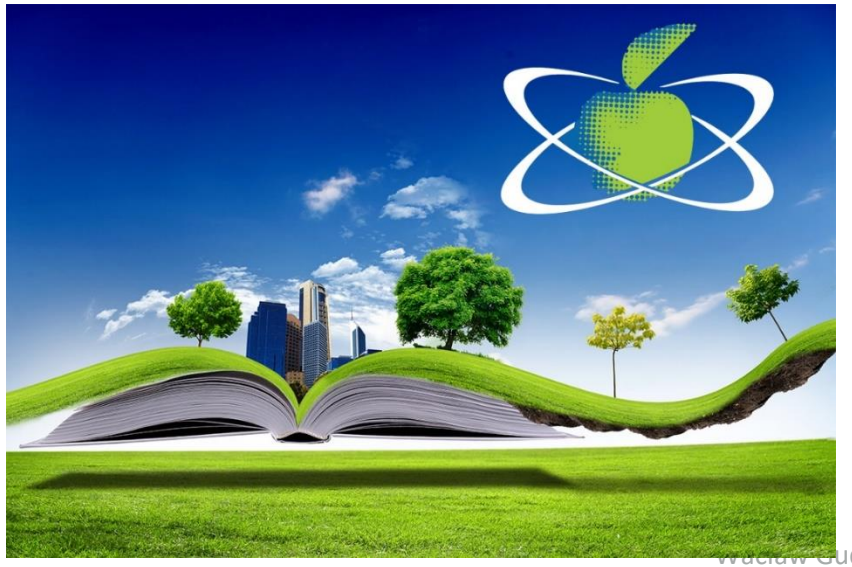
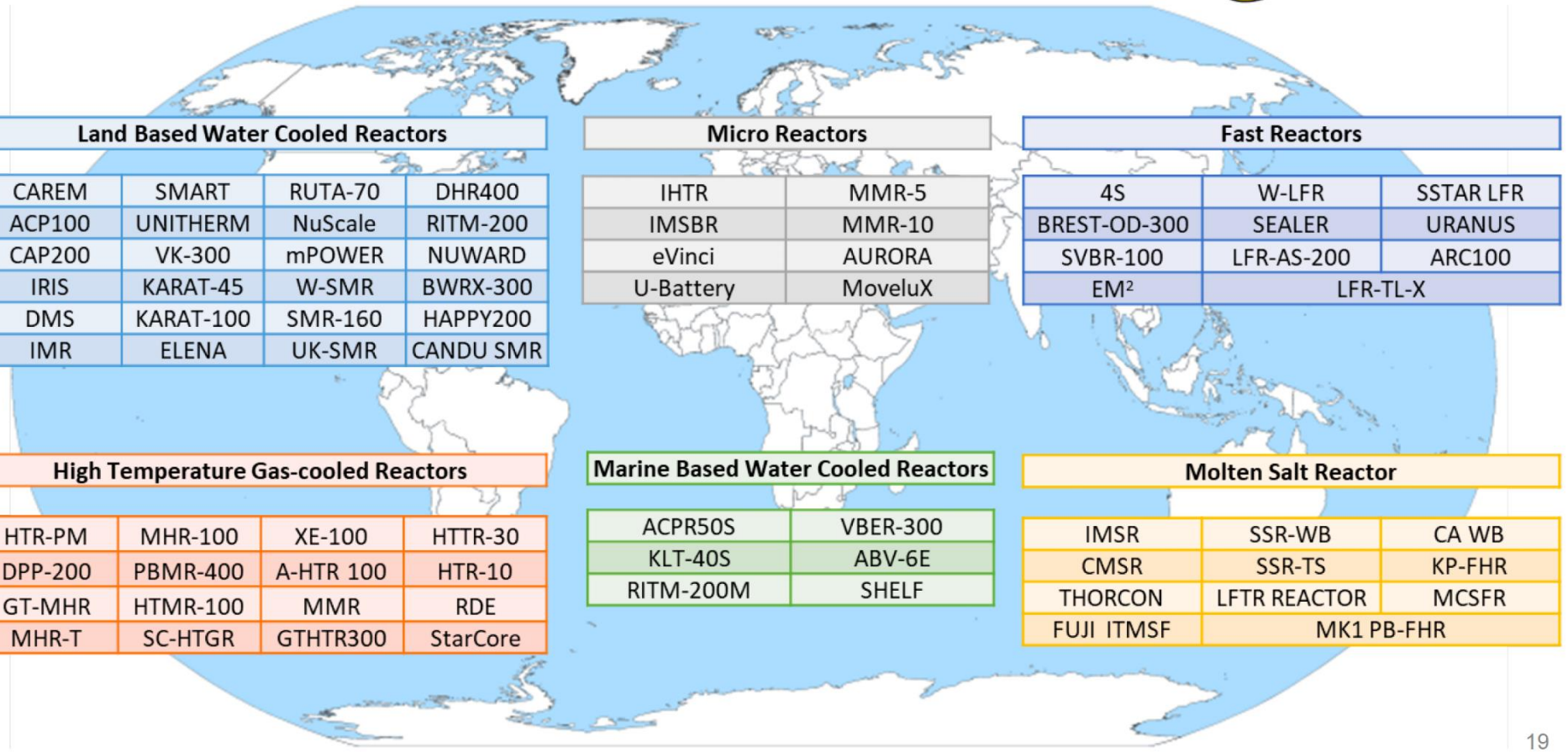
CET-2022 Conclusions, recommendations

Waclaw Gudowski , Professor and advisor



SMR Designs around the World

GEN IV International Forum℠



Land Based Water Cooled Reactors

CAREM	SMART	RUTA-70	DHR400
ACP100	UNITHERM	NuScale	RITM-200
CAP200	VK-300	mPOWER	NUWARD
IRIS	KARAT-45	W-SMR	BWRX-300
DMS	KARAT-100	SMR-160	HAPPY200
IMR	ELENA	UK-SMR	CANDU SMR

Micro Reactors

IHTR	MMR-5
IMSBR	MMR-10
eVinci	AURORA
U-Battery	MoveluX

Fast Reactors

4S	W-LFR	SSTAR LFR
BREST-OD-300	SEALER	URANUS
SVBR-100	LFR-AS-200	ARC100
EM²	LFR-TL-X	

High Temperature Gas-cooled Reactors

HTR-PM	MHR-100	XE-100	HTTR-30
DPP-200	PBMR-400	A-HTR 100	HTR-10
GT-MHR	HTMR-100	MMR	RDE
MHR-T	SC-HTGR	GTHTR300	StarCore

Marine Based Water Cooled Reactors

ACPR50S	VBER-300
KLT-40S	ABV-6E
RITM-200M	SHELF

Molten Salt Reactor

IMSR	SSR-WB	CA WB
CMSR	SSR-TS	KP-FHR
THORCON	LFTR REACTOR	MCSFR
FUJI ITMSF	MK1 PB-FHR	

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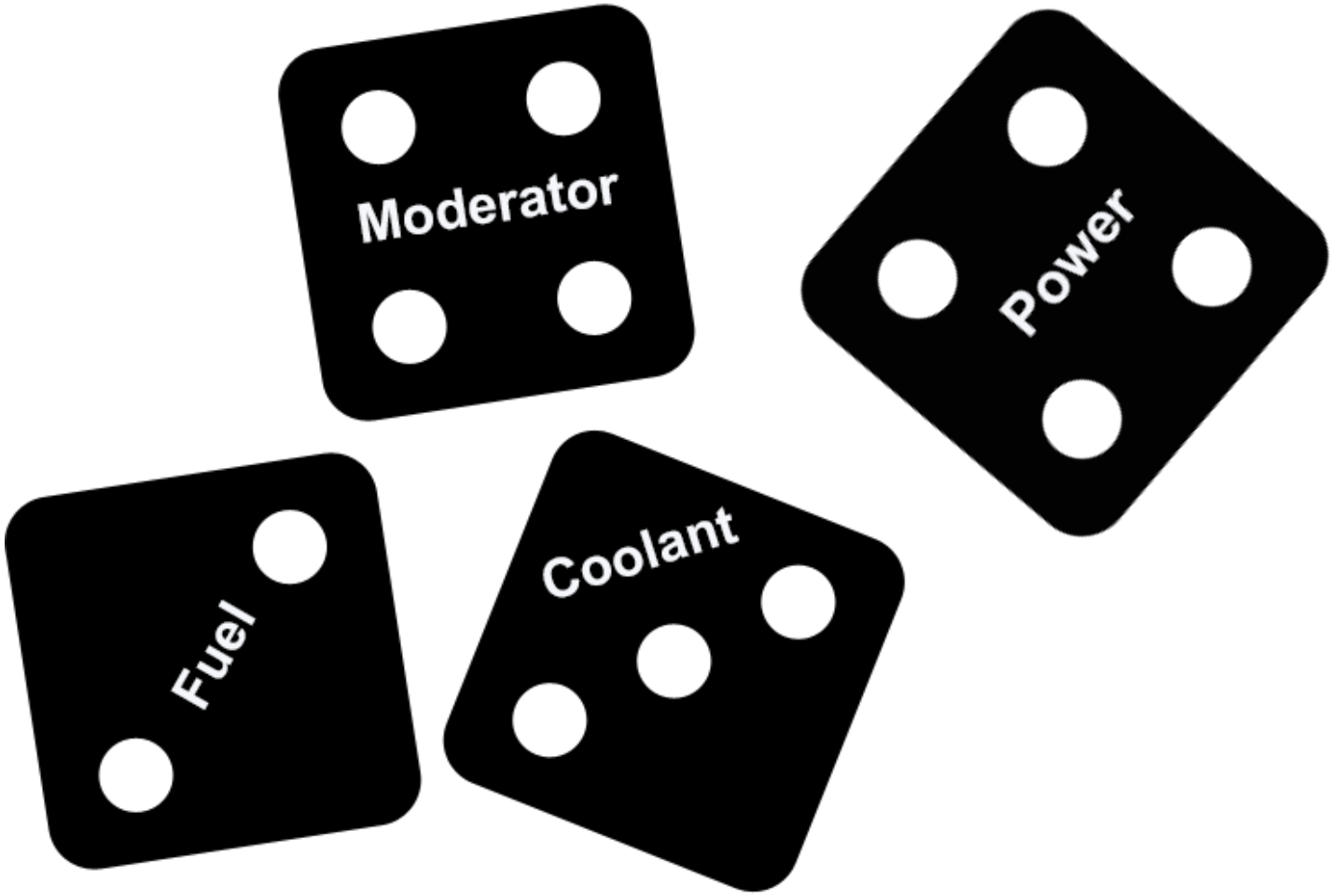
SMR development – the most advanced projects in the world

1. BWRX-300 GE Hitachi Boiling Water Reactor USA
2. UK SMR Rolls-Royce Pressurized Water Reactor UK
3. Westinghouse Pb-cooled fast reactor + Swedish SEALER
4. NuScale NuScale Power Pressurized Water Reactor USA 77 MWel
5. IMSR Terrestrial Energy Molten Salt Reactor Canada
6. MMR Ultra Safe Nuclear Corp. TRISO/Helium USA
7. Xe-100 X-energy pebble bed HTGR USA
8. U-Battery, UK HTGR microreactor
9. CMSR Seaborg Technologies Molten Salt Reactor Denmark
10. Hermes Kairos Power TRISO/Molten Salt USA
11. Moltex SSR-W Moltex Energy Molten Salt/Fast Reactor UK
12. TerraPower Sodium Cooled Fast Reactor USA
13. Oklo, sodium cooled microreactor
14. ARC-100 ARC/GE Hitachi Sodium Cooled Fast Reactor USA
15. PRISM GE Hitachi Sodium Cooled Fast Reactor USA
16. Westinghouse eVinci mobile, sodium cooled microreactor for steam generation
17. BANDI-60S KEPCO Pressurized Water Reactor South Korea
18. SMART KAERI Pressurized Water Reactor South Korea
19. SMR-160 Holtec International Pressurized Water Reactor USA

SMR creative environment – like “old, good times”



Which SMR type is the BEST??

The ONE, which satisfies the best customer's expectations and has a decent Technology Readiness Index

…. not the one that can built soon…

Challengies

Challengies - engineering

1. Be aware of ”paper reactor” (power point) offers. They can badly damage development plans.
2. ”Devil” in nuclear technolgy is mostly in details, not in principle. Do mot underestimate difficulties which are unavoidable in an intial phase of development/deployment.
3. Simple is beautiful (see BWRX-300 design simplification, RR modularisation approach etc.).
4. When feasible – find synergy with RES.
5. Adopt NS2W approach – No Single Watt Wasted.
6. ”Nuclear hydrogen” is a good driving force for SMRs but watch carefully economical and physics constraints.

Challengies - funding

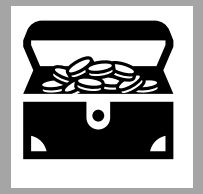
1. **Do not wait passively for governmental funding, attract private investor. See and follow example of Poland.**
2. **SMRs lower the investment treshold, exploit this.**

Challengies - licensing

1. Initiate in a very early stage a dialogue with the regulator. Follow the Canadian example!
2. Apply a GRADED APPROACH.
3. Licensing must have a very clear time and economical frames.
4. Overregulation does not promote safety – it rather invites inflation of problems.

Questions to be obligatory answered for SMRs:

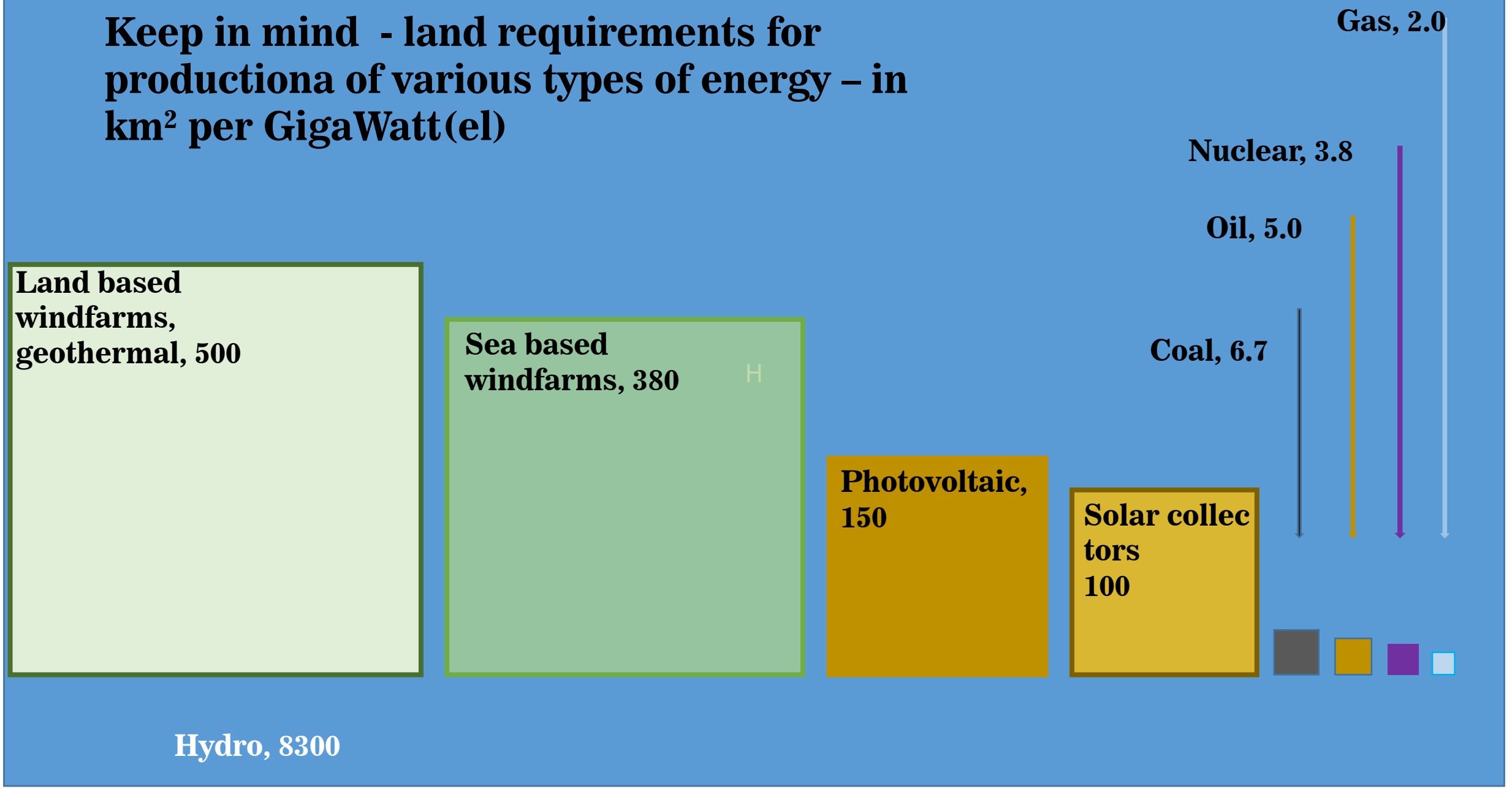
Are SMRs really very safe? Prove it for the public



How much does SMR cost?

What shall we do with used nuclear fuel/nuclear wastes?.

Keep in mind - land requirements for productiona of various types of energy – in km² per GigaWatt(el)



Conclusions for Sweden:

1. **NS2W – No Single Watt Wasted strategy is THE MUST!**
2. **If one needs 1 GWel go 1 GW unit, not several SMRs**
3. **If one needs 1 Gwel – one must have at least a GWth customer. If not go - SMR and find customers for heat**
4. **Sweden is a BWR country – go BWRX-300 at some particular locations**
5. **Fossil free steel industry (as well as other industries) needs nuclear electricity and heat**
6. **Hydrogen transition requires nuclear power**
7. **We do not want landscape degradation with low density power RES.**

What do we prefer??

Wishes for Oskarshamn

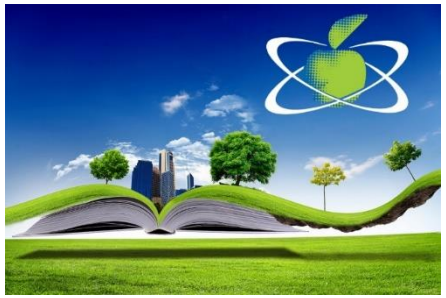
GO NUCLEAR AS SUCCESSFULLY AS BEFORE:

- Update your 30-30 Sustainable Oskarshamn vision to: **by 2030, Sustainable Oskarshamn will have 30 000 residents, again 3 reactors on line and 2*300000 SEK average income! And have a lot of Scanias and candles around!**

I wish you also not to be ever exposed to any unpleasant surprises like in 2015 with O2!

Closing remarks

1. **The technology gap between large, conventional LWR and SMR has been radically narrowed over the past 20 years. There are many more developers of SMRs than those working on Gen3 + reactors**
2. **Education and training are very important phases in SMR development. Needs to be addressed very early.**
3. **In the longer time perspective - there is no sustainable future for nuclear power without breeding i.e. either fast reactors fuelled with U-Pu cycle or Thorium fuel cycle.**
4. **Both options above require advanced research in nuclear physics, technology and chemistry, in particular mastering used fuel reprocessing.**
5. **And let's not forget about transmutation research, especially ADS**



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Thanks!

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