scientist Mike Lockwood, of Reading University, found 24 occasions in the past 10,000 years when the sun was declining as it is now, but could find none where the decline was as fast. He says a return of the Dalton Minimum (1790-1830), which included “the year without summer”, is “more likely than not”. In their book *The Neglected Sun* , Sebastian Luning and Fritz Varen-holt think that temperatures could be two-tenths of a degree Celsius cooler by 2030 because of a predicted anaemic sun. They say it would mean “warming getting postponed far into the future”.

If the world does indeed move into a cooling period, its citizens are ill-prepared. After the 2008 fin-ancial crisis, most economies are still struggling to recover. Cheap electricity in a colder climate will be critical, yet distorted price signals caused by renewable energy policies are driving out reliable baseload generators. Attracting fresh investment will be difficult, expensive and slow.

Only time will tell, but it is fanciful to believe that it will be business as usual in a colder global climate. A war-weary world’s response to recent events in the Middle East, Russia’s excursion into the Crimea and Ukraine and China’s annexation of air space over

Japan's Senkaku/Daioyu Islands has so far been muted. It is interesting to contemplate how the West would handle the geopolitical and humanitarian challenges brought on by a colder climate's shorter growing seasons and likely food shortages. Abundance is conducive to peace. However, a scenario where nations are desperately competing for available energy and food will bring unpredictable threats, far more testing than anything we have seen in recent history.

During the past seven years, Australia has largely fallen into line with Western priorities and redistributive policies. It is reminiscent of a family that has inherited a vast fortune constantly fighting over the legacy but showing little interest in securing the future.

However, a country that is so rich in nature's gifts should not be complacent or assume that in other circumstances there will not be adversaries prepared to take what we have.

But, in times of peace and when government debts and deficits are growing daily, it is hard to persuade voters to trade off immediate benefits for increased defence spending, let alone prepare them, after all the warming propaganda, that global cooling is a possibility.

Yet the global warming pause is now nearly 18 years old and, as climate scientist Judith Curry says, "attention is moving away from the pause to the

cooling since 2002". Anastasios Tsonis, who leads the University of Wisconsin Atmospheric Sciences Group, talks of "massive rearrangements in the dominant pattern of the weather".

But the political establishment is deaf to this. Having put all our eggs in one basket and having made science a religion, it bravely persists with its global warming narrative, ignoring at its peril and ours, the clear warnings being given by Mother Nature.

Voltaire was right when he said: "Superstition is to religion what astrology is to astronomy, the mad daughter of a wise mother. These daughters have too long dominated the Earth." Indeed.

Maurice Newman is chairman of the Prime Minister's Business Advisory Council. The views expressed here are his own.

5. Solar cycles linked to climate pause, assist in coastal planning

THE AUSTRALIAN
AUGUST 16, 2014 12:00AM

http://www.theaustralian.com.au/national-affairs/climate/solar-cycles-linked-to-climate-pause-assist-in-coastal-planning/story-e6frg6xf-1227026053386

Graham Lloyd

Environment Editor
Sydney

LONG-TERM natural cycles linked to the sun could explain the pause in global average surface temperatures and offer a better guide for coastal planners to predict sea level rises, storm surges and natural disasters.

Publication of the findings in *Ocean and Coastal Management* follows a decade-long struggle for the lead author, Australian scientist Robert Baker from the University of New England, whose work has challenged the orthodox -climate science view that carbon dioxide is the dominant factor in climate change.

Dr Baker, a former chair of the International Geographical Commission on Modelling Geographic Systems, said what had been a purely scientific debate on climate change until 2005 had become political. His latest paper with his PhD student faced a -series of -objections from scientists close to the Intergovernmental Panel on Climate Change but was published after an 11-member peer review panel voted 8-3 to publish. An editorial that accompanied the paper said it was an “excellent -example of how to approach these complex issues that are now vulnerable to often irrational and heated debate instead of the -required proper scientific discussion”.

The Baker paper suggests a -hybrid model that allows future climate change to be estimated with or without human influences. The authors said this would provide a better legal foundation for decision making. Problems with coastal planning in NSW, based on

sea-level predictions from climate modelling, were cited in the international paper.

The paper accepts that if there is a human influence on climate change, then it could result in a threefold increase in one-in-100-year extreme coastal events. But it says, as the hiatus shows, human influence can be overtaken by long-term natural cycles, making predictions less certain. The combination of natural and human-induced change in a hybrid model of natural cycles and human influence suggested by Dr Baker produces a “planner’s -dilemma” of determining whether extreme events are natural fluctuations or from anthropogenic warming.

The paper shows, from scientific analysis of a large number of data sets, that previous fluctuations are periodic and likely to repeat, which has previously been ignored in climate models. According to the paper, the new model was able to simulate a number of climate features . This included greater heat uptake in the oceans to explain the present temperature “pause”; regional effects whereby global warming impacts were not evenly spread; and planetary, lunar and solar cycles being embedded within the chaotic fluctuations in short-term mean sea-level data. Historic cycles could be predicted to repeat, except with the addition of anthropogenic warming, where the impact could be magnified.

The IPCC’s latest report said the “pause” was due to natural variation and ocean warming. Climate scientists say they expect warming to resume in the

near future.

6. Aboriginal push to host nuclear waste dump sparks land council ructions

THE AUSTRALIAN
AUGUST 16, 2014 12:00AM

http://www.theaustralian.com.au/national-affairs/aboriginal-push-to-host-nuclear-waste-dump-sparks-land-council-ructions/story-fn59niix-1227026082653

Amos Aikman
Northern Correspondent
Darwin

AN Alice Springs-based group of Aborigines is pushing to revive plans to host Australia's nuclear waste 30km north of the town, with help from the Northern Territory and federal governments.

The proposal has become -entwined with ructions inside the powerful Central Land Council that have seen chairman Maurie Ryan suspended for the second time this year.

Members of the group told *The Weekend Australian* they were recognised as traditional owners at a full CLC meeting they attended at Mr Ryan's invitation.

They said the office of Minister for Indigenous Affairs Nigel Scullion had intervened to force the reluctant CLC to accept and fund their visit.

The group later met Northern Territory Chief Minister Adam Giles to discuss the dump plan, which is understood to be gathering support. During that meeting representatives of one family group asked to be paid $2 million to negotiate, but were rebuffed.

The site, known as Mount -Everard, was put forward as one of four potential sites for a nuclear waste dump under the Howard government.

Lesley Tickner, who believes his family owns the country, said the family could see no problem with storing low-level radioactive waste on ancestral lands. “They’re all for it,” he said. “We’ve got some paperwork from Adam Giles.”

Russell Bray, another member, said Mr Giles had indicated -another site, near Lajamanu, about 900km northwest of Alice Springs, was also being looked at.

Mr Bray accused the CLC executive of improperly trying to overturn his family’s declaration as traditional owners, and of neglecting the interests of its Aboriginal constituents. A CLC spokes-woman rejected this.

CLC director David Ross has been locked in a bitter battle for several months with Mr Ryan, with whom Mr Bray and Mr Tickner are aligned. Mr Ryan, who is in a legal dispute with the CLC executive over

attempts to suspend him from his chairman's post, called on Senator Scullion to investigate. "I want the Land Rights Act brought back to the Northern Territory so we can do development," he said.

Senator Scullion expressed concern about the CLC ructions, and the expiring three-month window to find an NT dump site. "I would expect that the CLC will listen to the interests of its constituents and I hope that it is up to the challenge, if traditional owners want to pursue this," he said.

Mr Giles said several traditional owners had expressed interest in hosting a nuclear dump.

7. Glacier loss 'man-made': blame for two-thirds of rapid melting

AP
AUGUST 16, 2014 12:00AM
http://www.theaustralian.com.au/news/world/glacier-loss-manmade-blame-for-twothirds-of-rapid-melting/story-e6frg6so-1227026009346

MORE than two-thirds of the recent rapid melting of the world's glaciers can be blamed on humans, a new study finds.

Scientists looking at glacier melt since 1851 didn't see a human fingerprint until about the middle of the 20th century. Even then only one-quarter of the warming

wasn’t from natural causes.

But since 1991, about 69 per cent of the rapidly increasing melt was man-made, said Ben Marzeion, a climate scientist at the University of Innsbruck in Austria. “Glaciers are really shrinking rapidly now,” he said.

“I think it’s fair to say most of it is man-made.”

Scientists fault global warming from the burning of coal, oil and gas as well as changes in land use near glaciers and soot pollution. Glaciers in Alaska and the Alps in general have more human-caused melting than the global average, Dr Marzeion said.

The study is published in the journal *Science*.

The research is the first to calculate just how much of the glacial melting can be attributed to people and “the jump from about a quarter to roughly 70 per cent of total glacier mass loss is significant and concerning”, said University of Alaska Fairbanks geophysicist Regine Hock, who was not part of the study. About 269 billion tonnes of ice is melting each year on average due to human causes and about 121 million tonnes a year are melting because of natural causes, Dr Marzeion calculated.

Glaciers alone add about 10mm to the rise in sea levels every decade, along with even bigger increases from melting ice sheets — which are different than glaciers — and the expansion of water with warmer temperatures.

Dr Marzeion and colleagues ran multiple computer simulations to see how much melting there would be from all causes and then did it again to see how much melting there would be if only natural causes were included. The difference is what was caused by humans.

Scientists are not quite certain what natural causes started glaciers shrinking after the end of the Little Ice Age in the middle of the 19th century, but do know what are human causes: climate change, soot and local changes in land use.

There is a sizeable margin of error so the 69 per cent caused by humans may be as low as 45 per cent or as high as 93 per cent, but is likely in the middle.

AP

8. ITER Nuclear Fusion Tokamak Could Be "The Way" to Solve World's Energy Problems

By: David Russell Schilling | October 18th, 2013

http://www.industrytap.com/iter-nuclear-fusion-tokamak-could-be-the-way-to-solve-worlds-energy-problems/4650

Huge ITER Cryosat to Tap Energy Generation Of Stars

The word "politician" is almost an obscenity these days, but looking back at an event involving Ronald Reagan, Mikhail Gorbachev and Jacques Chirac, we may be reminded politicians sometimes try to do good. In November 1985, these three large-than-life figures signed an agreement for a $12.8 billion International Thermonuclear Experimental Reactor (ITER) to be built in southern France.

What is even more notable is they probably had no idea what they were doing. After all, the agreement called for using fuel, a mixture of deuterium and trillium and two isotopes of hydrogen heated to more than 150 million °C, hoping it would solve the world's energy challenges without "unintended consequences." In fact, ITER required 22 years of intense and painstaking conceptual engineering and design before it could be officially christened viable, finally becoming an official organization in 2007.

ITER: Latin for "the way" or "the road"

In May, 2013 IndustryTap wrote "Can Fusion Energy Generate Unlimited Clean Energy by 2017?" about the current state of nuclear fusion. The ITER Cryosat Fusion Reactor, soon to be the world's largest experimental tokamak nuclear fusion reactor, is under construction with opening expected in 2027. Using ITER, scientists will attempt to produce 10 times more thermal energy from fusion heating than by auxiliary heating; produce a steady-state plasma; maintain a sustained fusion pulse; ignite a self-sustaining, burning plasma, develop technologies needed for a full-scale fusion power plant, test tritium breeding concepts and refine neutron shield and heat conversion technology.

History of Tokamak Design

The Tokamak design was invented by Soviet physicists Igor Tamm and Andrei Sakharov in the 1950s. Tokamak reactors use four kinds of heating: ohmic, neutral-beam injection, magnetic compression and radio-frequency heating. Liquid helium and nitrogen are used to cool the reactor.

"Tokamak" is a transliteration of the Russian word **токамак,** an acronym for "Toroidal Chamber With Axial Magnetic Field". The Tokamak design has been widely adopted because scientists believe it provides the best environment in which to safely and efficiently run a fusion reaction.

In simpler terms, tokamak is a doughnut-shaped magnetic confinement reactor that suspends a fusion reaction inside the doughnut within electromagnetic fields. This is necessary because no solid material has yet been found or created that could withstand the extremely high temperatures, greater than 15 keV or 150 million degrees Celsius, of fusion plasma.

9. SCIENCEINSIDER

Breaking news and analysis from the world of science policy

U.S. energy agency jumps into fusion funding

Follow @danclery

By Daniel Clery 14 August 2014 3:00 pm

Dan is a deputy news editor for *Science*.

ARPA-E, the U.S. government agency for funding innovative energy technologies, is preparing to launch a program to support alternative approaches to fusion energy that have the potential to steal a march on existing mainstream projects. The news will come as a relief to some fusion researchers at government labs, who had their funding cut completely in this fiscal year because of the ballooning cost of the U.S. contribution to the international ITER fusion reactor project in France. And it will offer an opportunity to a small number of privately funded fusion efforts that are proposing

alternatives to traditional tokamaks and laser fusion approaches.

On 11 August, ARPA-E gave advanced warning of the new funding stream, called Accelerating Low-cost Plasma Heating and Assembly (ALPHA), so that researchers would have time to form into teams to bid for funding. The funding opportunity will be formally announced later this month or in September. Programs at ARPA-E, a part of the Department of Energy (DOE), typically have budgets of about $30 million and award 3-year grants of roughly $3 million each.

Creating a fusion reaction that can produce energy requires taking an ionized gas, or plasma, and heating it, compressing it, or both until it reaches hundreds of millions of degrees—much hotter than the core of the sun. Different types of reactors take different approaches: Tokamaks aim for low plasma densities but long confinement time; laser fusion opts for extremely high density but only for billionths of a second.

ALPHA will seek to explore the largely untested

middle ground—moderate density for pulses measured in millionths or thousands of a second. It will also focus separately on "targets"—ways of getting the plasma into a stable, contained state—and "drivers"—the systems for delivering energy into the plasma to raise its temperature and density.

DOE previously funded such approaches through a program called High Energy Density Plasma (HEDP). It supported experiments in compressing plasma with electrical pulses, magnetic fields, lasers, and high explosives at national laboratories, including the Sandia and Los Alamos labs in New Mexico, and the Lawrence Livermore lab in California. But the ever increasing cost of building components for ITER has put a squeeze on such approaches as the DOE fusion budget has remained flat. HEDP was zeroed out of the budget altogether in the 2014 fiscal year, which began this past 1 October.

ARPA-E first expressed its interest in fusion in October 2013 when it organized a workshop on drivers for economical fusion technologies. ARPA-E staff visited many of the national labs to see HEDP projects. But insiders say that the program was held up because DOE's Office of Fusion Energy Sciences

objected to another DOE agency spending money on fusion when it was struggling to meet its commitments to ITER and other projects.

"I am delighted that ARPA-E has chosen to look for a fusion approach that might offer a lower cost development path than the traditional magnetic and inertial fusion approaches," says Stephen Dean, director of the Gaithersburg, Maryland–based educational foundation Fusion Power Associates. "By choosing to focus on plasma fuel densities intermediate between the lower density tokamaks and the very high density laser approaches, they have laid claim to a regime that has been largely ignored by the large government-funded programs."

***Update, 15 August, 11:08 a.m.:** This article has been updated to include a statement from Fusion Power Associates' Stephen Dean.*

10. Neutron facility needed to speed up fusion development

11 August 2014
By Tereza Pultarova
http://eandt.theiet.org/news/2014/aug/nuclear-source-fusion.cfm

UK researchers have proposed a concept of a neutron facility to test materials for future fusion power plants.

The facility, basically a large neutron source, would be used to bombard materials considered for use in tokamaks by a powerful stream of neutrons, creating similarly harsh conditions as occur inside a tokamak.

“We've come up with a workable plan to build a neutron source quickly and at low technical risk, largely using what we know now,” said Michael Porton, from the Culham Centre for Fusion Energy, the lead author of the Facility for Fusion Neutron Irradiation Research (FAFNIR) project.

With the construction of ITER, the world's largest experimental tokamak nuclear fusion reactor, underway, the scientists are already thinking about future and the DEMOnstration Power Plant (DEMO), foreseen as the next step after ITER, which will bridge the gap between ITER and the first commercial fusion power plants.

If approved, the FAFNIR project would give the designers of DEMO crucial data on materials with which to build the machine. It would also serve as a bridge to the planned International Fusion Materials Irradiation Facility (IFMIF), expected to play a similar role for the first generation of commercial fusion reactors.

“It's generally accepted that there's a gap to be filled between today's devices and IFMIF,” Porton said. “Whatever shape the final facility takes, we hope our work is a positive step to get the idea off the ground.”

The extremely fast neutrons produced by fusion reactions in tokamaks carry an energy of 14 million electron volts (MeV) – about 70 times more than photons in hospital X-ray equipment – and pose a threat to the tokamak's structures.

The neutrons cause damage within the structure of the material which leads to swelling through the creation of voids. Subsequently, the material becomes brittle and hardens because of accumulation of hydrogen gases.

Scientists know that to make fusion energy viable, new and extremely sturdy materials need to be developed that are capable of lasting for the designed life of the tokamak.

The materials will also have to be able to get rid of the radioactivity generated during the fusion process to allow for safe decommissioning.

The proposed facility will be able to shoot a beam of 40 MeV

deuterium ions at a graphite target, releasing a stream of neutrons to fire at samples of candidate materials and simulating the effect of deuterium-tritium fusion reactions on materials in the reactor.

Using accelerated ion beams to produce neutrons is well established, but at present there are no devices able to produce sufficient neutrons with the correct range of energies that fusion researchers need to work with. As the engineering design for DEMO is planned to be locked down by 2030 such a facility has been included in the European roadmap to fusion electricity, published in 2013.

The neutrons produced in FAFNIR would cause enough irradiation to observe material degradation relevant for DEMO – measured by displacements per atom, a phenomenon leading to material damage.

The FAFNIR proposal has been put together by CCFE, the Science and Technology Facilities Council, the University of Birmingham, the University of Manchester and the University of Oxford.

The consortium foresees building the facility could cost about €300m and the construction would take about seven years followed by a three-year cycle of operation to generate data.

11. **Could the moon fuel Earth for 10,000 years? China says mining helium from our satellite may help solve the world's energy crisis**

Helium 3 in dumped on moon's surface in vast quantities by solar winds

The rare helium isotope could power clean fusion plants back on Earth

It could be extracted from the moon by heating the lunar dust to 600°C

Astronauts would then shuttle the nonradioactive material back to Earth

While China has expressed an interest, it has yet to outline concrete plans about how it would mine the moon for helium

By ELLIE ZOLFAGHARIFARD
PUBLISHED: 19:51 AEST, 5 August 2014 | **UPDATED:** 01:44 AEST, 6 August 2014

http://www.mailonsunday.co.uk/sciencetech/article-2716417/Could-moon-fuel-Earth-10-000-years-China-says-mining-helium-satellite-help-solve-worlds-energy-crisis.html

The lunar dirt brought back by mankind's first moonwalkers contained an

abundance of titanium, platinum and other valuable minerals.
But our satellite also contains a substance that could be of even greater use to civilisation – one that could revolutionise energy production.
It's called helium 3 and has been dumped on the moon in vast quantities by solar winds.

Now China is looking to mine the moon for the rare helium isotope that some scientists claim could meet global energy demand far into the future, according to a report in **The Times.**
Professor Ouyang Ziyuan, the chief scientist of the Chinese Lunar Exploration Program, recently said, the moon is 'so rich' in helium 3, that this could 'solve humanity's energy demand for around 10,000 years at least.'
Helium 3, scientists argue, could power clean fusion plants. It is nonradioactive and a very little goes a very long way.

For instance, two fully-loaded Space Shuttle cargo bay's worth - about 40 tonnes worth - could power the United States for a year at the current rate of energy consumption.

This would require mining an areas the size of Washington, D.C.
The isotope is so rare on the Earth because our atmosphere and magnetic field prevent any of the solar helium 3 from arriving on the surface.
The moon doesn't have this problem as there is nothing to prevent helium 3 being absorbed by the lunar soil.
Fabrizio Bozzato, a doctoral candidate at the University of Tamkan in Taiwan, recently wrote in **World Security Network** that helium 3 could be extracted by heating the lunar dust to around 600°C, before bringing it back to the Earth.
The gas, he estimates, has a potential economic value of $3 billion (£1.78 billion) a tonne, making it economically viable to consider mining from the moon.
According to experts in the U.S., the total estimated cost for fusion development, rocket development and starting lunar operations would be about $20 billion (£11.8 billion) over two decades.
While China has expressed an interest, it has yet to outline concrete plans about how it would mine the moon for helium.
The prospect, however, raises the controversial issue about who owns our satellite.
The United Nations Outer Space Treaty, signed by China, suggests that lunar resources are for all mankind.
However, legal experts claim the language is ambiguous enough to allow for commercial exploitation of the moon.
In a recent paper, Mr Bozzato said: 'China appears determined to make [lunar mining] a reality of tomorrow.
'China maintains its lunar mining would be for the benefit of all humanity,' he added.

'However, given the absence of willful competitors, it is also speculated that the Chinese intend to establish a helium 3 monopoly.'
Private enterprise is also interested in using fuel from the moon – although

possibly by extracting water rather than helium 3.
The Shackleton Energy company envisages providing propellant for missions throughout the solar system using lunar water.

Some teams vying for the Google Lunar X-Prize also see mining as an ultimate goal of their landers. ESA has also considered using the Moon to help missions farther into the Solar System.
Arguments have also been made for mining Helium-3 from Jupiter, where it is much more abundant – it would need to be given the distances involved. Extracting the molecule from Jupiter would also be a less power-hungry process.

12. Could Lower Fusion Reactor Costs

Tue, 08/05/2014 - 2:41pm
Kathy Kincade, NERSC

Supercomputers at NERSC are helping plasma physicists "bootstrap" a potentially more affordable and sustainable fusion reaction. If successful, fusion reactors could provide almost limitless clean energy.

In a fusion reaction, energy is released when two hydrogen isotopes are fused together to form a heavier nucleus, helium. To achieve high enough reaction rates to make fusion a useful energy source, hydrogen contained inside the reactor core must be heated to extremely high temperatures — more than 100 million degrees Celsius — which transforms it into hot plasma. Another key requirement of this process is magnetic confinement, the use of strong magnetic fields to keep the plasma from touching the vessel walls (and cooling) and compressing the plasma to fuse the isotopes.

So, there's a lot going on inside the plasma as it heats up, not all of it good. Driven by electric and magnetic forces, charged particles swirl around and collide into one another, and the central temperature and density are constantly evolving. In addition, plasma instabilities disrupt the reactor's ability to produce sustainable energy by increasing the rate of heat loss.

Fortunately, research has shown that other, more beneficial forces are also at play within the plasma. For example, if the pressure of the plasma varies across the radius of the vessel,

a self-generated current will spontaneously arise within the plasma — a phenomenon known as the "bootstrap" current.

Now, an international team of researchers has used NERSC supercomputers to further study the bootstrap current, which could help reduce or eliminate the need for an external current driver and pave the way to a more cost-effective fusion reactor. Matt Landreman, research associate at the University of Maryland's Institute for Research in Electronics and Applied Physics, collaborated with two research groups to develop and run new codes at NERSC that more accurately calculate this self-generated current. Their findings appear in *Plasma Physics and Controlled Fusion* and*Physics of Plasmas*.

"The codes in these two papers are looking at the average plasma flow and average rate at which particles escape from the confinement, and it turns out that plasma in a curved magnetic field will generate some average electric current on its own," Landreman said. "Even if you aren't trying to drive a current, if you take the hydrogen and heat it up and confine it in a curved magnetic field, it creates this current that turns out to be very important. If we ever want to make a tokamak fusion plant down the road, for economic reasons, the plasma will have to supply a lot of its own current."

One of the unique things about plasmas is that there is often a complicated interaction between where particles are in space and their velocity, Landreman added.

"To understand some of their interesting and complex behaviors, we have to solve an equation that takes into account both the position and the velocity of the particle," he said. "That is the core of what these computations are designed to do."

Evolving Plasma Behavior

The *Plasma Physics and Controlled Fusion* paper focuses on plasma behavior in tokamak reactors using PERFECT, a code Landreman wrote. Tokamak reactors, first introduced in the 1950s, are today considered by many to be the best candidate for producing controlled thermonuclear fusion power. A

tokamak features a torus (doughnut-shaped) vessel and a combination of external magnets and a current driven in the plasma required to create a stable confinement system.

In particular, PERFECT was designed to examine the plasma edge, a region of the tokamak where "lots of interesting things happen," Landreman said. Before PERFECT, other codes were used to predict the flows and bootstrap current in the central plasma and solve equations that assume the gradients of density and temperature are gradual.

"The problem with the plasma edge is that the gradients are very strong, so these previous codes are not necessarily valid in the edge, where we must solve a more complicated equation," he said. "PERFECT was built to solve such an equation."

For example, in most of the inner part of the tokamak, there is a fairly gradual gradient of the density and temperature. "But, at the edge, there is a fairly big jump in density and temperature — what people call the edge pedestal. What is different about PERFECT is that we are trying to account for some of this very strong radial variation," Landreman explained.

These findings are important because researchers are concerned that the bootstrap current may affect edge stability. PERFECT is also used to calculate plasma flow, which also may affect edge stability.

"My co-authors had previously done some analytic calculations to predict how the plasma flow and heat flux would change in the pedestal region compared to places where radial gradients aren't as strong," Landreman said. "We used PERFECT to test these calculations with a brute force numerical calculation at NERSC and found that they agreed really well. The analytic calculations provide insight into how the plasma flow and heat flux will be affected by these strong radial gradients."

From Tokamak to Stellarator

In the *Physics of Plasmas* study, the researchers used a

second code, SFINCS, to focus on related calculations in a different kind of confinement concept: a stellarator. In a stellarator, the magnetic field is not axisymmetric, meaning that it looks different as you circle around the donut hole. As Landreman put it, "A tokamak is to a stellarator as a standard donut is to a cruller."

First introduced in the 1950s, stellarators have played a central role in the German and Japanese fusion programs and were popular in the U.S. until the 1970s when many fusion scientists began favoring the tokamak design. In recent years several new stellarators have appeared, including the Wendelstein 7-X (W7-X) in Germany, the Helically Symmetric Experiment in the U.S. and the Large Helical Device in Japan. Two of Landreman's coauthors on the *Physics of Plasmas* paper are physicists from the Max Planck Institute for Plasma Physics, where W7-X is being constructed.

"In the W7-X design, the amount of plasma current has a strong effect on where the heat is exhausted to the wall," Landreman explained. "So, at Max Planck, they are very concerned about exactly how much self-generated current there will be when they turn on their machine. Based on a prediction for this current, a set of components called the 'divertor' was located inside the vacuum vessel to accept the large heat exhaust. But, if the plasma makes more current than expected, the heat will come out in a different location, and you don't want to be surprised."

Their concerns stemmed from the fact that the previous code was developed when computers were too slow to solve the "real" 4D equation, he added.

"The previous code made an approximation that you could basically ignore all the dynamics in one of the dimensions (particle speed), thereby reducing 4-D to 3-D," Landreman said. "Now that computers are faster, we can test how good this approximation was. And what we found was that basically the old code was pretty darn accurate and that the predictions made for this bootstrap current are about right."

The calculations for both studies were run on Hopper and Edison using some additional NERSC resources, Landreman

noted.

"I really like running on NERSC systems because, if you have a problem, you ask a consultant and they get back to you quickly," Landreman said. "Als,o knowing that all the software is up-to-date and it works. I've been using NX lately to speed up the graphics. It's great because you can plot results quickly without having to download any data files to your local computer."

About NERSC and Berkeley Lab The National Energy Research Scientific Computing Center (NERSC) is the primary high-performance computing facility for scientific research sponsored by the U.S. Department of Energy's Office of Science. Located at Lawrence Berkeley National Laboratory, the NERSC Center serves more than 4,000 scientists at national laboratories and universities researching a wide range of problems in combustion, climate modeling, fusion energy, materials science, physics, chemistry, computational biology, and other disciplines. Berkeley Lab is a U.S. Department of Energy national laboratory located in Berkeley, CA. It conducts unclassified scientific research and is managed by the University of California for the U.S. DOE Office of Science.

13. **ANALYSIS**
08/19/2014 - 12:11

From fission to fusion: the need for a quick transition

Jason Parisi
http://thebulletin.org/fission-fusion-need-quick-transition7391

When the first atomic bomb test, code-named "Project Trinity," was conducted on July 16, 1945, civilization moved from the chemical era—during which atomic energy was outsourced to the sun—to the nuclear era, when induced atomic reactions on Earth could produce energy. Humanity's relationship with the atom may be about to change again, into an age of controlled nuclear fusion for electricity generation.

If handled skillfully and with sufficient political will, fusion could reduce the threat of both nuclear weapons proliferation and climate change, the two risks that academic Noam Chomsky claims have the greatest chance of ending our very existence in the 21st century. But the transition from fission-generated electricity to fusion will be precarious if appropriate safeguards are not taken.

A new energy source is clearly needed, considering the five- to seven-fold increase in electrical demand predicted to occur between the years 2000 and 2100 and the potentially devastating impacts of man-made climate change caused by consuming fossil fuels to meet this demand. To overcome these challenges, nuclear energy may be part of the solution—however reluctant society may be to consider it.

When we think of nuclear energy, we have an overwhelming tendency to think of fission. There may be an even better source of nuclear energy, however, in the form of fission's close cousin: fusion.

Nuclear fusion could come into play as soon as 2050, depending upon funding, the success of upcoming fusion experiments, and the viability of other alternatives, says a position paper published by the European Fusion Development Agreement in November 2012. And considering the problems involved with fission, the sooner we move to fusion, the better.

Fusion benefits regarding proliferation. In the most likely nuclear fusion reaction contemplated for use in energy production, atoms of two isotopes of hydrogen join, creating a helium isotope and throwing off energy. (In comparison, fission generates energy by splitting a heavy atom into several lighter atoms.)

A reactor using fusion to generate electricity is intrinsically safe: First, a runaway nuclear chain reaction cannot take place, under any circumstances. Second, no long-lived, highly

radioactive products are created. Third, of those magnetic confinement fusion reactors that will require radioactive fuels such as tritium, both the radioactive fuel requirements and fuel half-life are orders of magnitude lower than their fission counterparts.

In contrast, a fission reactor is inherently more dangerous: If its safety systems fail, it can undergo a fatal chain reaction; significant quantities of spent, radioactive fuel are produced; and the re-fuelling and disposal of waste requires that highly radioactive materials be transported.

Another bonus of fusion power is that there is enough raw material on Earth to supply the needs of fusion reactors for hundreds of thousands—if not millions—of years at current consumption levels, according to David Mackay, professor of engineering at Cambridge University and author of *Sustainable Energy*.

With these potential benefits in mind, there have been significant research and development efforts on fusion power since the 1950s. At present, the device most widely backed by physicists and engineers is the tokamak, a toroidal (doughnut-shaped) vacuum chamber that uses magnetic fields to confine plasma inside the device. This plasma is heated up to very high temperatures, giving the atoms within enough velocity to overcome the forces of electric coulomb repulsion and fuse together, releasing energy in the process. First-generation tokamak reactors generating electricity for the grid will use the heavy hydrogen isotopes of deuterium and tritium as fuels; deuterium is abundant in nature and stable, while tritium is extremely rare and radioactive, with a half-life of 12 years.

Decades of tokamak research has led to the construction of the International Thermonuclear Experimental Reactor, or ITER, in southeastern France. This international collaboration, with an estimated €13 billion ($18.9 billion) in construction costs, is designed to prove once and for all the feasibility of the tokamak design for energy generation. While there are other

contenders, including stellarators (mechanisms in a figure-eight shape that control plasmas via magnetic confinement, much like a tokamak), and inertial confinement devices (mechanisms that compress and heat fuel, typically by using lasers), the tokamak probably most closely fits the bill for a first-generation, commercially viable fusion reactor.

Not that other areas of research are standing still. Investigators announced a major advance in fusion research in the February 12, 2014 issue of the journal *Nature*, when the National Ignition Facility used a powerful assembly of lasers to extract more energy from a controlled fusion reaction than was absorbed by the fuel to trigger it, an important symbolic milestone. But because this fusion reaction only showed a minimal net gain—it released about one percent of the total energy required to power the lasers that caused the reaction—laser inertial confinement fusion still needs to make profound scientific and technological advances before becoming commercially viable. In contrast, the world's largest operating tokamak, the Joint European Torus, or JET, is already close to producing as much energy as is put in. Meanwhile, ITER is expected to produce 10 times as much energy as is put into it.

Fusion and weapons. From the standpoint of controlling nuclear weapons proliferation, the tokamak has several important plusses.

First, tokamak reactor cores are surrounded by a "lithium blanket," which absorbs escaping neutrons to breed more tritium for use as reactor fuel. While this approach could theoretically be used to enrich fuel to weapons grade level by inserting thorium or uranium, researchers Robert J. Goldston and Alexander Glaser concluded that it would not be realistic for anyone to do so surreptitiously. This means that in a fusion-only era, any "horizontal proliferation"—the process by which non-nuclear states or entities obtain nuclear weapons—would become significantly harder. While in theory pure-fusion weapons could be created that release a lethal neutron dose within a radius of several hundred meters, this has not

been achieved in practice.

Second, the tokamak device itself inhabits only a small part of an entire tokamak reactor site. A large number of non-nuclear external systems are required to run it, such as vacuum systems, cryogenics, and power supplies; to fit them in, the ITER "platform" housing all the scientific apparatus is 42 hectares in size (approximately 104 acres)—a landmass more than five times larger than New York City's Rockefeller Center. The sheer geographic size of a tokamak reactor complex drastically lowers the possibility of any clandestine fusion plant construction, Goldston and Glaser say.

What's more, once a fusion plant has been built, the detection of any weapons-grade fissile material produced there should be simple. By monitoring the lithium blanket for traces of fissile material, it should be easy to detect if a fusion plant is diverting some of its material to illegal weapons enrichment. Most likely, only a very small amount could be enriched, hardly enough for making a bomb, before attracting attention.

If such illicit activity is detected, disabling a tokamak would be relatively straightforward, due to that vast array of essential support systems. Even if the entire fusion reactor had to be destroyed—by dropping conventional bombs on it, for example—the radioactive fallout would be negligible, due to the low levels of fuel in the reactor at any given time (just a few grams). The worst damage would come from the destruction of the tritium storage system, which would release two-to-four kilograms of tritium—a substance with a 12.3-year half-life.

Because of these factors, it would be relatively easy to quickly and safely disable a fusion facility and eliminate any nuclear weapons grade materials located on site. Therefore, in a world powered only by fusion, it would be significantly harder to clandestinely enrich fissile material, putting the brakes on nuclear proliferation. (This is based on the assumption that no new clandestine enrichment technologies come onboard by

that time; while centrifuges are fairly easy to detect, laser enrichment, for example, may be harder to monitor.)

Transition risks. The period during which both fission and fusion plants coexist could be dangerous, however. Just a few grams of deuterium and tritium are needed to increase the yield of a fission bomb, in a process known as "boosting."

Because a full-sized fusion reactor would use about 250 kilograms of fuel per year that is half tritium and half deuterium, this would significantly increase the amount of material available for such activities. Assuming that a one-gigawatt fusion plant uses 125 kilograms of tritium per year, and allowing for a very conservative one-percent level of uncertainty in the amount of tritium produced in the lithium blanket, a country with 10 one-gigawatt fusion reactors would have as many as 12.5 kg of tritium unaccounted for each year, or enough for several thousand boosted weapons.

Thus, it would not be feasible to monitor and control tritium supplies down to the tiny levels required to boost a bomb.

Another problem during transition lies in the ever-increasing sophistication of advanced facilities to simulate the effects of the explosion of nuclear weapons at laboratories such as the US National Ignition Facility. As the technology for computerized simulation of nuclear weapons becomes more widespread, more countries will be able to build and design increasingly powerful boosted weapons without actual testing, and at a pace that would be much faster than before. Consequently, the number of high-yield nuclear weapons and the number of countries that own them could increase substantially during the period of overlap between the eras of fission and fusion.

As a result, if humanity does decide to have fusion play a major role in energy generation, it should complete the changeover swiftly, before the capacity to build boosted and thermonuclear weapons becomes widespread. Even if only a

handful of countries have the technology, resources, and willpower to construct facilities for making boosted and thermonuclear weapons, their very existence is a liability.

Will Fusion be Affordable? Some physicists and engineers have expressed concerns that even if a fusion reactor that produced significantly more energy than it consumes could be built, it still might not be economically viable within the current pricing framework. While the costs of a demonstration fusion reactor are fairly well known, first-generation tokamak electrical plants could be unaffordable when compared to nuclear fission, conventional fossil fuels, and even renewables.

But economic viability depends upon one's point of view. The price of a fusion reactor (or any product for that matter) contains significant negative or positive external costs, or "externalities," which distort one's perceptions of its value. For example, greenhouse gases emitted by fossil fuels carry significant externalities, in the form of carbon emissions into the atmosphere, although they are typically not included in the price of electricity that a customer sees on a monthly electric bill. Rather, future generations pay those costs. As long as carbon is not priced or heavily underpriced, fossil fuel technologies will continue to appear cheap compared to cleaner sources such as fusion.

However, even with these distortions, an extensive US study called ARIES-AT found that first-generation fusion reactors would be competitive with renewables and fossil fuel, even without a carbon tax. Since it is likely that such a carbon-pricing mechanism will be enacted by the time fusion reactors come online, there is a strong likelihood that fusion will be very economically attractive.

If by 2050 there is a choice between building large numbers of fast breeder reactors (which could clandestinely provide fission fuel for thousands of nukes per year), or emitting an extra several billion tons of carbon dioxide into the atmosphere, the decision will not be easy. To avoid this dismal

choice, then widespread, commercially viable fusion is required—assuming there are no other viable technologies.

There comes a critical point in a civilization's development when its resource and energy consumption are so great that exploiting the atom may well be the only way to maintain a high level of advance. While nuclear technology has the potential to terrify, dehumanize, and exterminate, if used wisely it also has the potential to liberate human civilization from the shackles of fossil fuels. A swift transition from fission to fusion not only would allow us to escape the worst medium-to long-term environmental and social ramifications of climate change, it also would enable the creation of a more stable and credible equilibrium in a world with no nuclear weapons. A world without nuclear weapons but with fissile material will always be in fragile equilibrium; a world without both would be far more sustainable.

Humanity's past failure to wield the double-edged nuclear sword skillfully has been permanently etched into the annals of history, from the bombing of Hiroshima and Nagasaki, to the world build-up to 65,000 nuclear weapons, to dozens of serious near-misses, during which nuclear war was only narrowly averted. Reaching and navigating the fusion era, an advanced step in the progression of nuclear technology, would be a testament to humanity's foresight and organization, as well as a catalyst for nuclear weapons abolition and the curtailing of the extremes of climate change.

14. **A well-prepared route**

By: Christian Doepgen
http://www.transportjournal.com/en/home/heavylift-breakbulk/artikeldetail/a-well-prepared-route.html

34 nations supply components to the Iter project, a nuclear fusion reactor in the Cadarache research centre (see page 22 of the Heavy-lift Special in ITJ 45-46 / 2013). A second three-night pilot shipment for Iter, with a 600 t test load, has now been successfully completed in the Marseille area. Klaus Schymke of the Hanau-based German entity Nuclear Cargo + Service told the ITJ about the operation.

Following a first pilot shipment, carried out in September 2013, a second one reached the Cadarache research centre in April, as training for the Iter project's global procurement processes in southern France. Once again, a 600 t load measuring 19 m by 9 m width and 9 m height was transported a distance of 104 km. It was possible to reduce the transit time to three nights on this run. The heavylift division of the transport service provider Daher-HCS, based in Hanau (Germany), handled the heavy consignment.

Coordination and speed

The first pilot shipment with an identical weight and volume was initially carried out to confirm the load capacities of the bridges involved and the general efficiency of the route. Following its completion, the second test run primarily facilitated the efficient coordination of all parties involved, that is to say the authorities and the police, Iter itself and the logistics service provider's transport management. Another aim was to achieve the fastest possible speed through the city.

44 parallel-coupled heavylift axle lines were used, each equipped with a 680 hp engine unit and driver's cab at the front and rear. The 600 t pilot load consisted of 360 concrete blocks.

Between 2008 and 2011 the French public sector invested a total of EUR 110 million to prepare the route for the transportation of the experimental reactor's components. The overland and inland canal option covers 104 km from the Mediterranean port of Fos-sur-Mer to Iter's Cadarache site at Saint-Paul-lez-Durance, via the Canal de Caronte and the Port de la Pointe-de-Berre.

26 bridges have been rebuilt or strengthened, four bypasses created, 19 roundabouts upgraded, four level motorway crossings developed, 35 km of roads straightened and another 10 km specially rebuilt, amongst other things, to accommodate the heavylift shipments.

28 loads weighing more than 500 t

Following the successful second pilot run, the main phase of the project can now begin. A total of 212 heavy components, including 28 with a load weight of more than 500 t, will be transported on the route till 2019, when the reactor is due to be completed.