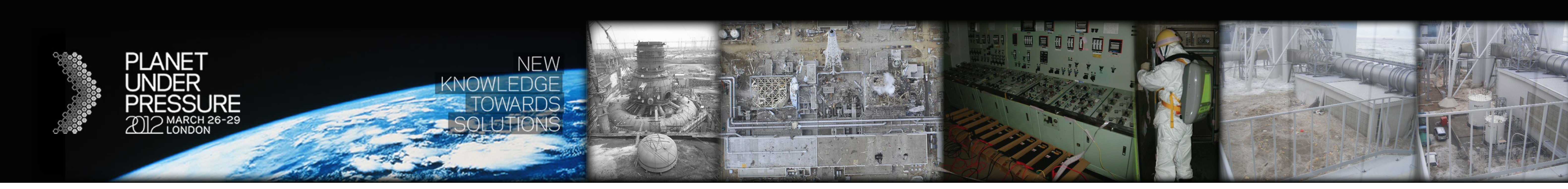

When The Temperature Rises More Than 2 ^{0}C What *Will* We Do?:

Non Linear Interrelationships Between Atmospheric And Ecosystem Stressors And Human Activity

If we cannot provide an adequate response to disasters now, what will happen when the temperature increases by more than two degrees centigrade?

When the temperature rises more than 2^{0} C what *will* we do? What can we learn from our response to present catastrophes which are increasingly caused by extreme weather conditions associated with climate change? Our present emergency procedures for coping with human and ecological disasters are inadequate or non-existent. Given the ever increasing volume of disasters that people experience worldwide, we should be better prepared. *Knowing* that the temperature could rise 4^{0}C should galvanize us to support and participate in the planning and preparations, but it has not. Urgent action is required, but:

How can timely actions be undertaken at unprecedented and multiple geographical and geopolitical scales, where the nature and scale of the issues involved means that the actors have widely differing—and—disconnected values, ethics, emotions, spiritual beliefs, levels of trust, interests and power?

It is the enduring question, the QoQ, first asked by ICSU during the 2009-2010 Visioning that scientists are limited in their capacity to address and have no way of answering.

This poster draws on the findings of ongoing 11 year transdisciplinary study which includes emergency first response initiatives and research on social and biogeophysical disasters. The research explores "in situ" the epistemic complexity of the interconnections between: (1) climate change and extreme weather events; (2) ecological crises; (3) economic crises; (4) extreme wealth; (5) extreme poverty; (6) armed conflict; and (7) public health emergencies. The work re-examines the interconnections between the social, cultural, psychological, biological, and physical sciences, and *the humanities* – philosophy and literature –so that new questions can be asked, new understandings gained, and actions taken.

The non linear interrelationships between atmospheric and ecosystem stressors and human activity bring into sharp focus the epistemic complexity of the relationships between the physical, biological and social sciences. The potential for a step change challenges our understandings of the status quo, encourages us to rethink our positionalities within institutions, our relationships with other scientists, with the public, and with global decision makers. Any response to catastrophic events both in the present and in the future will be highly dependent on the ability of all those who participate to take into consideration the professional challenges of working with participants who hold different views of science and humanity.

"What might a 4^{0}C world look like?" Mark New *et al.*, ask the question in "Four Degrees and Beyond", in the *Philosophical Transactions of the Royal Society A*," January, 2011. New *et al.* pose the question even though, as they point out, the 2009 Copenhagen *Accord "recognized the scientific view 'that the increase in global temperature should be below 2 degrees Celsius' despite growing views that this might be too high"*. If we cannot provide an adequate response to Real World Hazardous Events (RWHE's) at the present time, what will happen in the not too distant future? New *et. al.* write. *"Even with strong political will, the chances of shifting the global energy system fast enough to avoid 2^{0}C are slim. Trajectories that result in eventual temperature rises of 3^{0}C or 4^{0}C are much more likely, and the implications of these larger temperature changes require serious consideration, and the nature of the changes in climate we experience may well start shifting from incremental to transformative"*

Richard Betts *et. al.*, in the same themed edition of *Philosophical Transactions* ask *"When could global warming reach 4^{0}C?" They state, "While much political attention is focused on the potential for global warming of 2^{0}C relative to pre-industrial, the AR4* (ICPP Fourth Assessment Report) *projections clearly suggest that much greater levels of warming are possible by the end of the twenty-first century in the absence of mitigation. The centre of the range of AR4-projected warming was associated with the higher emissions scenarios and models, … including uncertainties in carbon-cycle feedbacks, and also comparing against other model projections from the IPCC, our best estimate is that the A1FI* (A1: "family of scenarios"; FI: "fossil intensive") *emissions scenario would lead to a warming of 4^{0}C relative to pre-industrial during the 2070s. If carbon-cycle feedbacks are stronger, which appears less likely but still credible, then 4^{0}C warming could be reached by the early 2060s in projections that are consistent with the IPCC 'likely range'"*. Mark Stafford Smith et al., (2011) state in the same themed edition, "Adapting to global warming of 4^{0}C cannot be seen as a mere extrapolation of adaptation to 2^{0}C," they state, "it will be a more substantial, continuous and transformative process".

The Millennium Development Goals Report (2011), refers to the 2012 UN Rio+20 *Conference on Sustainable Development, as "a major opportunity for new progress"*. But what progress will be made when the increasing scale and intensity of the complex interrelationships of RWHEs challenges the capacity of human societies to respond? The massive migrations of people and the millions of internally displaced people the Earth is currently experiencing are an indication that not only are we unprepared now, we are *un*prepared for future RWHEs.

The global erosion of social trust and the resistance of global decision makers to becoming catalysts for positive change has increased the pressure on the scientific community to "deliver knowledge", "build the capacity to deliver solutions", "effectively deliver end-to-end environmental services", "to provide new insights and solutions", "to solve real world problems", and most recently to deliver "actionable science". This begs the question: *Can science save us if scientists have outpaced the governmental capacity to respond to what's happening to the planet, or have governments outpaced science?* The paradoxical situation in which we find ourselves is that scientists can calculate planetary boundaries, but cannot "calculate" *the everyday*. Hannah Arendt writes of this as *"the curious contradictions inherent in the impotence of power"*. Curiouser and Curiouser, is that global decision makers who have a tight grip on "power" and only a rudimentary understanding of what's happening to the planet calculate the everyday as if there are only short term profits and no long term price to pay. If their present response to RWHE's and humanitarian crises is anything to go by, the impotence of their response to future disasters and potentially cataclysmic events, will , in and of itself, be a global catastrophe.

"(T)he scientific community must now deliver the knowledge that will enable countries, regions, and economic sectors to embark on transitions to sustainability in order to secure human development in the face of rapid global change," ICSU, ISSC and IGFA (the Alliance) write, *"as a means to solve real world problems. … while deepening our understanding of the Earth System and of human impacts, we must build the capacity to deliver solutions to pressing sustainability challenges at regional and global scales"*. But in real world terms what does it mean to respond as the temperature rises more than 2 degrees?

If we juxtapose a RWHE *happening now* with the Alliance proposal for Earth system Research for Global Sustainability, can we *"measure"* the effectiveness of the knowledge delivered? For instance, if we focus on *actual events* that have taken place in a country in which, against all odds, *the shift to renewable energy has occurred, that mitigates against the temperature rising, what knowledge was delivered? What actionable science* was available to provide *real world solutions* to the pressing *sustainability challenges* that the country faced?

Fukushima: Gathering Car Batteries When the Temperature Rises

The first RWHE is the Tohoku Chihou Taiheiyou Oki Mega Earthquake, which began at 14:46 on March 11, 2011. The tsunami was the second RWHE. The third RWHE was the *human induced* nuclear disaster. The Fukushima Daiichi Nuclear Power Station survived the earthquake, but the tsunami which inundated the plant resulted in: (1) a complete station black out; (2) the meltdown of the cores of three reactors; (3) the explosive destruction of three reactor buildings when the hydrogen generated by the core meltdowns ignited; and (4) major releases of radiation from the destroyed reactor buildings. If we focus on the RWHE that occurred at the Fukushima Nuclear Power Disaster, can insights be gained into some of *"the most pressing questions that the world needs answered"*, as the Alliance puts it, *"in the context of securing human development in an era of rapidly escalating global environmental risks"?* The local, national, regional and global consequences of the nuclear disaster are immediately evident, but the *inextricable complexity* of the dynamic interrelationships between the RWHE and the delivery of scientific knowledge presents a challenge.

Sabu Kohso (2011) writes, *"What has been happening in Japan since 3/11/2011 cannot be deemed merely a situation particular to a nation-state in the Far East, but unfortunately a new phase of human history, an opening toward an apocalypse, or a total transformation or both. It is a universal experience in the sense not only of its economic and environmental impact but also of the self-destruction of the apparatuses that the modern world has been building up on a planetary scale".*

Kohso's shouts, his anguish, rooted in Hiroshima and Nagasaki, explodes on the page. Angry about the impact of the Fukushima nuclear disaster on the lives of the Japanese people, he uses the disaster as an allegory, an extended metaphor for a new phase in human history, self destructive and apocalyptic. He confronts us with the metaphoric imperative of what will happen to us on a planetary scale when the temperature rises, predicting the collapse of human societies on a planetary scale.

But in the immediacy of this moment the question that scientists must ask is whether knowledge had been delivered for actions needed to mitigate the nuclear disaster that occurred. The question can be approached from many different angles, but in this work serious consideration is given to the anomalous gathering of car batteries in an attempt to avoid a nuclear disaster. The use of car batteries challenges us to contest the rationalist assumptions about the *delivery* of scientific knowledge in the everyday world. The narratives that follow reflect a detailed analysis of three sets of documents, extracted from a much larger corpus of digitally mined data that focuses on Complete Station Blackout (CSB) conditions and the use of auxiliary power in commercial nuclear power stations both in Japan and the United States: 1)Official reports from Japan made public in the aftermath of Fukushima; 2) The Oak Ridge Nuclear Laboratory (ORNL) Browns Ferry Station Blackout Research; 3) Reports, memoranda, final draft revisions, and generic letters, supplements and corrections produced by the U.S. Nuclear Regulatory Commission (NRC).

The informational trace on auxiliary/battery power underscores the fact that scientists delivered the critical knowledge, but that it was *not effectively acted upon by policy makers in the U.S. or Japan, or by the U.S. Nuclear Regulatory Commission, or by stakeholders in the nuclear power industry.*

Official reports from Japan made public in the aftermath of Fukushima

The car battery question is grounded in an analysis of the first response account provided by TEPCO, which used plant records up to the point of the tsunami, photographs, white boards, operator logs, supervisor logs, to provide a record of what happened in the immediate aftermath of the Fukushima nuclear disaster. Excerpts from the firsthand account by Fukushima operators, the emergency response team and plant personnel follow. The underlined and bold text is in the original document.

<u>March 11, 15:42 p.m. – Activities after Loss of all AC Power.</u>

Situation at Main Control Room (MCR) of Unit 1/2

Lighting and indicators in the MCR (Main Control Room) gradually fading due to loss of all AC power. Sound of alarm was lost, too. In Unit 1-side of MCR only emergency lights remained. In Unit-2 side, all lighting was lost and it became completely dark. For IC (isolation condenser) and HPCI (high pressure coolant injection) were operable by DC (direct current, i.e. batteries) power. Operators judged HPCI was not operable because indicators on the control panel were gradually faded. For Unit 2, operating status of RCIC (Reactor Core Isolation Cooling) became unknown.

Restoration of MCR Instrumentation

The restoration team in the site emergency response headquarters prepared for necessary documents and drawings to restore power in MCRs. Also they started to gather batteries and cables at offices of contractor's office on site. The team carried batteries and cables which were collected in the site to MCR of Unit 1/2. Then confirming drawings, they started to connect the batteries to instrument panel in MCR. At the event of "ECCS (emergency core cooling system) was unavailable to inject water into the reactor", a top priority was to understand the status of water injection into the RPV (reactor pressure vessel). So restoration work was focused on connecting batteries to reactor water indicator which functions by DC power.

Batteries gathered from contractor's offices were used to supply power to the instrumentation in Unit 1 /2. Once the batteries were connected the operators were able to check the reactor water level indicators with flashlights. The tsunami took place at 15:35 and it was 21:19 for Unit 1 and 21:50 for Unit 2 when the first indications of the reactor water levels were known. Unfortunately it was too late. A Japanese Government report for Unit 1 states that TEPCO *"estimated that the fuel was uncovered about three hours* (17:46) after the earthquake with reactor damage starting one hour after that". In the immediate aftermath of the earthquake and tsunami, no one knew the state of the core, or the state of the RPV or the PCV, and so no one knew how much radiation was released into the reactor building (RB) during the first twenty four hours after the tsunami. The hydrogen generated during the core meltdown escaped both from the reactor vessel and the containment which was designed to prevent its release. The concentration of hydrogen that escaped into the huge Unit 1 reactor building was sufficient to cause the building to explode at 15:36 on March 12, twenty four hours after the tsunami. Gaseous radioactive components in the reactor escaped along with the hydrogen. All four engineered barriers to radiation release were breached or destroyed –fuel assemblies, RPV, PCV, and RB.

No one aspect of the Fukushima nuclear disaster can be fully understood without taking every other aspect of the disaster into consideration, but the use of car batteries recovered from parking lots by the emergency response team to provide auxiliary power to critical instruments in a nuclear power plant does provide an opportunity to ask *what actionable knowledge was delivered by scientists, and what happened to that knowledge once it was received?* Putting a trace on battery power makes it possible to connect past and present events and, perhaps, to mitigate disasters that might occur in the future.

ORNL Simulations of SBO Result in Core Melt at Browns Ferry

The critical knowledge that *one hour from battery loss core uncovery begins and three hours from battery loss fuel melt starts* was delivered by scientists at the Oak Ridge National Laboratory (ORNL) which was operated at that time by Union Carbide for the United States Department of Energy and the Nuclear Regulatory Commission. The research, which simulated the *Station Blackout at Browns Ferry Unit One—Accident Sequence Analysis*, was conducted by Cook, Greene, Harrington, Hodge, and Yue (1981), and is directly relevant to the Fukushima nuclear disaster. Cook *et al.* constructed a computer simulation to describe the predicted response of Unit 1 at the Browns Ferry nuclear power plant to a hypothetical SBO.

The researchers state that the computer simulation presumed "a loss of offsite power concurrent with all of the onsite diesel-generators to start and load". In the simulation *"the only remaining electrical power at the plant would be that derived from the station batteries"*, which was not the case at *Fukushima where all of the station batteries were lost.* Focusing on "Instrumentation Available Following Loss of 250 Volt DC Power" Cook et al., state, *"Reactor vessel level and pressure control can be maintained during a Station Blackout for as long as 250 DC power from the unit battery remains available"*. However, in the final phase, after the unit battery is exhausted, they write, *"a Station Blackout would constitute a Severe Accident because there would be no means of injecting water into the reactor vessel to maintain a water level over the core".*

The ORNL SBO simulation assumed that the unit battery would last from *four to six hours.* Six accident sequences, with other equipment failures assumed to occur, were considered in which onsite AC power and DC power were not restored. *Each sequence led to core uncovery, subsequent core melting, and reactor vessel failure. Cook et al. write, "Any sequence resulting in core melt will eventually lead to containment failure if electrical power is not restored before the reactor vessel fails".*

In the companion report, *Station Blackout at Browns Ferry Unit One—Iodine and Noble Gas Distribution and Release*, Wichner, et al., (1982) write, "Battery exhaustion results in loss of the HPCI High Pressure Coolant Injection and RCIC coolant injection systems, and a boiloff of coolant begins in which the reactor vessel level decreases as the decay-heat-generated steam is vented through the steam relief valves to the pressure suppression pool. *The top of the core is uncovered one hour after the loss of battery power.* At 95 min. after the loss of battery power, the first fuel rods reach 1000°C. … The fuel rods start to fail 103 min after battery exhaustion. The failure is caused by over-temperature (1300°C) and embrittlement from the steam oxidation of the Zircaloy cladding. … The steam-zircaloy reaction quickly heats the fuel rods in the central region of the core. Two hours after the start of the boiloff, portions of the core have reached the melting point of the fuel eutectic (~2280°C) …

The core collapses 137 min after the loss of battery power. … When the core collapses into the lower plenum of the vessel, the water quenches the molten pool. The water boils away and the molten fuel heats the lower head of the reactor vessel. The heat and pressure cause the head to fail 172 min after the start of the boiloff, and the contents of the reactor vessel are dropped into the drywell sump. … The water covering the molten pool boils dry, and the fuel starts to interact with the concrete floor in the drywell. … The high temperature in the drywell causes the electrical penetration assembly seals to fail at this time. … The gases which have passed through the electrical penetrations in the drywell wall flow through the reactor building and out to the atmosphere.

These excerpts from a comparative analysis of Fukushima and the ORNL Browns Ferry SBO simulations combining the *lived experience* of a nuclear disaster with descriptions derived from theoretical science is compelling. However, if our concern is the stated purpose of the Alliance to *deliver knowledge societies need to adapt and mitigate to hazardous global environmental change,* it is the meta-analysis including the *response of decision makers* that is most critical. We know that the findings of the ORNL SBO simulations were delivered to the U.S. NRC, but what happened when *the knowledge was delivered?* How was it received? Was it *acted* upon?

October 9, 1979: Memo: The subject: TAP A-44 STATION BLACKOUT ["task action plan for unresolved generic safety issue A-44, 12/31/79"]. "I think we all agree that there may be a few plants at which station blackout poses an unacceptable risk, but that at most plants there is time for a careful and thorough study of the problem before rushing into a licensing position".. Then an informational trace is established connecting Fukushima to the decision making of the NRC. "Event sequences entailing blackout and failure to start of non-AC-dependent cooling systems will be tackled first in PWR's (pressurized water reactor), then in BWR's (boiling water reactor). *Blackout out-lasting the point of no return for the restoration of AC power will be addressed later".*

February 25, 1981: Generic Letter (GL 81-04) to all licensees of operating nuclear power reactors on "EMERGENCY PROCEDURES AND TRAINING FOR STATION BLACKOUT EVENTS".A review of current plant operations is requested "to determine your capability to mitigate a station blackout event and promptly implement, as necessary, emergency procedures and a training program for station blackout events".

June 30, 1988: NRC publishes: "Evaluation of Station Blackout Accidents at Nuclear Power Plants: Technical findings Related to Unresolved Safety Issue A-44" (NURG-1032). Critical to this chronology is the following statements, *"Perhaps the most important support system for both PWRs and BWRs is the DC power supply. During a station blackout, unless special emergency systems are provided, battery charging capability is lost. Therefore, the capability of the DC system to provide power needed for instrumentation and control can be a significant time constraint on the ability of a plant to cope with a station blackout".*

August, 1988: Seven years after the ORNL Browns Ferry SBO report, the NRC published a "Regulatory Guide to Station Blackout" *rendering actionable science inactionable.* The NRC's regulatory response to the risk of an extended SBO and a reactor meltdown was to establish an accepted range of battery power of 2 to 16 hours. The average real-life battery time for the majority of U.S. nuclear plants was *four hours* – which is coincidently, perhaps, the same number of hours that the ORNL 1981 analysis assumed for the battery life in the six SBO simulations at Browns Ferry.

February, 1990: Brookhaven National Laboratory published a report prepared for the Office of Nuclear Regularity Research – NUREG/CR-5474—entitled "Assessment of Candidate Accident Management Strategies". The report focused on prevention or mitigation of in-vessel core damage and included strategies related to the loss of power. There were seven recommendations including: conserving battery capacity by shedding non-essential loads; using portable battery chargers or other power sources to recharge station batteries; and using diesel-driven firewater pump for core injection.

On April 4, 1990, the NRC sent another Generic Letter (Generic Letter 88-20, Supplement No. 2 which was the NUREG?CR-5474 Brookhaven report) to all holders of operating licenses and construction permits for nuclear power reactor facilities. The NRC states: *"This generic letter supplement does not establish any requirements for licensees to take the specific accident management strategies into account as part of the IPE or implement any of the strategies. Adoption on the part of a licensee of any accident management strategies in response to this supplement is voluntary"*

December, 2005: The NRC published "Reevaluation of Station Blackout (SBO) risk at Nuclear Power Plants: Analysis of Loss of Offsite Power Events: 1986-2004"(NUREG/CR-6890, Vol. 1). The report provided an update on the analysis of Loss of Offsite Power (LOOP) for all 103 U.S. nuclear power plants operating at that time, based on data collected between 1986 and 2004. The NRC states: *"the loss of all ac power can be a significant contributor to the risk associated with plant operation,* contributing more than 70 percent of the overall risk at some plants" followed by "when we focus on grid-related LOOP events, the *SBO risk has increased.* Our current results show that the grid contributes 53 percent to SBO core damage frequency. *Severe and extreme weather events, which are generally related to grid events, contribute 28 percent*. Therefore, *the increasing number of grid-related LOOP events in 2003 and 2004 is a cause for concern.*

Fukushima, Browns Ferry, and the NRC: An Allegory for the Profound Meaning of What Will Happen When the Temperature Rises on a Planetary Scale

July 12, 2011: The NRC published "Recommendations for Enhancing Reactor Safety in the 21st Century: The Near Term Task force Review of Insights from the Fukushima Dai-ichi Accident." Tier 1 - NTTF Recommendation 4.1. *The Task Force recommends that the NRC strengthen station blackout (SBO) mitigation capability at all operating and new reactors for design-basis and beyond-design-basis external events. 4.1 Initiate rulemaking to revise 10 CFR 50.63 to require each operating and new reactor licensee to: (1) establish a minimum coping time of 8 hours for a loss of all alternating current (ac) power, (2) establish the equipment, procedures, and training necessary to implement an "extended loss of all ac" coping time of 72 hours for core and spent fuel pool cooling and for reactor coolant system and primary containment integrity as needed, and (3) preplan and prestage offsite resources to support uninterrupted core and spent fuel pool cooling, and reactor coolant system and containment integrity as needed, including the ability to deliver the equipment to the site in the time period allowed for extended coping, under conditions involving significant degradation of offsite transportation infrastructure associated with significant natural disasters.*

August 19, 2011, NRC published the Commission Voting Record in response to the *Near-Term Report and recommendations for Agency Actions Following the Events in Japan* (SECY-11-0093). In commenting on the NTTF, Chairman Jaczko noted, *"Recommendation 4 provides for improving mitigation of station blackout events (SBO) where a nuclear plant loses all AC power. While many of the contributing causes to the conditions learning to core damage at Fukushima Dai-ichi remain unknown at this time, operating strategies and equipment did not provide sufficient operating margin to prevent core damage for the low-probability events involving extended loss of AC power. There is no doubt that the cross-cutting aspect of the prolonged loss of electrical power at Fukushima Dai-ichi severely impacted the ability of the site's operators to prevent and to mitigate the accident. The Task Force recommended that the Commission direct the staff to begin the actions to further enhance the ability of nuclear power plants to deal with the effects of prolonged SBO conditions at single and multiple unit sites without damage to the nuclear fuel in the reactor or spent fuel pool, and without the loss of reactor coolant system or primary containment integrity. …*

October 3, 2011: Letter: SUBJECT: PRIORITIZATION OF RECOMMENDED ACTIONS TO BE TAKEN IN RESPONSE TO FUKUSHIMA LESSONS LEARNED (SECY-11-0137). The NRC staff assessment is included as an enclosure: The specific July 12 NTTF recommendation 4.1 to replace the August 1988 "4 hour battery rule" and issue a new "8-72-extended coping as needed rule" is not in the Staff Assessment. The NRC staff concludes that: *This regulatory action would consider the need for SBO power source(s) and mitigating equipment to be diverse and protected from external events. This regulatory action would also examine whether there is a need to expand SBO mitigation requirements to require power reactors to mitigate an SBO event at a plant (each unit for multiunit site) until either the onsite or offsite power source is restored to bring the power reactor to a cold shutdown and to maintain spent fuel pool cooling.* The staff said the schedule for developing the new rule was 4.25 years.

October 11, 2011: The National Resources Defense Council (NRDC) expressed agreement with the NTTF recommendations and stated that the 4.25 year timetable for issuance of a final rule "is far too leisurely".

January 2012, the NRC published a brightly colored reassuring brochure described as "a plain language summary" for the public on the safety of nuclear power. *Modeling Potential Reactor Accident Consequences* is filled with reassurances. In the "Key Results" descriptors include "operators were successful", "they can prevent the reactor from melting", "accidents progress more slowly and release much smaller amounts of radioactive material than calculated in earlier studies", "the public health consequences are smaller", "reduce the risk of public health consequences", "no risk of death during or shortly after the accident", "longer term cancer fatality risks … are millions of times lower than the general U.S. cancer fatality risk". Thus irrefutable evidence is obfuscated by key decision makers in a textural maneuver that covers up dangerous scenarios and maintains the present status and protects the profits of the nuclear power industry.

Just five months (August 9, 2011) before *Modeling Potential Reactor Accident Consequences* was published, the Chairman of the NRC wrote: *Almost immediately after receiving the Task Force report, the Commission began discussions of the process to review the report, and not, unfortunately, on the content of the report and its profound meaning for nuclear safety. Several of my colleagues have found one aspect of the report they accept without question. The most frequently cited statement is that "continued operation and continued licensing activities do not pose an imminent risk to public health and safety." A majority of the Commission appears to accept this statement without the need for further scrutiny, debate, or discussion. On the other hand, the substantial body of the Task I Force report which details safety gaps in our regulatory system, and all of the recommendations about how to close those gaps do require additional analysis, according to my Commission colleagues.* The same "nuclear power is safe message" is also being given to the stakeholders and the public.

January 13, 2012, The NRC published a status update on the NTTF recommendations in which they state the staff has "reconsidered it's proposed approach" citing House and Senate Hearings, and letters from the Advisory Committee on Reactor Safeguards (ACRS). As it stands at the time of writing (March, 2012) the Commission has directed the SBO rulemaking be completed within 24-30 months.

It is more than 30 years since the ORNL Browns Ferry SBO research findings were published showing that after one hour the top of the core is uncovered, and that within two hours the core starts to melt. If we measured the effectiveness of the knowledge delivered? Fukushima delivered the knowledge. It took a cataclysmic nuclear accident to uncover the documentation produced by the NRC which reveals that the official discourse of decision makers is highly *persuasive* and extremely effective at *obfuscating scientific knowledge*. Which brings us back to Kohso's allegorical interpretation of the Fukushima disaster and the metaphoric imperative for scientists, the public, and those who hold power to rethink and reimagine what will happen on a planetary scale when the temperature rises and human societies are left high and dry or lost beneath the sea.

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Can Science Save Us? The Great Acceleration From Adaptation to Transformation or *Annihilation*? **What Happens When Life as We Know it Ends?**

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