HKU-Cambridge Symposium on
Challenges & Priorities for Trust-Based Cross-border Nuclear Safety Emergency Governance

Priorities on Design & Construction

presented on June 12, 2014 (Thursday)
revised on June 21, 2014- advocating The World Nuclear Safety-Peace Mission

K. P. Cheung, Associate Professor, Department of Architecture,
The University of Hong Kong, HKSAR , PRC.
香港大學 建築系 張國斌副教授
e-mail: kpcheuna@hku.hk

A key member on Clean Energy Research, HKU
http://www.rss.hku.hk/sra-round-2/env-key-members.html#clean-energy

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World Nuclear Power Generation Capacity

2014 : US is far leading , above 40,000 MW

2006 : US is leading

Russia, China , Japan, each about 40,000 MW

2020 : China: 88,000 MW, surpassing USA

[Ref. 1. 李克強:東部沿海適時建新核電, 21 April, 2014, Wenweipo news of Hong Kong , in Chinese, on nuclear power future in China. http://news.wenweipo.com/2014/04/21/IN1404210016.htm

Ref. 2. **List of nuclear reactors** http://en.wikipedia.org/wiki/List_of_nuclear_reactors]

HKUICEE
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Recent demands for Safety enhancement in Nuclear Power plants

Recently emerged nuclear safety concerns which were not considered before 2011:

1 Severity and core-melt down cases of Fukushima reactors in March 2011, due to TSUNAMI and Earthquake → 2 questions:

1.1 For new power plants , do we need higher design provisions for TSUNAMI and Earthquake?

1.2 For existing power plants, How do we make up the safety deficits?

2. Higher chances of Uncontrollable chances of "terrorist attack" on nuclear power pants due to:

2.1 Much higher rate of world terrorism incidents in recent years

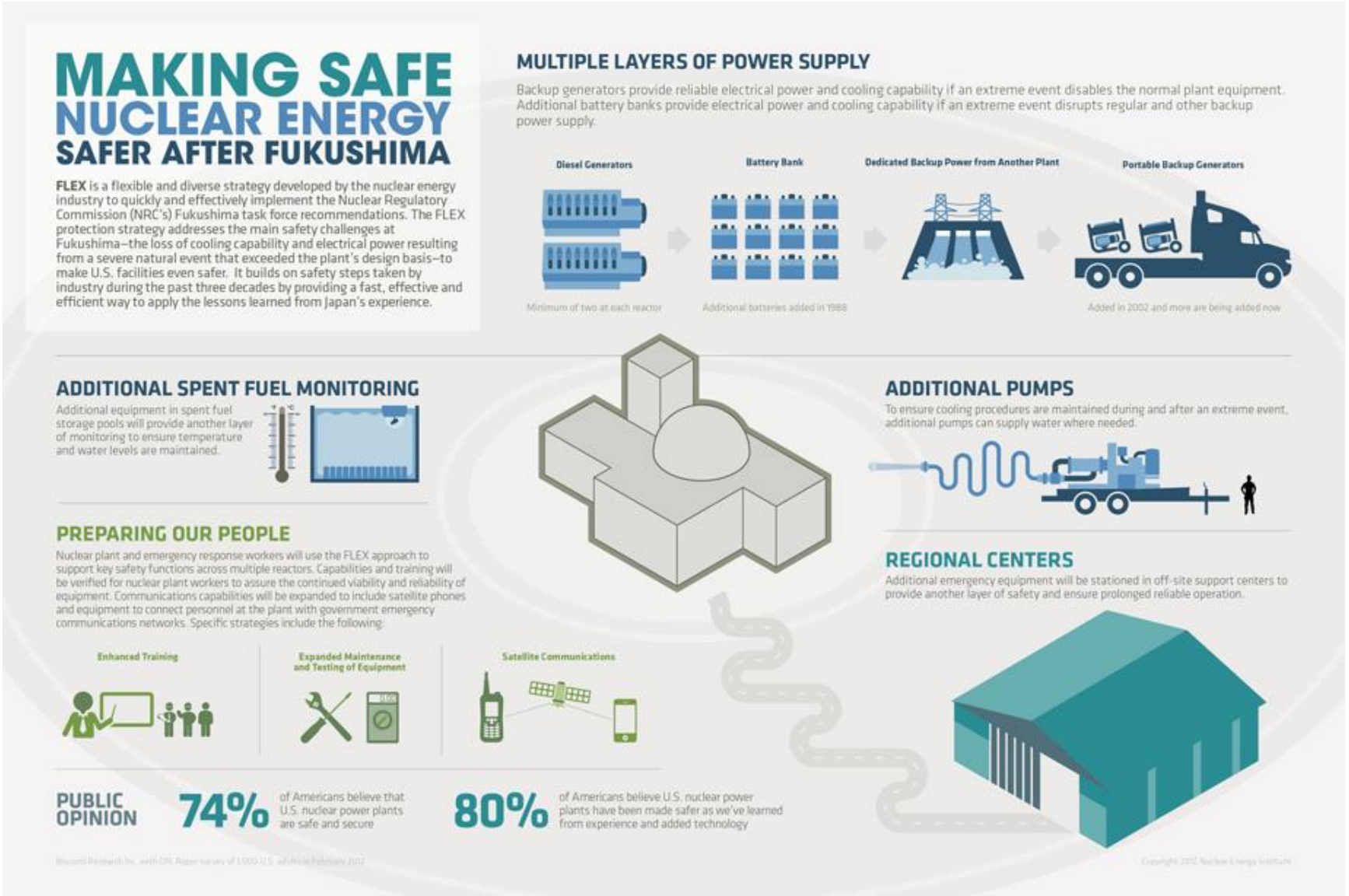
2.2 Increasing private spaceflight companies which would open up easier opportunities for possible undesirable attack on nuclear power plants by equipping explosives to such space vehicles [by terrorists] which could easily exercise ballistic *missile trajectory*

[ref. http://en.wikipedia.org/wiki/Ballistic_missile ; http://en.wikipedia.org/wiki/List_of_private_spaceflight_companies *]*

2.3 More frequent discovery of unidentified flying objects [Ref.http://en.wikipedia.org/wiki/Unidentified_flying_object]

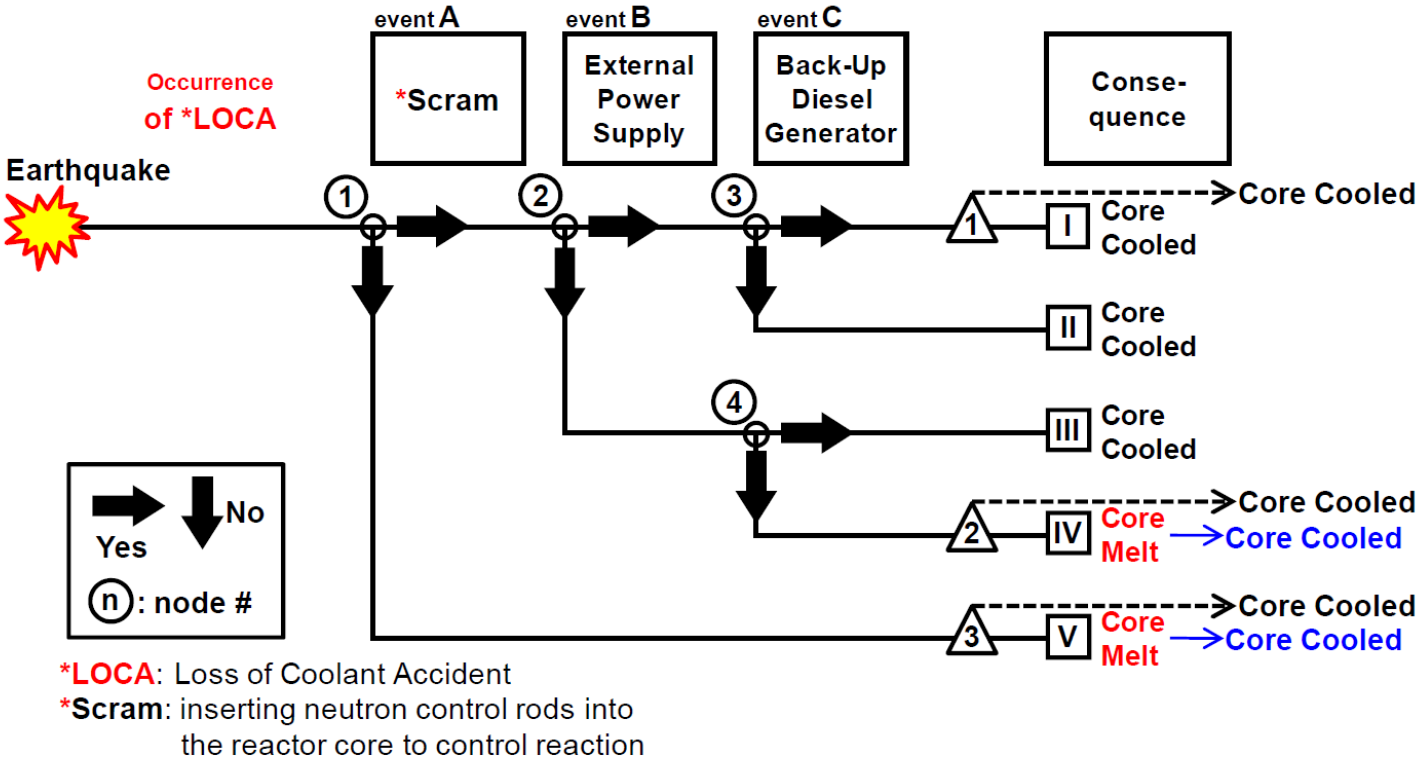
2.4 Unmanned aerial vehicles become common from government, private, military, civil sectors, imposing easier opportunities for possible undesirable attack on nuclear power plants, similar to cruise missiles [ref. http://en.wikipedia.org/wiki/Unmanned_aerial_vehicle]

Are the recent proposals of U.S. Nuclear Energy Institute (USNEI) safe enough to respond to curent safety demand ?



[image source : http://www.sustainableplant.com/assets/Sustainable-Plant/Images/nuclearsafetyinfographiclarge.jpg]

Recent "Core Cooled" proposals [2012] for Nuclear Power Safety Enhancement

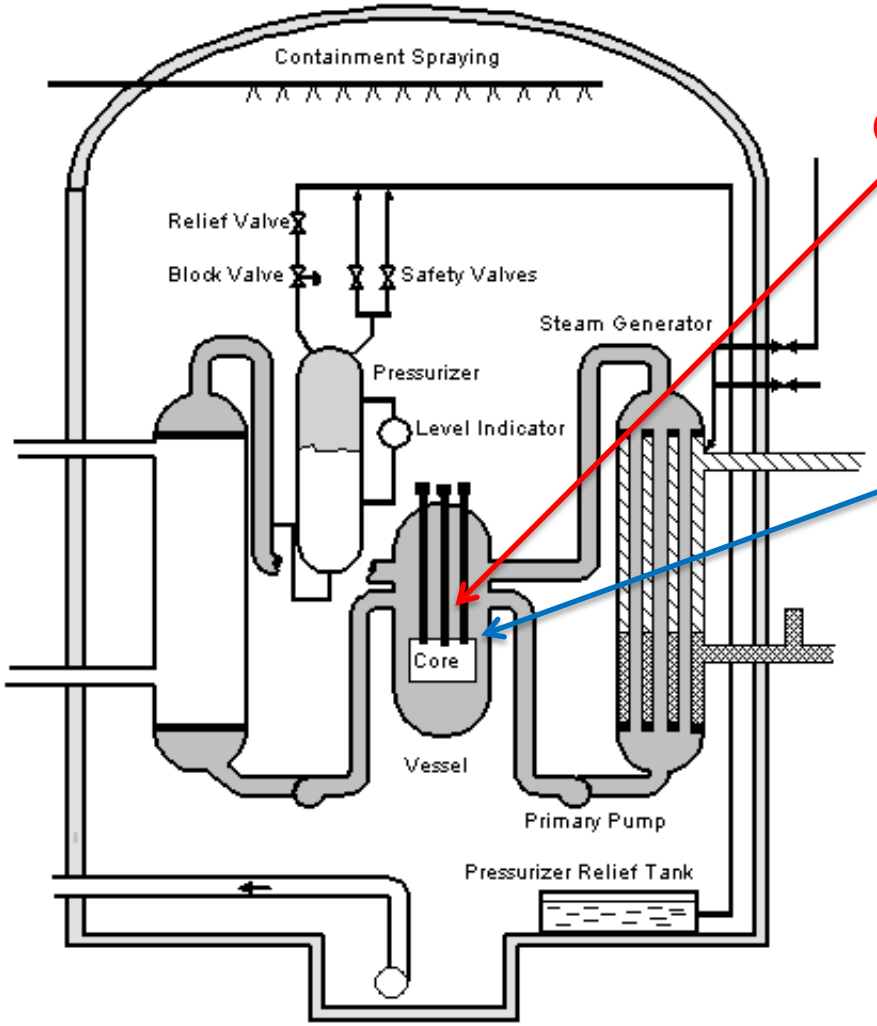


"Core Cooled" as the consequence – A simple event tree illustration

Diagram Source : Shinozuka, M., http://www.eng.uci.edu/users/masanobu-shinozuka
Probability and Fukushima Daiichi Nuclear Power Plant Catastrophe. The 15th World Conference on Earthquake Engineering will be held from September 24 to September 28, 2012, in Lisbon, Portugal. http://www.coming.pt/15wcee/index.html

Further ref. : M. Shinozuka, K. P. Cheung, T. Nifuku. **Intelligent damage mitigation for BWR nuclear reactors**. In Proceedings of ICOSSAR2013, 11th International Conference on Structural Safety & Reliability, June 16-20, 2013. Columbia University, New York, NY, USA. http://icossar2013.org/ . Wed, June, 19, session, Session 08: Health Monitoring II, Paper HM08. http://icossar2013.org/wp-content/uploads/2013/05/Preliminary-Program.pdf

Recent "Core Cooled" proposals [2012] for Nuclear Power Safety Enhancement

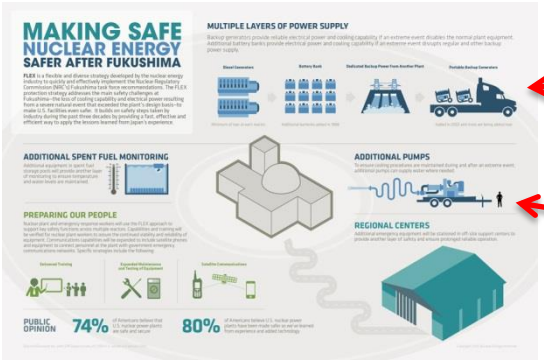


Core melt down [safe enough?]
– unthinkable , current attitude

"Core Cooled" proposals [2012]
-NO Core melt down
– end event, really safe

[image source : IAEA http://www.iaea.org/ns/tutorials/regcontrol/images/image027.gif]

Are 2012 proposals of U.S. Nuclear Energy Institute safe enough ?



Portable generators are not powerful enough to drive large cooling pumps

Mobile cooling pumps only perform water circulation, but DO NOT take away the overall system heat content

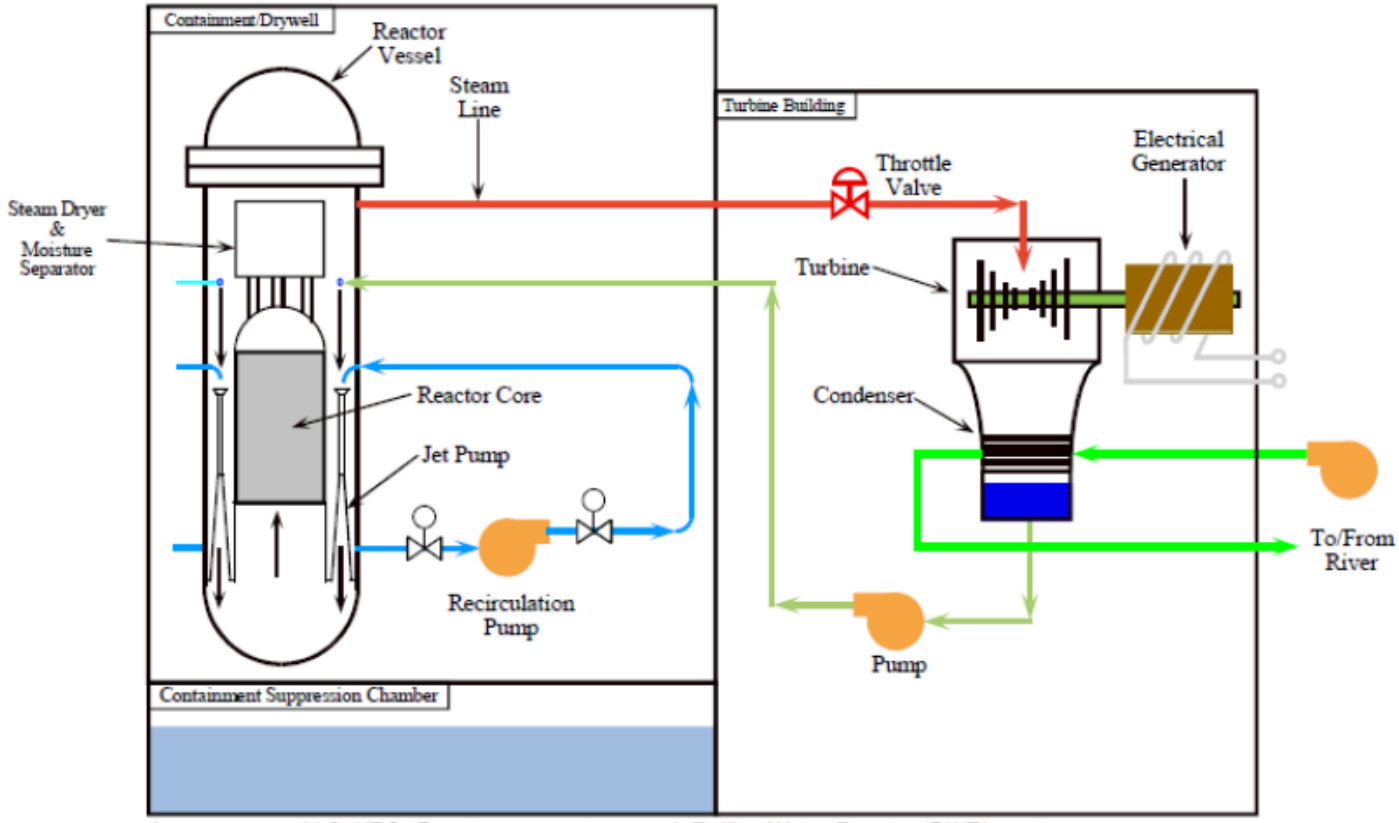
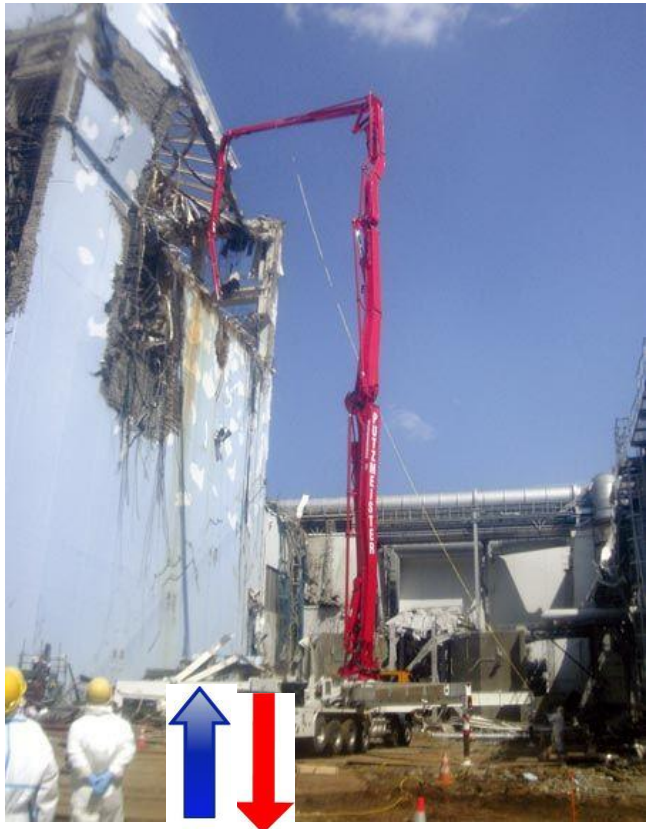


Image source: U.S. NRC. Reactor concepts manual, Boiling Water Reactor (BWR) systems.



After Fukushima of 20111 : Proposal of Mobile closed-loop water chilling system for Nuclear power plant [Fukushima illustrated]- to take away the overall system heat content – to attain "Core Cooled" target

- All equipment and devices are currently commercially available

Left image source : http://www.chinatimes.com/content-images/110504/C0041423.jpg

Ref. : M. Shinozuka, K. P. Cheung, T. Nifuku. **Intelligent damage mitigation for BWR nuclear reactors**. In Proceedings of ICOSSAR2013, 11th International Conference on Structural Safety & Reliability, June 16-20, 2013. Columbia University, New York, NY, USA. http://icossar2013.org/ . Wed, June, 19, session, Session 08: Health Monitoring II, Paper HM08.

Cheung, K. P., 1991. **A proposed back-up emergency heat removal system for nuclear power plants using mobile pumps and liquid chilling units**, ASHRAE Transactions, 97 (Part 1). http://industrycodes.com/products/9b0b4c/ashrae-3475-proposed-backup-emergency-heat

Closed-loop warm water from nuclear power plant

Closed-loop Cooled water to nuclear power plant

Warm water

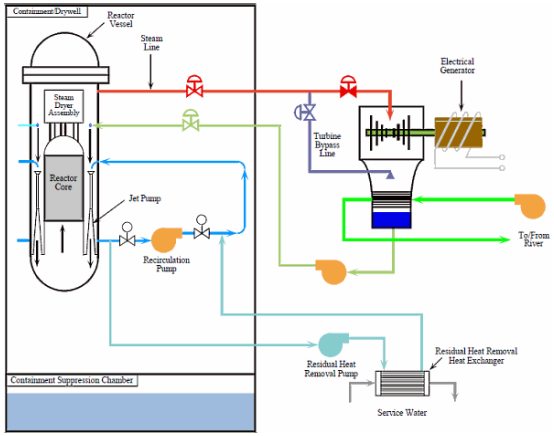
Power to chiller

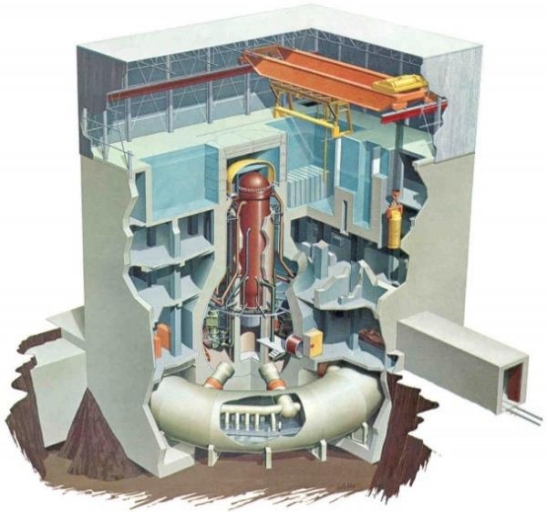
Mobile diesel power generator

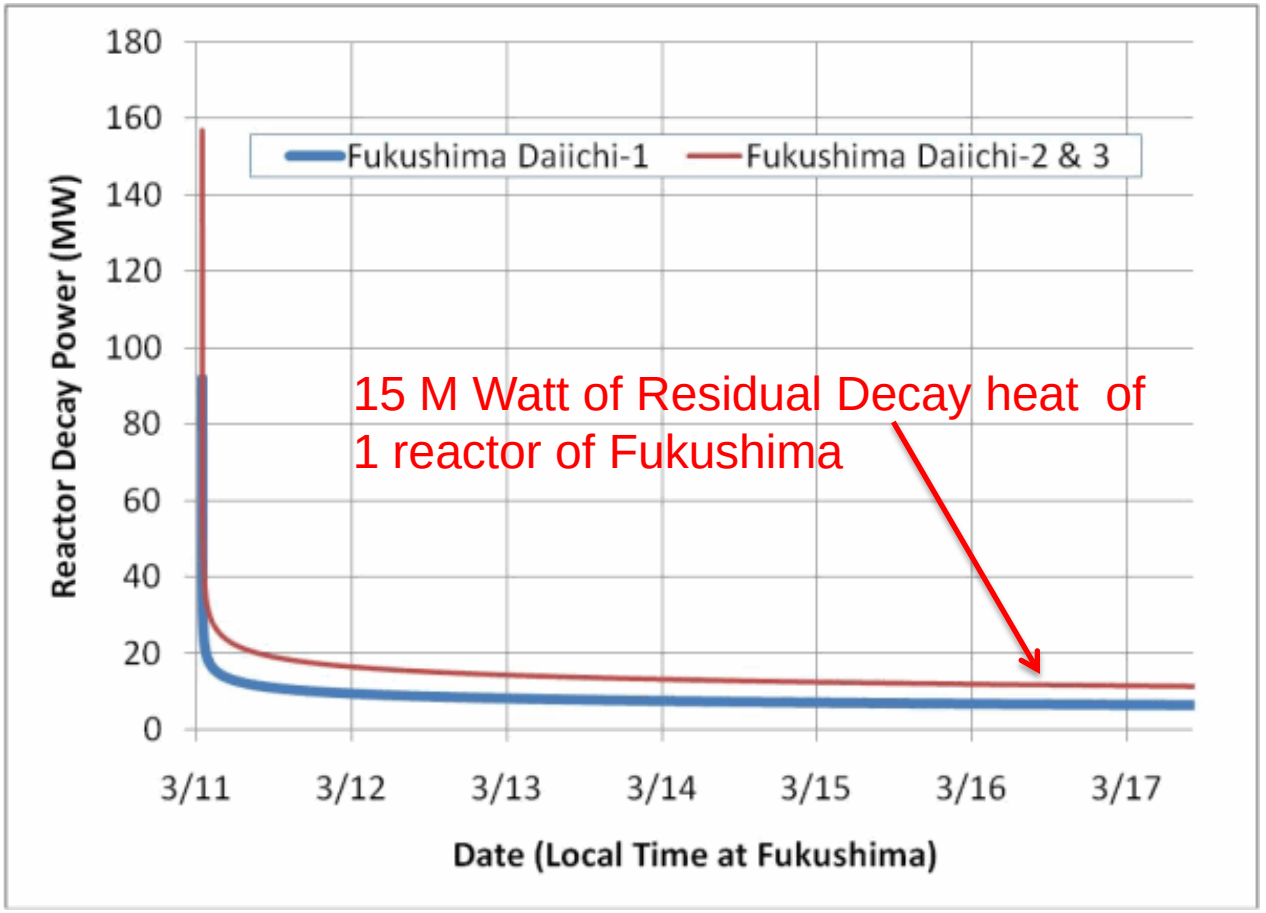
Mobile air-cooled water chiller

Mobile diesel water pump

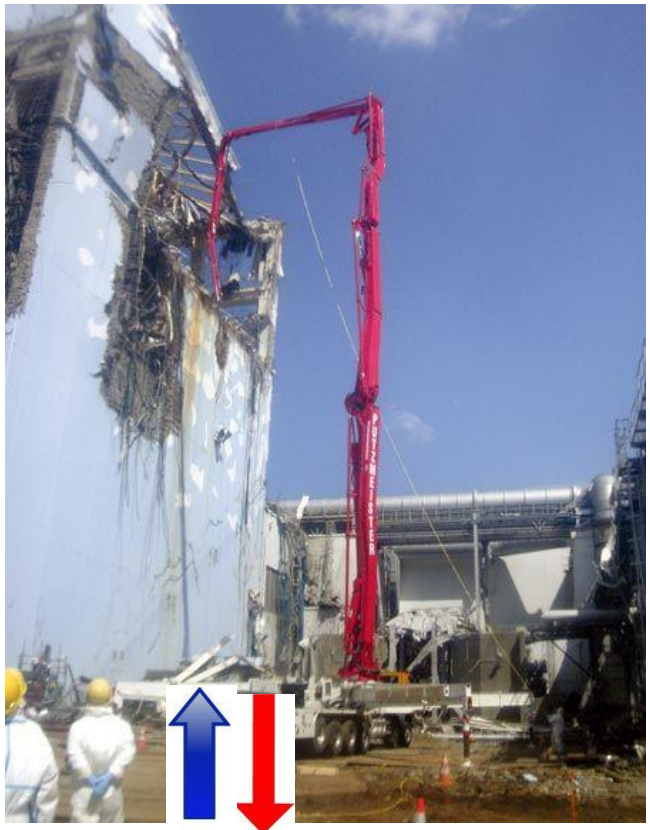
The nuclear residual heat to be removed







The report http://www.world-nuclear.org/info/fukushima_accident_inf129.html containing figures above shows that nuclear residual heat in Fukushima is averaged to around 10 MegaWatt for each reactor, going on for several months, in normal situations. **For abnormal conditions, higher heat content is generated, demanding increased cooling**.



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- All equipment and devices are currently commercially available

[Left image source : http://www.chinatimes.com/content-images/110504/C0041423.jpg]

*** **Provisions and deployment of 10 SETS of Mobile closed-loop water chilling systems [each system of 1.5 M Watt cooling capacity]** to take away 15 M Watt of Residual Decay heat of 1 reactor of Fukushima to attain "Core Cooled" target : **demanding Cross-border collaboration between neighbouring countries, and neighouring states, provinces, prefectures, counties**

Closed-loop warm water from nuclear power plant

Closed-loop Cooled water to nuclear power plant

Power to chiller

Mobile diesel power generator

Mobile air-cooled water chiller

Warm water

Mobile diesel water pump

Proposals for Safety enhancement in Nuclear Power plants to attain "Core Cooled" target

Mobile closed-loop water chilling systems, & power plant matching changes [proposed]

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1.1 For new power plants , do we need higher safety design provisions for TSUNAMI and Earthquake?

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[proposed]

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*** **Proposed Provisions and deployment of aerial intercepting devices to guard and eliminate** flying objects which will attack nuclear power plants : **demanding Cross-border international collaboration between neighbouring countries, and neighouring states, provinces, prefectures, counties**

Enhanced security measures such as additional physical barriers and check points [proposed]

“Vulnerability of nuclear plants to attack” discusses

[Ref. http://en.wikipedia.org/wiki/Vulnerability_of_nuclear_plants_to_attack]

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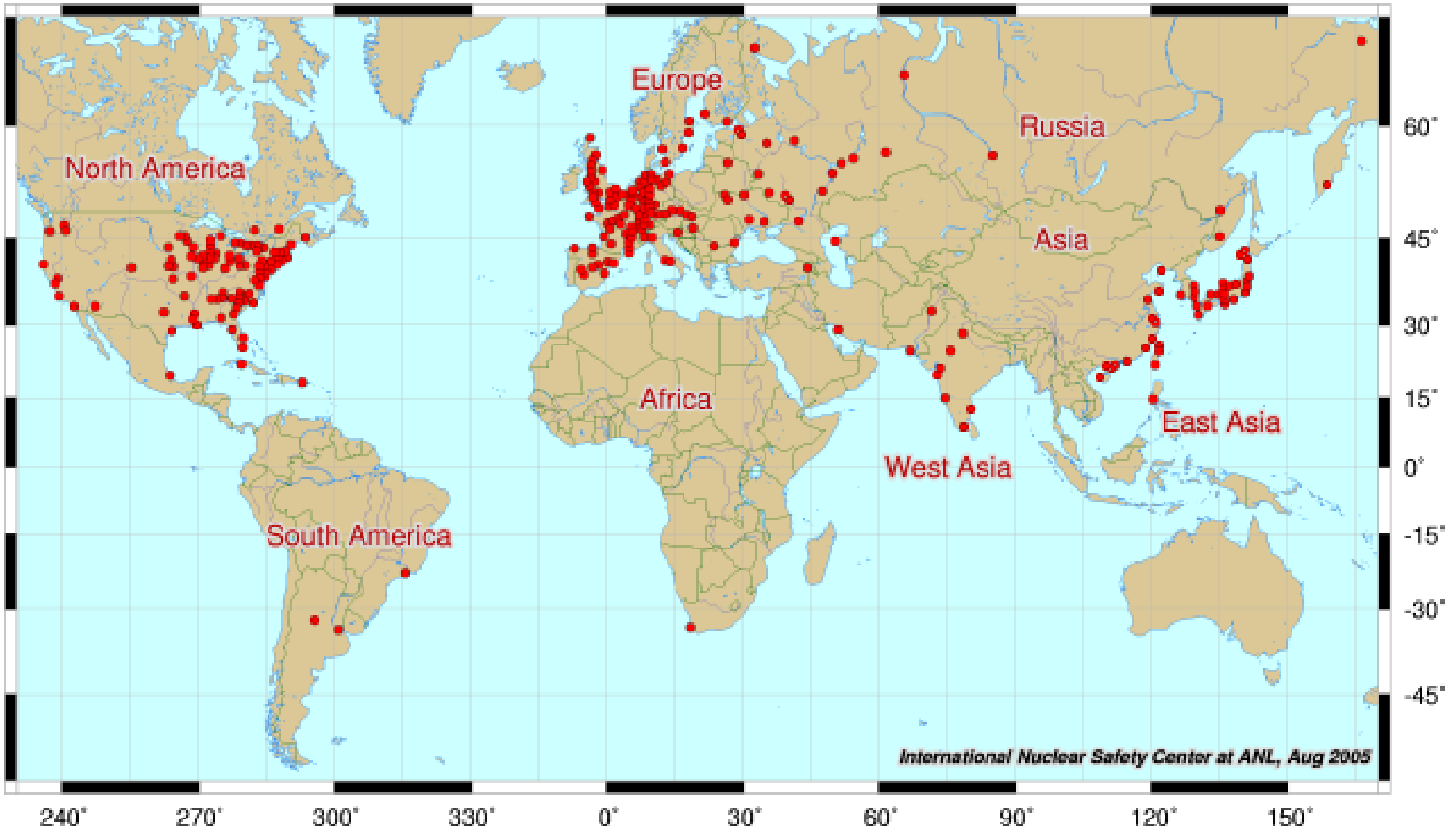
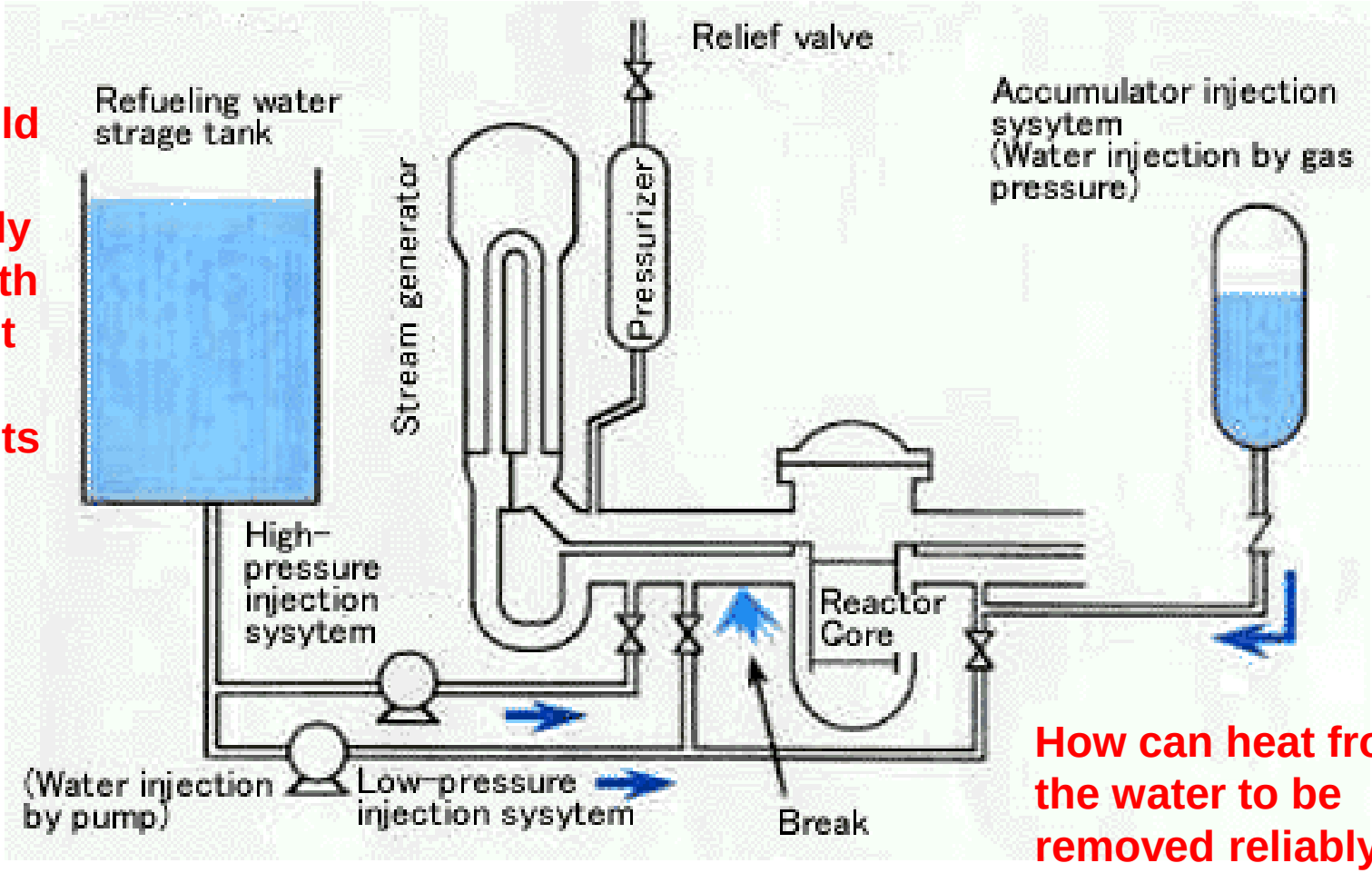
The unwanted attack on nuclear facility [not country-military] is ever increasing in probability, beyond the ability of the current nuclear engineering safety and provisions to cope with, WITHOUT nuclear core melt down.



Worldmap of all nuclear power stations (2006)- many more in 2016, 2026- **Vulnerability to attack** **Ref.**
http://en.wikipedia.org/wiki/Vulnerability_of_nuclear_plants_to_attack ;
http://en.wikipedia.org/wiki/List_of_nuclear_power_stations]

How can cold water be continuously supplied with NO END, yet without increasing its amount?

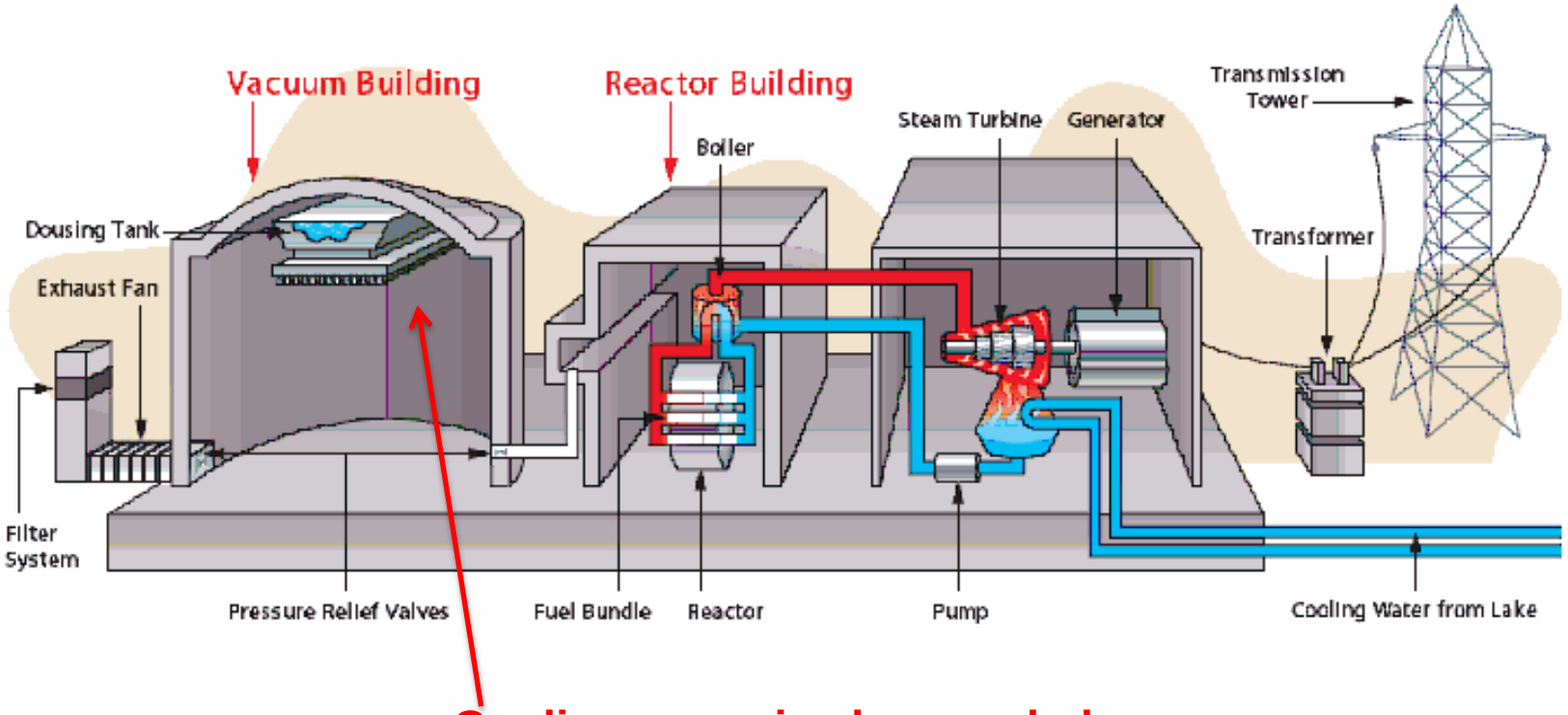


How can heat from the water to be removed reliably?

How would effective cooling go on when all the pumps fail to operate and gas pressure is gone?

Concept of reactor core cooling – CURRENT PROBLEMS

[Diagram source http://www.jaea.go.jp/jaeri/english/press/980917/gif/zu01-2.gif]



Cooling spray is also needed
-the mobile close-loop water chilling systems would help

Image source - FIGURE 2.3 : PRIMARY ZONE AND RESPONSE SECTORS
https://www.emergencymanagementontario.ca/english/beprepared/ontariohazards/nuclear/nuclear_plan_bruce.html

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*** **Provisions and deployment of Mobile closed-loop water chilling systems** to take away Residual Decay heat of reactors will attain “Core Cooled” target : **demanding Cross-border collaboration between neighbouring countries, and neighouring states, provinces, prefectures, counties**

To increase nuclear power plant safety against Unwanted attack:

-To put nuclear reactor building underground?

-To build stronger enclosure for related facilities such as power center, control center, cooling water intake and outfall, etc.?

-Internationally collaborative military protection against aerial attack on nuclear power plants, by detecting, monitoring, shooting down of flying objects likely to attack nuclear facilities; calling for **Cross-border collaboration between neighbouring countries, and neighouring states, provinces, prefectures, counties – The World Nuclear Safety-Peace Mission** ?

The World Nuclear Safety-Peace Mission

Thank you very much

Acknowledgment : This is a research project of HKU- Initiative on Clean Energy & Environment, http://icee.hku.hk/index/index.html , An area of HKU Strategic Research Area on Environment, http://www.hku.hk/research/sras/areas-and-themes.html , supported by University Development Fund, HKU

鳴謝 : 本研究專項研究項目為香港大學Initiative on Clean Energy & Environment 「清潔能源與環境研究中心」[http://icee.hku.hk/index/index.html] 其中一項研究項目，承蒙香港大學發展基金資助。