

## HISTORY AND STATUS OF THE TRISO-PEBBLEBED TECHNOLOGY IN GERMANY

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### **Abstract**

*As a latecomer, I thank the few people I could listen to since 2005. American and German geniuses invented and developed the TRISO fuel elements (FE) for nuclear HTR. Farrington Daniels invented the tennis ball shaped FE filled with gastight coated particles. Rudolf Schulten doctorate of Werner Heisenberg developed the HTR. From 1960 to 1990 he worked at BBC/Krupp for the AVR experimental reactor at the Jülich nuclear research facility (KfA). These topics were emphasized among many others:*

- composition and form of the fuel*
- moderator*
- coolant*
- heat exchanger*

*Etc.*

*Germany condemned all nuclear energy to phase-out, including TRISO technology. After the death of Prof. Schulten in 1996, work on it ceased.*

*In 2010, the operational life was extended, one year later a definite end was decided within 10 years. TRISO technology was also doomed to die. When the HTR-PM in Shidaowan went online in December 2021, it was the long-awaited -by very few people - confirmation of TRISO technology. The phenomenon of the spiral of silence continued. In 2023 the last three LWR power plants were shut down.*

*Fossil power generation is increasing. Subsidies for windmills and PV panels abound. There is only one chair (at Dresden university) that teaches nuclear technology. A very hesitant small wake up of nuclear discussion is coming since 2 years. Most people do not believe, that nuclear energy will. The German nuclear law in § 7 strictly forbids the use of nuclear power to generate electricity. Hope is mostly for the promise of nuclear fusion and two Gen IV projects. The very real successes of pebble bed technology in HTR-PM technology is publicly suppressed.*

### I. INTRODUCTION

#### Slide 1

As a latecomer, I would like to thank the few people who gave me valuable information since 2005. The Internet helped me to do the necessary research to fill gaps and to understand complex facts behind keywords. Especially in Germany, where the early and decisive development took place, there is hardly any knowledge left today of high-temperature nuclear technology. All the experts, movers and shakers are no longer with us. Less than 3 survive and are well into their 90s. I am therefore very open to any corrections, additions, tips and help.

#### Slide 2

Both American and German geniuses contributed to the important invention of the fuel elements for the HTR-nuclear reactors. They are the key components to this technology. Parallel inventions and developments in Japan and the UK have further ignited the progress.

#### Up to 1960

Farrington Daniels invented the tennis ball shaped fuel element (FE, BE) filled with

gastight coated particles containing the radioactive heavy metals like Thorium, Uranium, Plutonium.

### Slide 3

In Germany, Rudolf Schulten obtained his doctorate under Werner Heisenberg in Göttingen in 1953 and was subsequently his assistant at the Max Planck Institute. He knew the FE and their potential.

Since Adenauer's chancellorship – the first democratic after WW II - the use of nuclear power had been limited to civilian purposes.

### From 1960 to 1990

Prof. Dr. Rudolf Schulten was initially responsible at BBC/Krupp for the planning and construction of the AVR experimental reactor at the Jülich nuclear research facility (KfA). There he became Director of the Institute for Reactor Development in Jülich and Professor of Reactor Technology at the RWTH Aachen University. From the very beginning, he pondered about the current situation: large power plants require large interconnected grids. These and the reactor itself require high and complicated safety measures. They represent a high risk and place a great deal of responsibility on decision-makers. He concluded:

- The global climate problem calls for a broader range of energy sources.
- This is particularly true in emerging and developing countries.
- Nuclear power plants appear to make more sense with
  - lower outputs
  - transparent safety concepts
  - low costs

So he posed questions like:

- Are the existing plants, with outputs of 1+ gigawatt the right way forward?
- Can these demands be met with new nuclear technology?
- Can safety be achieved in the event of incidents without radioactivity spreading?
- Can sufficient safety components be produced and operated economically enough in countries with less technological affinity?

- Can fuel supply and final disposal be guaranteed?
- Can nuclear plants generate other forms of energy in addition to electricity?
- Can they be used for the large heating requirements of industry, housing and other needs?
- Which reactor types are suitable for this?

### Slide 4

This led to his research and developments at Jülich. He with his more the 250 doctorates worked on many subjects, especially on the following:

- composition of the fuel
- form and shape of the elements
- moderator kind and placement
- coolant – non water
- heat exchanger, material, fittings and processing
- design stability dimensions and cooling
- pebble transport system

Many experiments and modifications were carried out in Jülich over a period of 20 years to further optimize the system.

### Slide 5,6,7

### Slide 8

In the 1970s, a good dozen municipal utilities founded a company to use this energy. A 300 MW power plant, the THTR 300, was built in Hamm, which mainly used thorium as fuel. This brought further advantages. It was operated until the end of the 1980s. Many other important experiences were gathered.

### Slide 9,

The core was housed in a prestressed concrete vessel

### Slide 10

Control rods directly into the pebble bed were blamed to be the cause for malfunctions. Wikipedia overstates negative aspects, which overshadows positive results.

**Slide 11**

Now it is closed within the “safe enclosure”.  
No visitors allowed, like in Jülich, too.

Research Center were able to tell me  
anything about the transfer of documents  
and know-how to China and South Africa.

**Slide 12**

Experiences led one engineer – Dr. Cleve –  
to propose a ring core design for large  
reactors over one hundred MWel

In 2010, the Merkel government agreed to  
extend the operation of the existing 17  
nuclear power plants for an initial period of  
10 years. The two TRISO reactors in Jülich  
and Hamm were not included.

**Slide 13**

Summing up the bottom line shows the  
German milestones. At the end of the  
1980s, opposition to nuclear power plants in  
Germany became increasingly strong. They  
opposed any kind of further development,  
even research. Even then, Schulten sensed  
that Germany was in danger of phasing out  
nuclear energy. He made sure that the HTR  
could be further developed in China (and  
also in South Africa).

Many Chinese and other experts visited  
Germany to familiarize themselves with this  
technology.

**Slide 15**

To see the Jülich AVR I had to work  
through the thorny bushes outside the fence  
around Jülich.

***From 2011 to 2021***

**Slide 16**

After Fukushima in 2011, the Merkel  
government finally decided to shorten the  
operating life again and to finally phase out  
the civilian use of nuclear energy. This  
included TRISO technology, so it was  
doomed too. To this day, there is no new  
generation of people, nor any interest from  
the frustrated industry. All people still alive  
from back then are over 90 years or no  
longer with us.

***From 1990 to Fukushima***

**Slide 14**

In the 1990s, Germany condemned all  
nuclear energy to phase-out, including the  
far safer high-temperature TRISO  
technology. After the early death of Prof.  
Schulten in 1996, research continued in  
Jülich for just a few more years. There was  
also resistance to HTR-TRISO technology  
in the LWR industry. Young talents found  
little prospect for professional success in  
nuclear.

By several contradictory decisions for and  
against further operation of the LWR power  
plants led Germany to a complete nuclear  
standstill. Growing green influence with  
media support discouraged industry and  
science. Most of the nuclear power plants  
were closed and dismantling began.

In China the great chances were recognized  
and consequently followed. Neither the  
Ministry of Economic Affairs nor the Jülich

**Slide 17**

Knowledge, expertise and experience have  
fallen to almost ZERO. Fear and uncertainty  
are the consequence.

**Slide 18**

When the HTR-PM in Shidaowan went  
online in December 2021, it was the long-  
awaited confirmation of TRISO technology,  
unnoticed in Germany. The phenomenon of  
the spiral of silence continues to prevail.

Even such highlight like the 6. December  
2023 was completely suppressed in our  
Media. Other than the windmill event at the  
same day.

**Slide 19**

This has prompted me to volunteer my free  
time to preserve knowledge. Internet,

lectures, Zoom and books are the means to do this. Fortunately, I had benevolent and knowledgeable advisors cited down below.

With the websites [www.biokernsprit.org](http://www.biokernsprit.org) and [www.gaufrei.de](http://www.gaufrei.de), an extensive collection of texts, images and knowledge has been created that provides efficient and compact access for those interested.

#### Slide 20

My books are translated into 8 languages.

#### Slide 21

#### Slide 22

Chinas HTR-PM currently without parallel among new projects

#### Slide 23

Big chances for industrial heat plus electric power. Meanwhile in Germany the last three LWR power plants were shut down. Since demand for electrical power is steadily increasing, the fossil power generation is increasing too.

Incentives and subsidies for the installation of windmills and PV panels are the promise to become climatically neutral in the 30-ies or 40-ies.

### Status

For almost 20 years there has only been one chair (in Dresden) that works and teaches nuclear technology. Very few students. The prospects in Germany are ZERO, apart from the study of decommissioning technology, which is offered in Aachen.

Industrial companies involved in the construction and operation of NPPs have ceased almost all their activities. Hardly anyone expects to ever manufacture or operate nuclear reactors in Germany again. Machines for manufacturing the spheres were given away abroad.

An emeritus professor from Dresden is working with a company in Jena on further

optimization of the pebble FE. Small channels are built into each sphere. This allows the cooling helium to better absorb the heat generated inside the spheres. One German graphite producer might be working with foreign users of the FE and the inner shields. There is no other known nuclear activity in my country.

The nuclear technology of high temperature with TRISO elements is often completely unknown even to experts. Some have heard of it without knowing the details. It is therefore often regarded as insignificant or ridiculed. Ministries claim to know everything. When asked, this knowledge is many years old and outdated.

Generally, words like "nuclear energy" or "nuclear fission" were taboo. Nuclear and radioactive knowledge in schools, universities and media still are very limited. The radiation specialist of Greenpeace Germany told me, that radiation should be Zero.

It is only in the last two years that the topic is mentioned occasionally and increasingly in the media or in personal conversations. Television programs occasionally pick it up, but always with a negative undertone. The dangers are strongly emphasized, the opportunities are not mentioned. A former employee of Jülich and anti-Atom whistleblower confessed his main goal was to stop development of the TRISO-pebble technology.

About 6 years ago, an association was formed, Nuklearia e.V., which actively promotes nuclear energy, but exclusively for LWRs or so-called new reactor concepts. Attempts to introduce the HTR with TRISO elements were rejected.

### Societal

The German nuclear law in § 7 strictly forbids the use of nuclear power to generate electricity.

In general, there is hardly any rudimentary knowledge in society about atoms, nuclear

fission, the use of nuclear energy and even less about HTR technology.

The promise of nuclear fusion and two Gen IV projects are discussed rather than the concrete successes of pebble bed technology.

#### Slide 24-31

Two proposals for the special capabilities of the HTR-TRISO technology

1. replacing some 500 fossil powerplants by modules of the HTR-PM size
2. hydration of coal, wood and waste to Ethanol by Fischer Tropsch

#### **Personal profile**

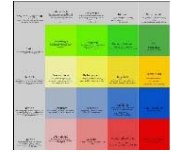
7. from 2010 I am the only one in Germany, saving this ingenious technology from oblivion. Website, Books, Articles, Zoom meetings. Voluntary, independent, sponsors for financial outlays
6. 1981 to 1984 CEO of a medium sized data center in the pharma industry
5. 1973 to 2010 self-employed management consultant for IT financial management for data centers in very large companies – some 200 publications
4. 1970 to 1973 management consultant with Booz Allen Hamilton / PWC Strategy&
3. 1960 to 1970 Robert BOSCH / IBM Germany, France, US
2. 1955 to 1960 Technical university Berlin, Uni Cologne, industrial engineer, after being certified locksmith craftsman with DEUTZ
1. 1933 born in cologne Germany

#### ACKNOWLEDGMENTS

Heinrich Bonnenberg, Urban Cleve, Günther Dietrich, Michael Fütterer, Hermann J. Werhahn and a few other people, including some from China. I have no scientific claims. this report is fed by many talks, reading and listening to experienced people

# High temperature TRISO-Energy in Germany

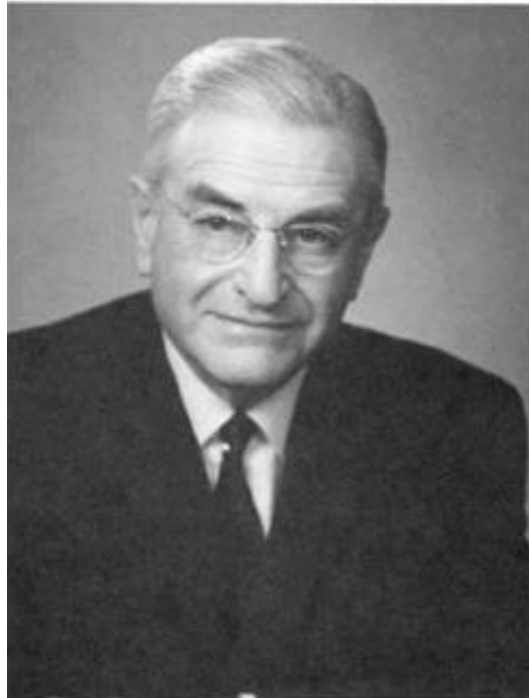
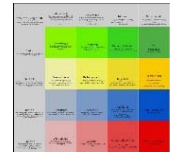
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## History and Status of the TRISO-Pebblebed Technology in Germany

# High temperature TRISO-Energy in Germany

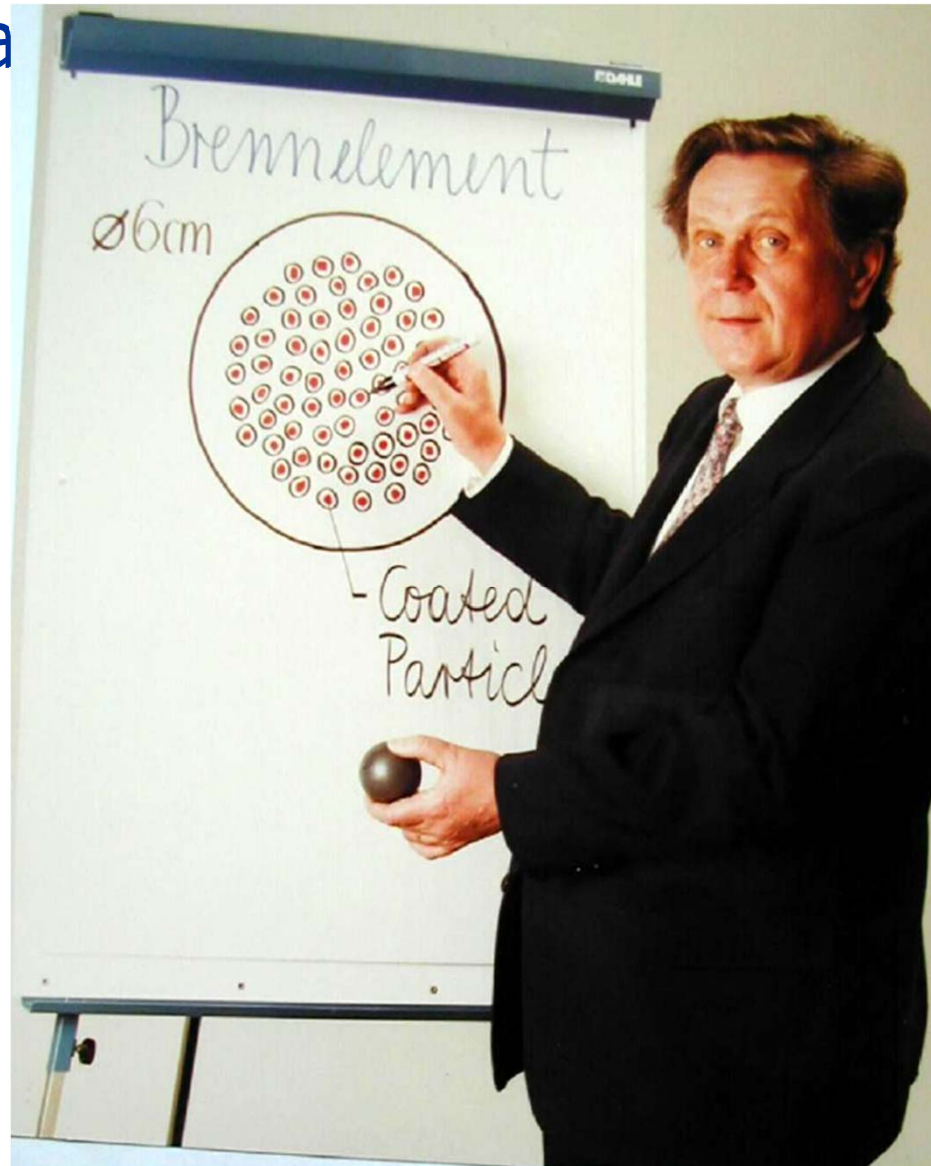
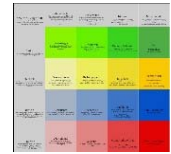
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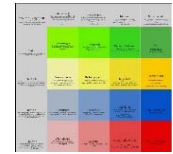


Farrington Daniels 1940-er - inventor - Rudolf Schulten 1960-er developer

High tempera

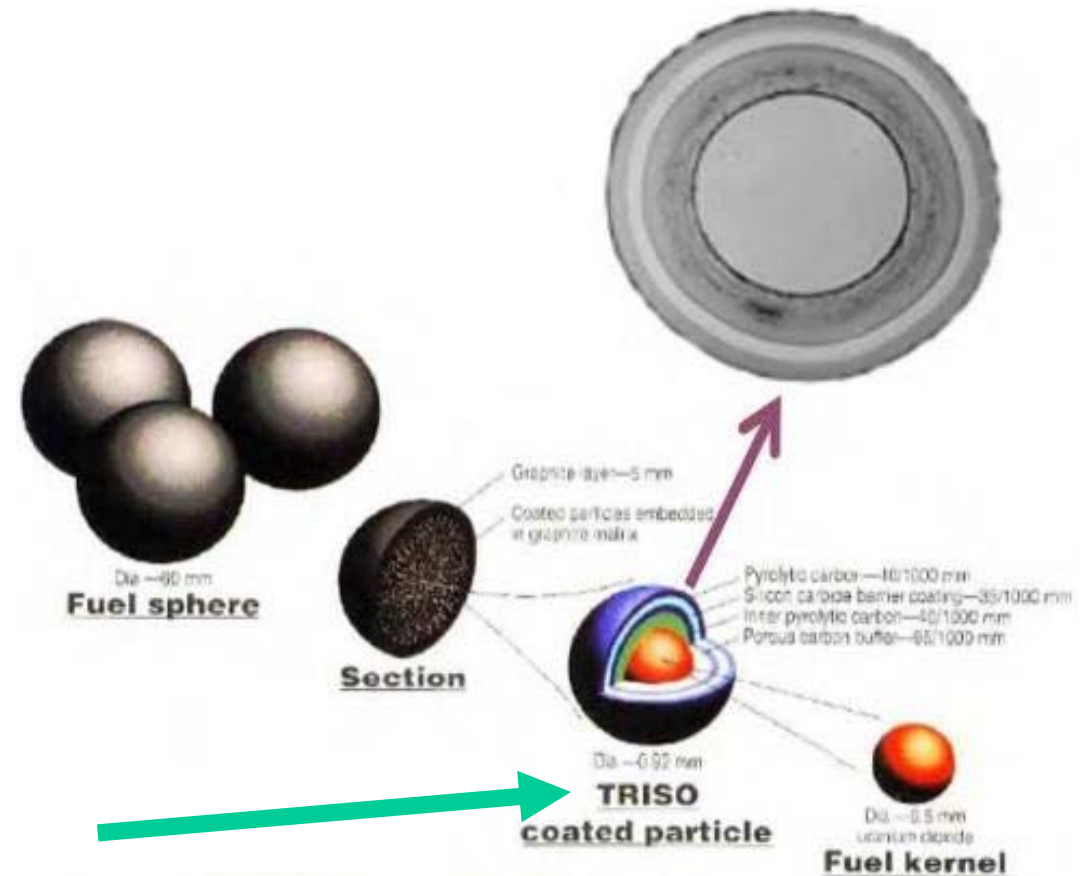
many  
ufrei.de





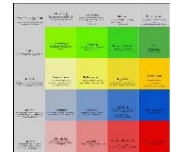
## Confinement of Radioactive Materials

- No of CP:  $4 \times 10^5$  FE,  $4 \times 10^9$  CP
- Failure rate in manufacture and operation  $< 10^{-4}$
- No likelihood of massive failure in accidents
- SiC can resist intrusion of external water and air



# High temperature TRISO-Energy in Germany

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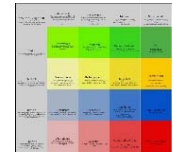


coated  
particle

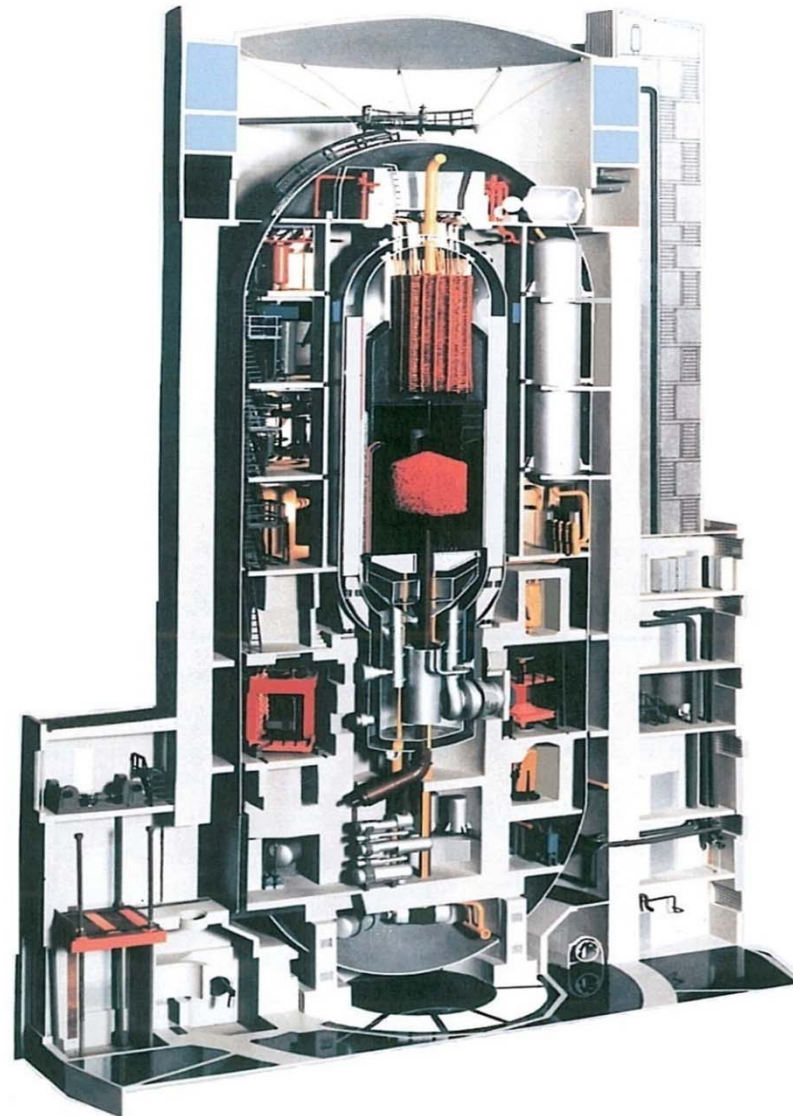
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type)

# High temperature TRISO-Energy in Germany

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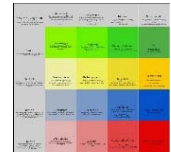
**AVR**  
**Reactor**  
**building**  
**Julich**



Quelle: 50 Jahre AVR

# High temperature TRISO-Energy in Germany

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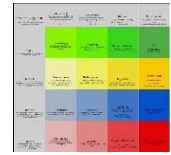


**AVR**  
**in the**  
**KFA**  
**Jülich**  
**ca. 1980**

Source: 50 Jahre AVR

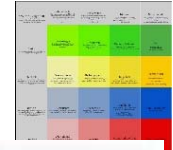
# High temperature TRISO-Energy in Germany

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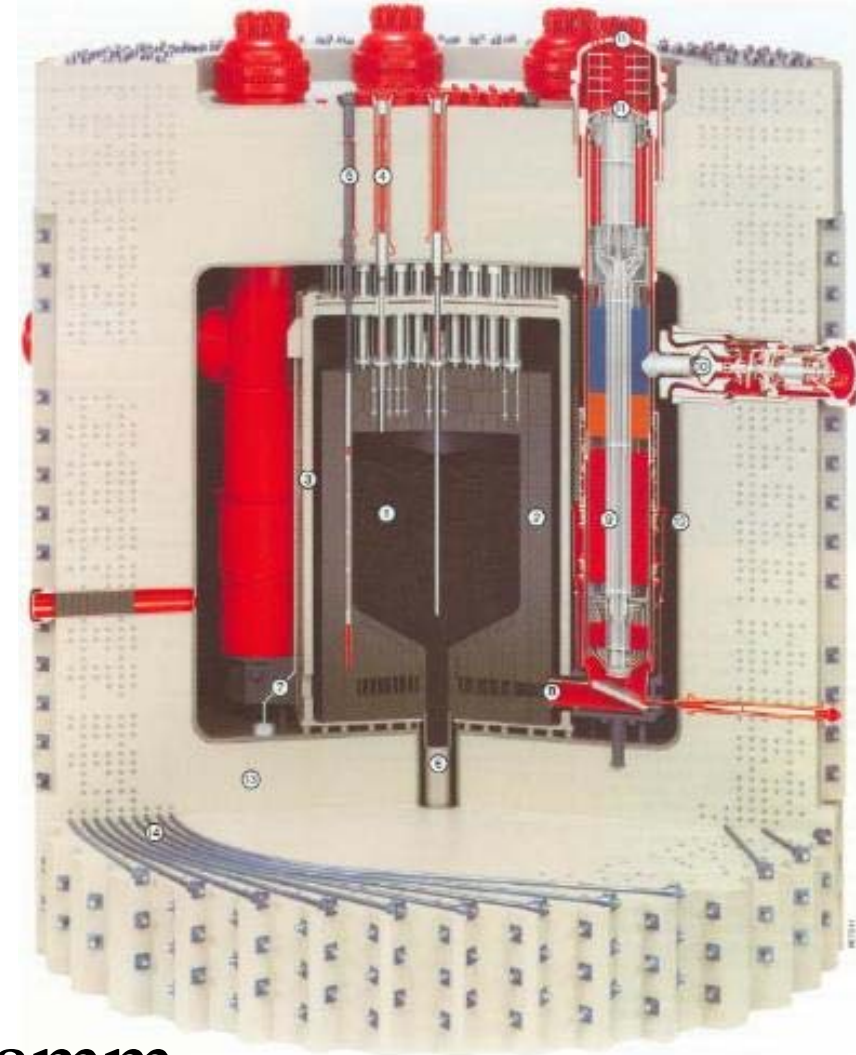
**THTR 300  
Hamm-  
Uentrop  
up to 1988  
with  
waterless  
cooling  
tower**

# High temperature TRISO-Energy in Germany



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- ① *Reactor core*
- ② *Graphite reflector*
- ③ *Thermal shield*
- ④ *Incore rod*
- ⑤ *Reflector rod*
- ⑥ *Fuel element discharge pipe*
- ⑦ *Fuel element loading tube*
- ⑧ *Hot gas duct*
- ⑨ *Steam generator*
- ⑩ *Coolant gas circulator*
- ⑪ *Vessel closure*
- ⑫ *Liner*
- ⑬ *Prestressed concrete reactor vessel*
- ⑭ *Prestressing cables*

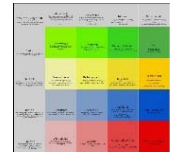


## Prestressed concrete in Hamm

Q: Dr. G. Dietrich

# High temperature TRISO-Energy in Germany

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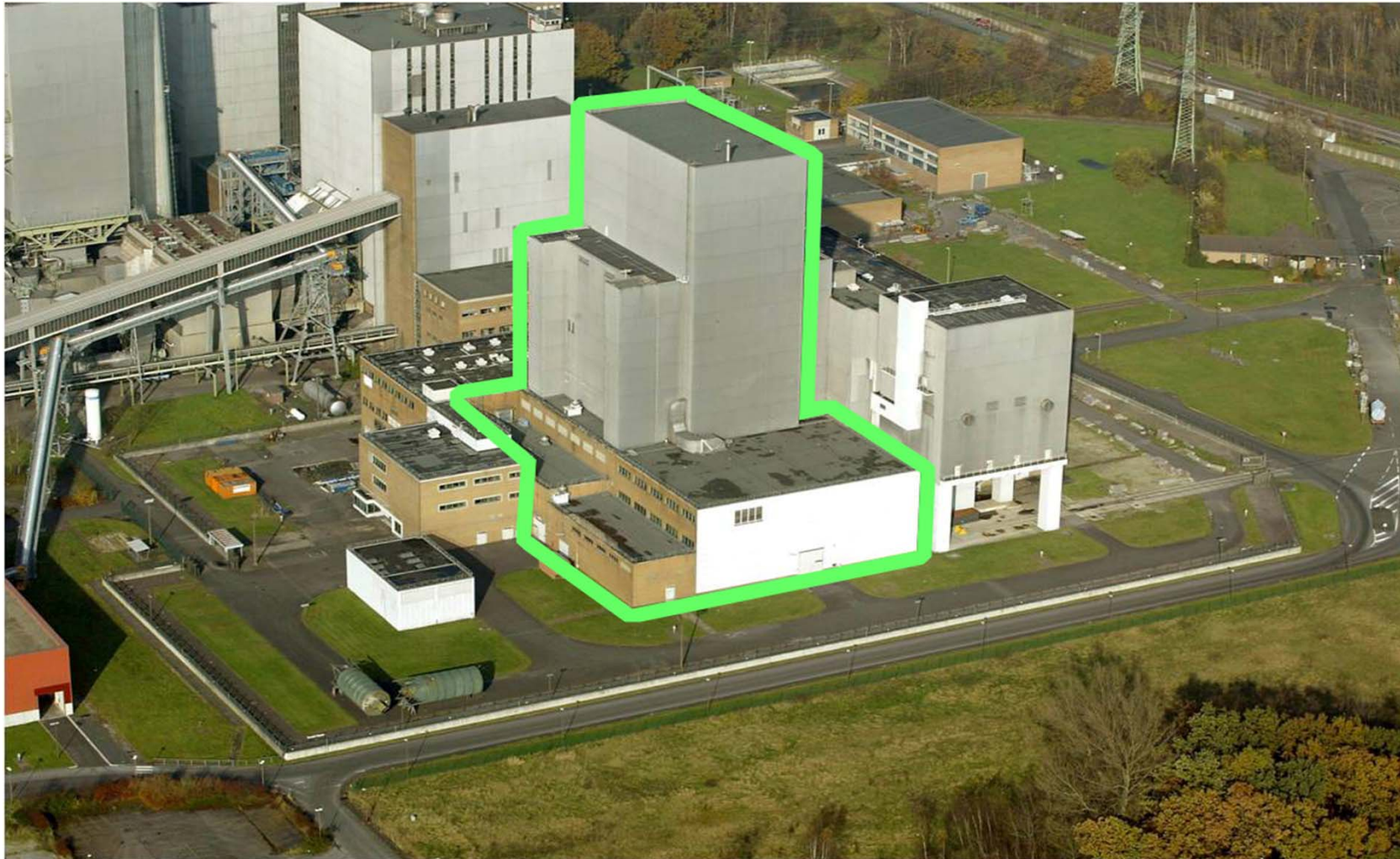
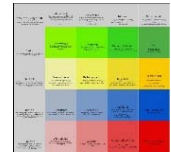
Pebble Bed  
Core of the  
THTR  
Reactor  
  
in  
  
Hamm

Quelle Dr. G. Dietrich

# High temperature TRISO-Energy in Germany

„Sicherer Einschluss“ des THTR 300, Hamm

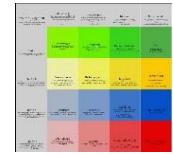
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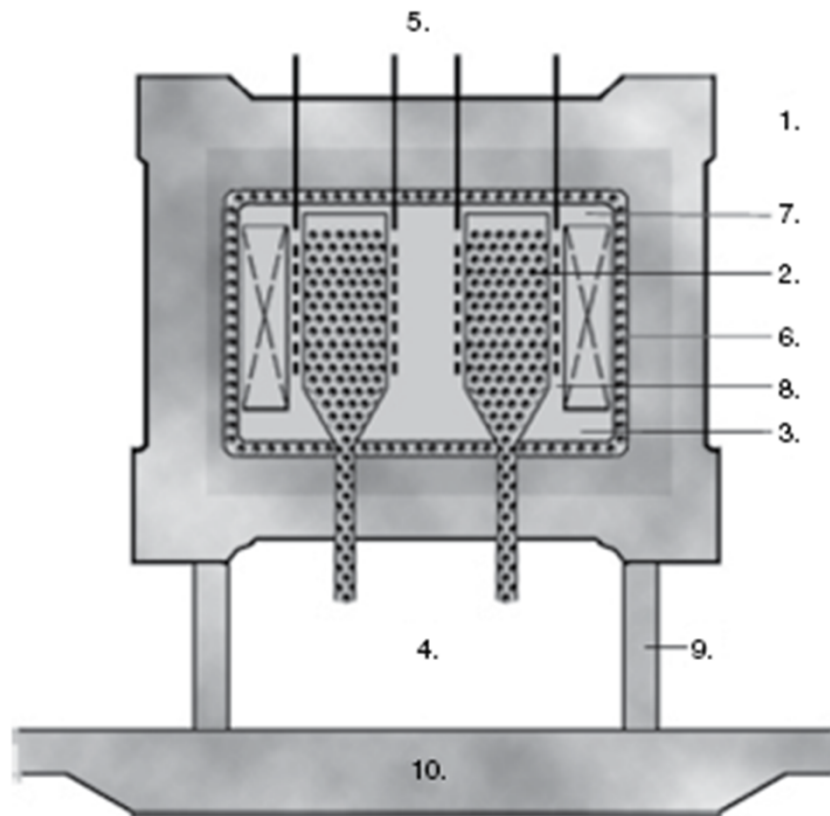
Q: Dr. Dietrich

# High temperature TRISO-Energy in Germany

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proposed ring-Core for 100+ MW

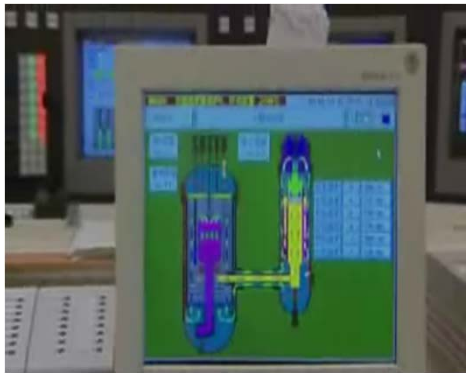
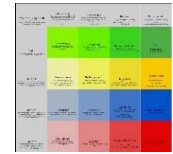


1. Prestressed concrete pressure vessel
2. Ring pebble bed reactor core
3. Graphite structure
4. Fuel chamber
5. Regulation and shutdown rods
6. Liner with insulation and water cooling system
7. Helium heat exchanger inlet
8. Helium heat exchanger outlet
9. Concrete support for prestressed pressure vessel and biological shield
10. Concrete foundation

Source: Dr. Urban Cleve ICAPP 2011

# High temperature TRISO-Energy in Germany

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2007 Scientific HTR- 10



2018 Demo in HTR-PM in China, Shidaowan

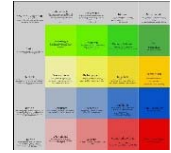


1960-ies: Origin in Juelich, Germany



1980-ies: Demo in Hamm



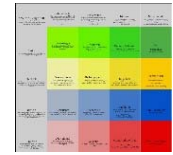


## Spiral of Silence

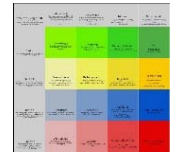
„let the Chinese go on“

# High temperature TRISO-Energy in Germany

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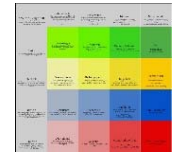
AVR –  
ruin  
in Jülich  
summer  
2020



# Status and prospects

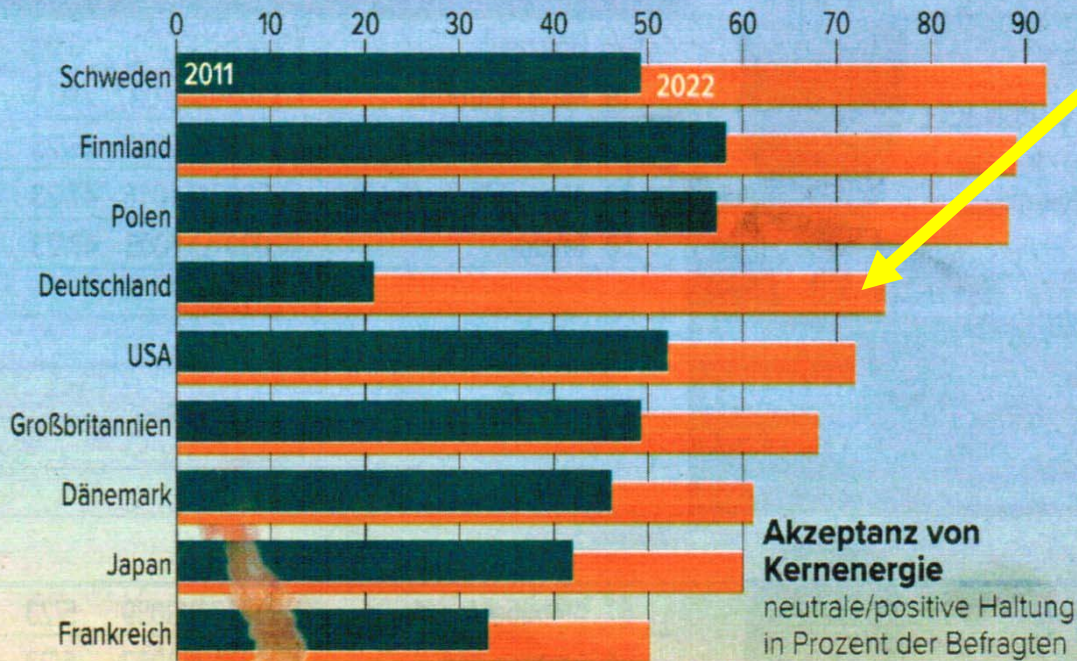
# High temperature TRISO-Energy in Germany

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## Kernenergie ist wieder hoffähig

Nach dem Reaktordesaster von Fukushima im März 2011 fiel die Akzeptanz für die Kernkraft stark ab. Ende 2022 zeigt sich ein ganz anderes Bild. Atomkraftwerke werden als nötig befunden, um aktuell den Strombedarf zu decken



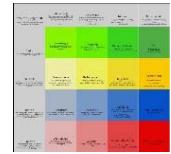
Germans have shaky relations.

Reason:  
probably lack  
of knowledge

Q: Focus Money 42/21 p. 56

# High temperature TRISO-Energy in Germany

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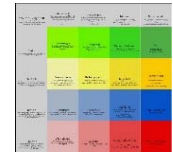


## German Media about China, 6. Dez. 2023

- largest windpowerplant 25.000 households
- ~~worldwide first TRISO pebblebed reactor in~~  
~~comercial operation~~ 250.000 households

Sc: Haferburg/EIKE

# High temperature TRISO-Energy in Germany



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## 1 – Home

**Umsteigen statt Aussteigen – Maß statt Extrem – Natur statt Mechanik – Naturgesetze statt Apparate – auffangen statt abprallen – heimisch statt Import – nachwachsend statt fossil – Besonnenheit statt Unbeweglichkeit – Ideen statt Weiterso – differenzieren statt Bauschundbogen – Kugelbettofen statt Atommeiler**

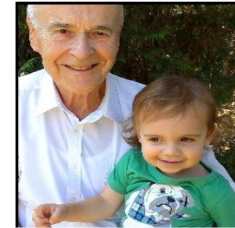
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Technik Die Kacheln rechts in dieser Zeile geben Einblicke zur Technik von konventionellen Designs und deren Voraussetzungen wieder	Generationen 1 bis IV, modular, Monoreaktor, Novoweltreaktor, HT-, PRISM, Terrapower, SMR, Elektrokatalysatoren, Temperaturs, Kugelbett	H-Temperatur Nichterschmelzende, Neutronenfang, Kugelbett, Molten /Oxy, flüssig, Heum, Taigehua, HTR-PM	Kugelbett Inhärente Sicherheit, negativer Temperaturkoeffizient, Gase, Pyrolyse, Kugeln, Graphit, Coated particles	Tec/Wirtsch Passwort erforderlich BIT - Dokument Wirtschaftlichkeits-Rechnung
Umfeld Die Bedingungen und die Umgebung der Kernenergie. Nutzung sind Gegenstand der Kacheln rechts - insbesondere das Ziel: "Bessere Mobilität"	Geschichte Politik, Events, Reaktionen, Atomassessing, NHV Begle-terung, GATIS zur Energie	Sicherheit Endlagerung, Wirtschaftlichkeit, Spallation, Transmutation,	Mobilität Fossil, Elektrisch, Gas, Biobrennstoffe, Hydro-erzeugung, Katalysatoren Außenland: Arbeits-, Schiffs-, Richte- teils passwortgeschützt	Um - geschützt mit PW erforderlich
Projekte Die roten Kacheln stellen konkrete Projekte dar, insbesondere zu Hochtemperatur - Kugelbett- Design im In- und Ausland	Deutschland Forschung, Politik, HTR, oeross konventionell, Ausstieg, Rückbau, Entsorgung	Ausland USA, Japan, Russland, Südafrika, andere Länder	China - Aktuell das Zentrum Vielzahl, Taigehua, Shidawan, HTR-PM	Proj - geschützt mit PW erforderlich

### ENERGIE FÜR ENKEL



#### EVENTS, VORTRÄGE, TREFFEN

- EV1 – Events
- EV2 – Vorträge
- EV3 – Treffen

#### EXPERTEN SAGEN:

- Kolumne1 – Dr. U. Cleve
- Kolumne2 – Dr. G. Dietrich
- Kolumne3 – Prof. Dr. J. Knorr
- Kolumne4 – ungenannt
- Kolumne5 – Prof. Dr. H. Bonnenberg

#### BÜCHER, BROSCHÜREN

- NEU – Energiewende – nun aber richtig!
- BioKernSprit - 4. Auflage 2019
- Buchliste

#### ARCHIV

- AR1 – Rundarchiv
- AR2 – China-Log – Fortschritt HTR-PM
- AR3 – Sammlung Dr. Cleve



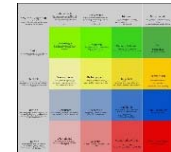
## Suchergebnisse für biokernsprit

Anzahl Treffer: 12

Treffer pro Seite: 15

Ändern

Suche verfeinern



### BioKernSprit

Synfuel aus Abfall, Holz und Kohle, klimaschonend erzeugt mit sicherer Wärme-, Energie- und Kraftwerktechnik  
AV Akademikerverlag (18.12.2019) - ISBN-13: 978-620-2-22627-1

45,00 €



### BioKernSprit Umsteigen statt Aussteigen!

Mobile Energie aus Biomasse mit GAU-freier Kernenergie

Technik  
Südwestdeutscher Verlag für Hochschulschriften (10.02.2011) - ISBN-13: 978-3-8381-2248-9

98,00 €



### BioKernSprit. Synopaliwo z odpadów, drewna i węgla

Przyjazne dla klimatu wytwarzanie bezpiecznej energii jądrowej  
Wärme-, Energie- und Kraftwerktechnik  
Wydawnictwo Bezkresy Wiedzy (12.06.2020) - ISBN-13: 978-620-2-44694-5

45,00 €



### Biokernsprit -Trilogie - Zweiter Teil "Kern"

Mobile Energie aus Biomasse mit GAU-freier Kernenergie

Sonstige  
AV Akademikerverlag (28.02.2012) - ISBN-13: 978-3-639-38942-5

45,95 €



### BioKernSprit - Trilogie - Dritter Teil "Sprit"

Mobile Energie aus Bioabfall mit GAU-freier Kernenergie  
Fahrzeuge, Flugzeuge, Schiffe, Raumfahrt  
AV Akademikerverlag (12.03.2013) - ISBN-13: 978-3-639-45858-9

38,90 €



### BioKernSprit - Trilogie - Erster Teil "Biomasse"

Mobile Energie aus Biomasse mit GAU-freier Kernenergie

Wärme-, Energie- und Kraftwerktechnik  
Südwestdeutscher Verlag für Hochschulschriften (29.09.2011) - ISBN-13: 978-3-8381-2458-2

45,00 €



### BioKernSprit. Synfuel from waste, wood and coal

produced in a climate-friendly way with safe nuclear energy  
Wärme-, Energie- und Kraftwerktechnik  
LAP LAMBERT Academic Publishing (05.03.2020) - ISBN-13: 978-620-0-55013-2

45,00 €



### BioKernSprit: Brandstof uit afval, hout en kolen

Klimaatvriendelijke opwekking met veilige kernenergie

Wärme-, Energie- und Kraftwerktechnik  
GlobeEdit (04.05.2020) - ISBN-13: 978-613-9-42166-4

45,00 €



### BioKernSprit. Synfuel a partir de resíduos, madeira e carvão

produzidos de forma ecológica com energia nuclear segura  
Wärme-, Energie- und Kraftwerktechnik  
Novas Edições Acadêmicas (09.04.2020)

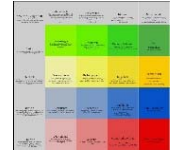


### BioKernSprit. Sifuel da rifiuti, legno e carbone

Generazione rispettosa del clima con energia nucleare sicura  
Wärme-, Energie- und Kraftwerktechnik  
Edizioni Accademiche Italiane (04.03.2020)

# High temperature TRISO-Energy in Germany

Gaufrei.de

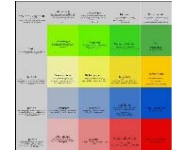


## My View:

HTR-PM current leader  
in worldwide SMRs

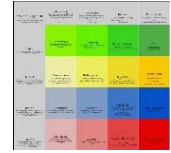
# High temperature TRISO-Energy in Germany

Gaufrei.de



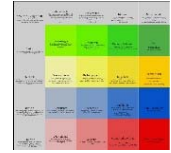
Typ des Reaktors	Information von:	Ideen und Vorschläge	Konzepte und Designs	Projekte in Forschung	In Entwicklung	Forschungs-R. in Betrieb	Betrieb beendet	Demo-R. Im Bau	Demo-R. Im Betrieb	Betrieb beendet	Kommerz.-R. Im Bau, bzw. Betrieb	(Progn.) Datum kommerz. Betr.	Bemerkungen
HTR-PM	JKM											Ende 2021	Demoexemplar mit Strahlungsüberwachung
HTR-10	JKM											2007	Forschung in der Tsinghua-Universität
THTR 300	JKM											1988	Seit 1990 sicherer Einschluss
AVR	JKM											nicht vorgesehen	Seit 1990 Betrieb abgeschlossen
EBR II												keine Angabe	kein Betrieb mehr
X-Energy												ca. 2025	
Rolls-Royce												keine Angabe	
Aurora von Oklo												keine Angabe	
Dual Fluid Reactor												ca. 2042	von Dr. Wendland geschätzt
Copenhagen Atomics												keine Angabe	
NUScale												keine Angabe	
Terrapower												ca. 2025	
Kairos												keine Angabe	
USNC Micro Mod. Reactor												keine Angabe	
PRISM												keine Angabe	
General Electric/Hitachi												keine Angabe	
Pele Micro Reactor ( DOD)												keine Angabe	
Marvel (DOE)												keine Angabe	
DOME Test Bed NRIC												keine Angabe	
Lotus Test Bed NRIC												keine Angabe	nat. React. Innov. Centr.
HWMSR												keine Angabe	Schwerwasser moderiert
ACP 100 China													

Various SMR in  
research and  
development  
worldwide.  
**TRISO HTR-PM  
is first**



## Market niche, because:

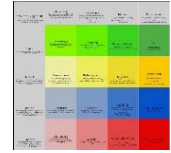
- Industrial heat (800+°C)
- 80 GW power needed in EU)
- for chemical use, e. g. :
  - hydrogen
  - motor fuel and many more
- Electricity a byproduct
- Ideal for threshold countries (personnel)



## Proposal one: replace fossil ovens by HTR- ovens

# High temperature TRISO-Energy in Germany

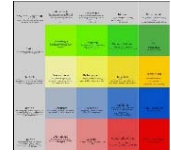
Gaufrei.de



**Today: fossil, 462 locat. 69 GWe**  
**nonfoss. 947 locat. +165 GWe**  
**=1.409 locat. 235 MWe**  
**Req'd investment ca. 600 Bil. USD**

## Proposal :

**NPP modular: 1.060 locat, 84.5 GWe**  
**Req'd investment ca. 300 Bil. USD**



## Proposal two:

### **E-fuel by Fischer Tropsch**

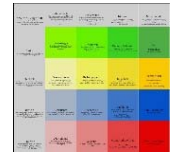
**1 bil. Liter Ethanol p.a.**

2,5 % of German consumption per year

total is 40 bil. Liter per year)

# High temperature TRISO-Energy in Germany

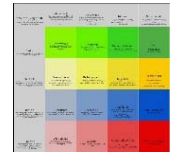
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Product of Bergius – Pier process about 1926

# High temperature TRISO-Energy in Germany

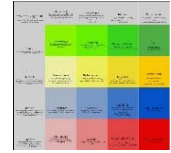
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fuel- distill in Leuna 1959

# High temperature TRISO-Energy in Germany

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## **available Input:**

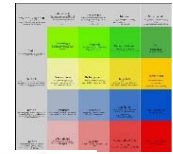
Bio-waste, Wood-waste, CO<sub>2</sub>, Gichtgas, Plastic-waste, hard-coal, lignite-coal

## **Ouput e.g.:**

**Ethanol from wood-waste**

# High temperature TRISO-Energy in Germany

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## Energiewende - nun aber richtig



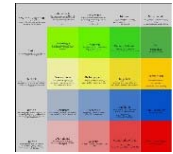
Wie der Kugelbett-Ofen die Energiewende doch noch zum Erfolg machen kann

Wärme-, Energie- und Kraftwerktechnik

AV Akademikerverlag (17.06.2020) - ISBN-13:  
978-620-2-22575-5

39,90 €

# High temperature TRISO-Energy in Germany



Gaufrei.de  
**Bücher**

## „Biokernsprit“

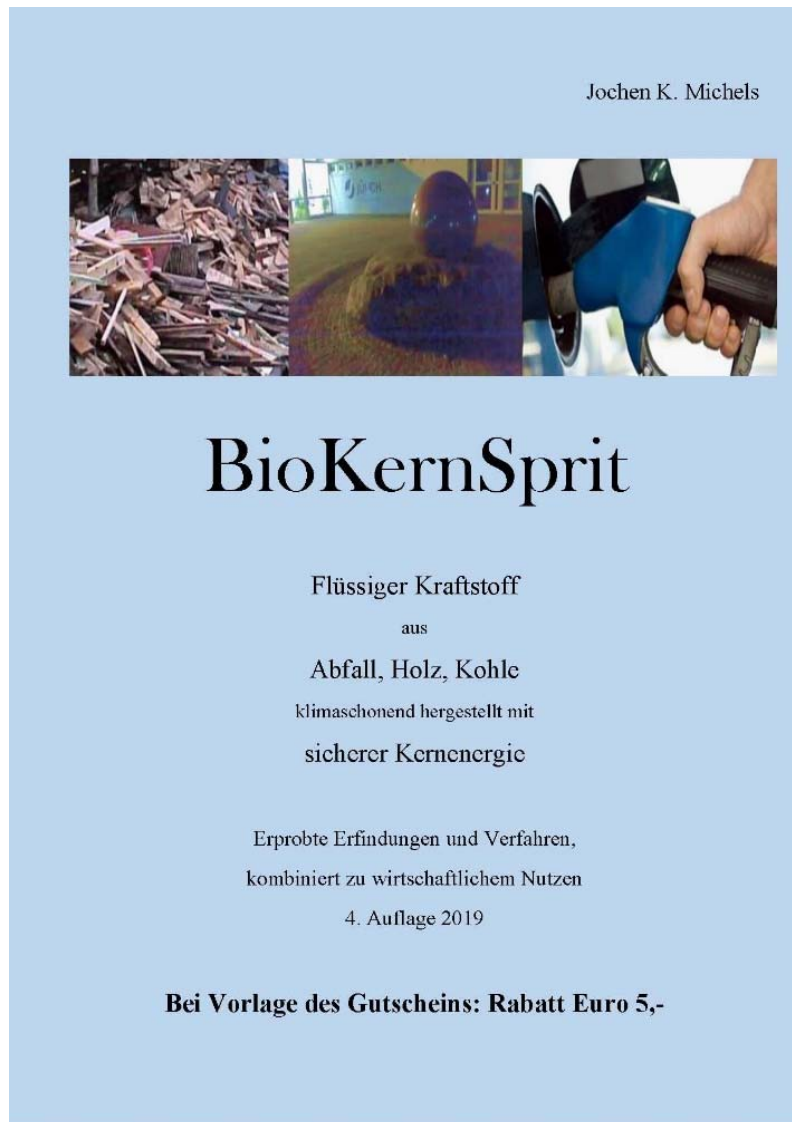
4. Auflage

Papierbuch (€ 45,00)

Streamingbuch (€ 29,99)

Kurzbuch Papier (€ 6,99)

Kurzbuch-ebook (€ 3,99)



Auswahl auf:  
[www.gaufrei.de](http://www.gaufrei.de)