RENA Technologies GmbH

The Path to Smooth TOPCon Scaling: Proven Wet-Processing Solutions from Wafer to Cell

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Dr. D. Brunner, A.Pediaditakis, B. Straub, Dr. Eljaouhari,F. Dorn, M. Passig, C. Scheiwe,

J. Vollmer, T. Dannenberg, P. Schmid, M. Weber, M. Kamp, M. Vees, Dr. Kuehnlein

Katrin Krieg, Mert Isik, Dr. Martin Zimmer (Fraunhofer ISE)

R. Kopecek, F. Buchholz, T. Kolleck, L. Koduvelikulathu, et al. (ISC)

H. Lignier, C. Roux, L. Bounaas, W. Favre (CEA INES)

U. Baumann, V. Mertens, T. Dullweber

State of the art

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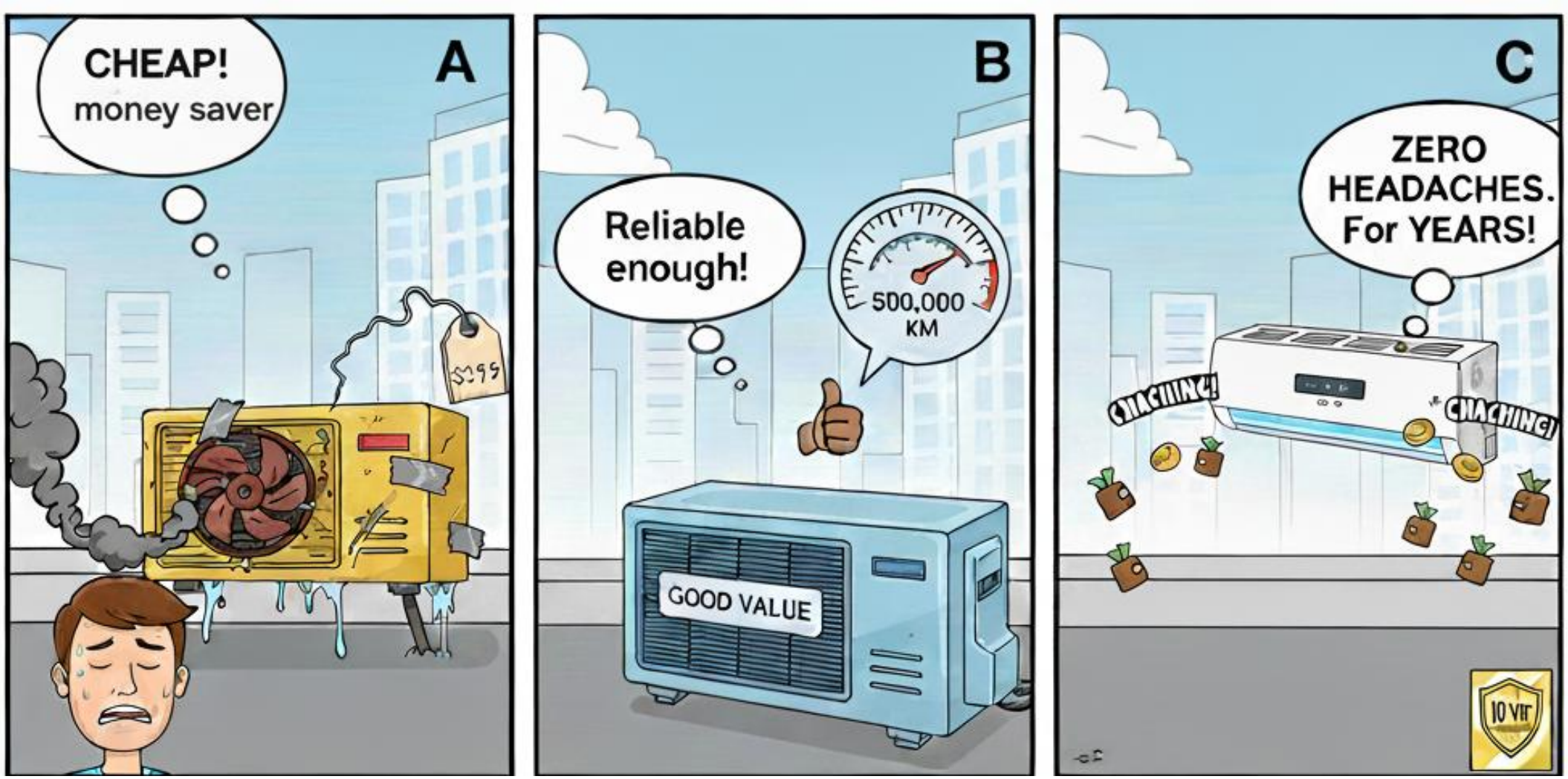
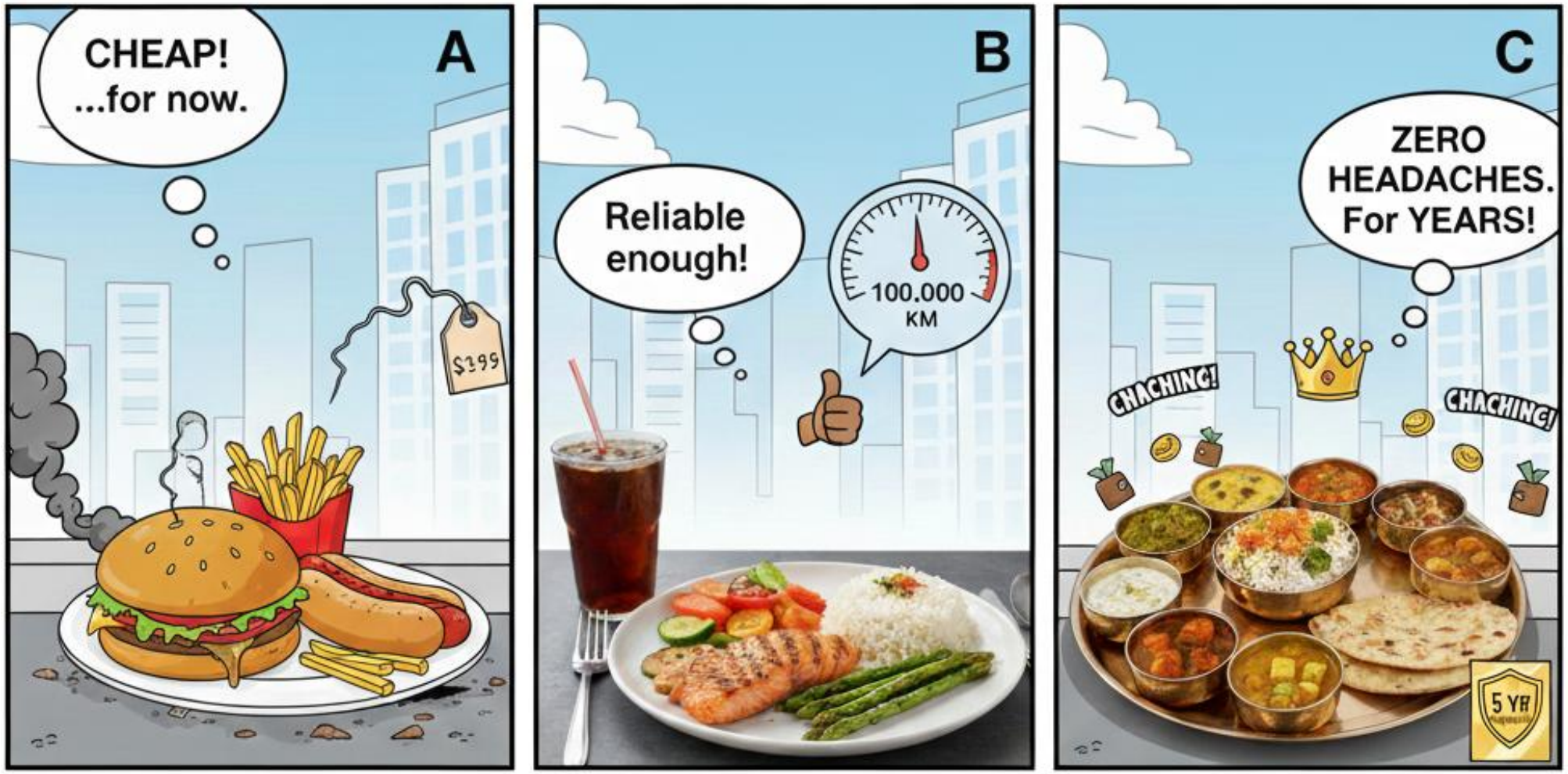
BEST
5G PHONES
UNDER
40K

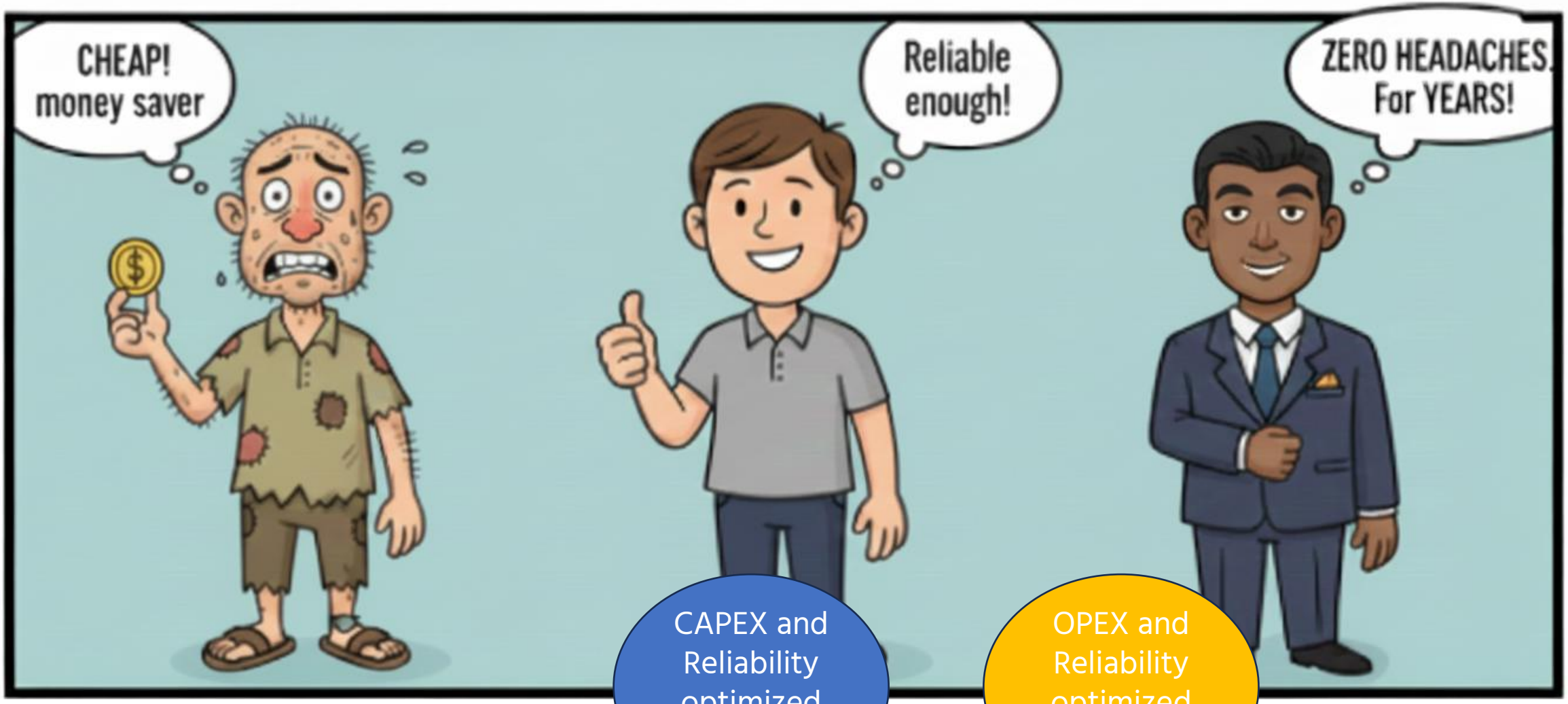

SAMSUNG

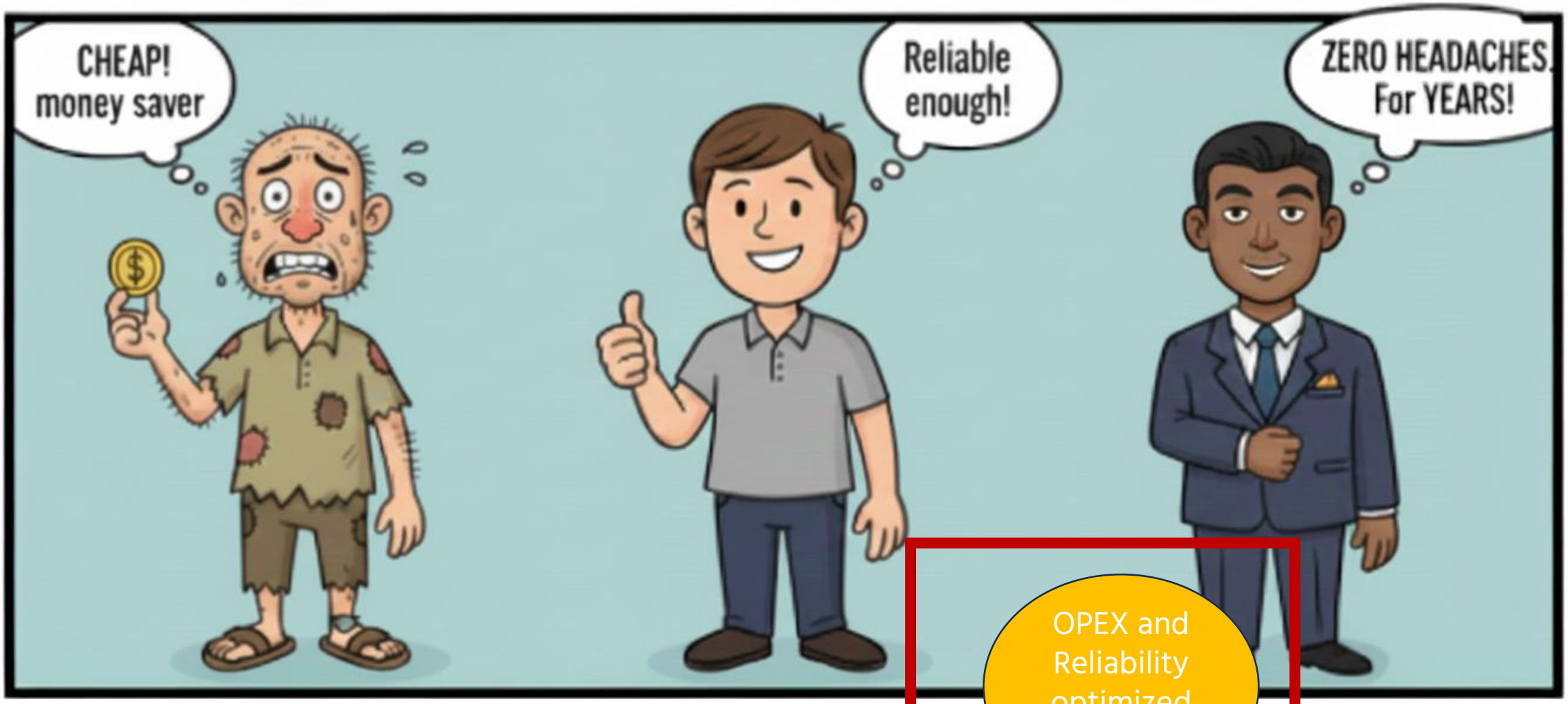
What kind of an AC do you apply at home?




$595
B
GOOD VALUE
C
PREMIUM


A
CHEAP!
...for now.
$199
B
Reliable enough!
100.000 KM
C
ZERO HEADACHES. For YEARS!
CHACHING!
CHACHING!
5 YR


CHEAP!
money saver
Reliable
enough!
ZERO HEADACHES
For YEARS!
CAPEX and
Reliability
optimized
Solution
OPEX and
Reliability
optimized
Solution



OPEX and Reliability optimized Solution

State of the art

OPEX and reliability optimized Solution

NEW: InEtchSide 4/4+

- 12/14-lane Inline Single Side Glass/Oxide Etching tool length 4.8m
- RFL (RENA Functional Layer = water capping) for optical yield improvement & front-side protection (freedom to operate)
- 17500 w/h proven in production (14 lanes)*

Batch 3 N600

- Batch-type tools for **texturing**, **edge iso, poly-wrap**
- Process based on O3 pre-clean & O3 post-clean
- Water saving of 50 % guaranteed

OPEX optimzed Line

* Proven on a 12 lane tool

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RENA Consumable savings

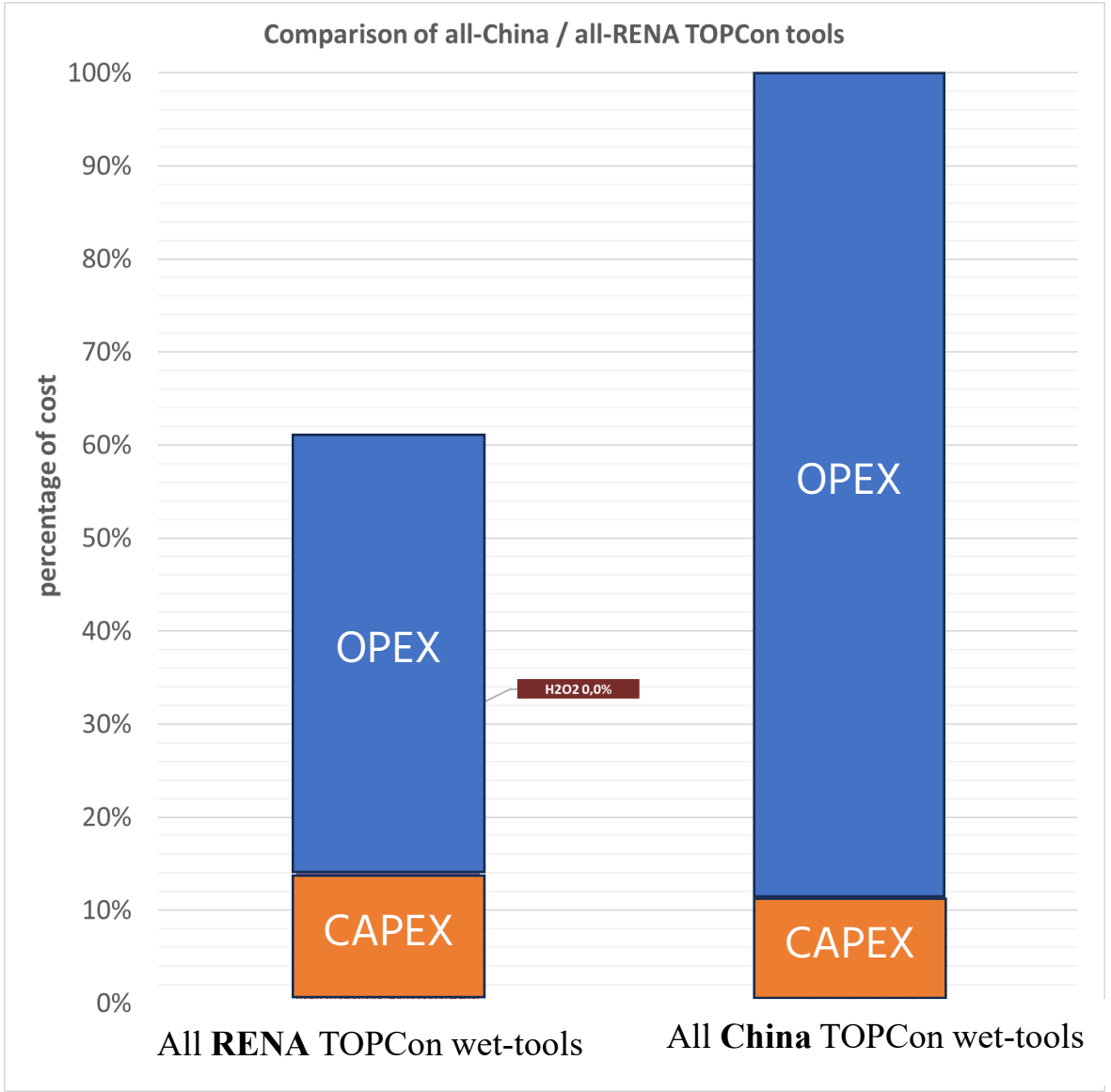
Optimization of machine design for sustainable savings of consumables

Chemistry
- Reduction of chemical and waste accordingly

Electricity
- Heat recycling: usage of waste heat from thermal processes for DI-Water heating

Waste and Water
- RENA saving technology

-> Savings in OpEx
-> Positive impact on facility cost!



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Smart cleaning with Ozone

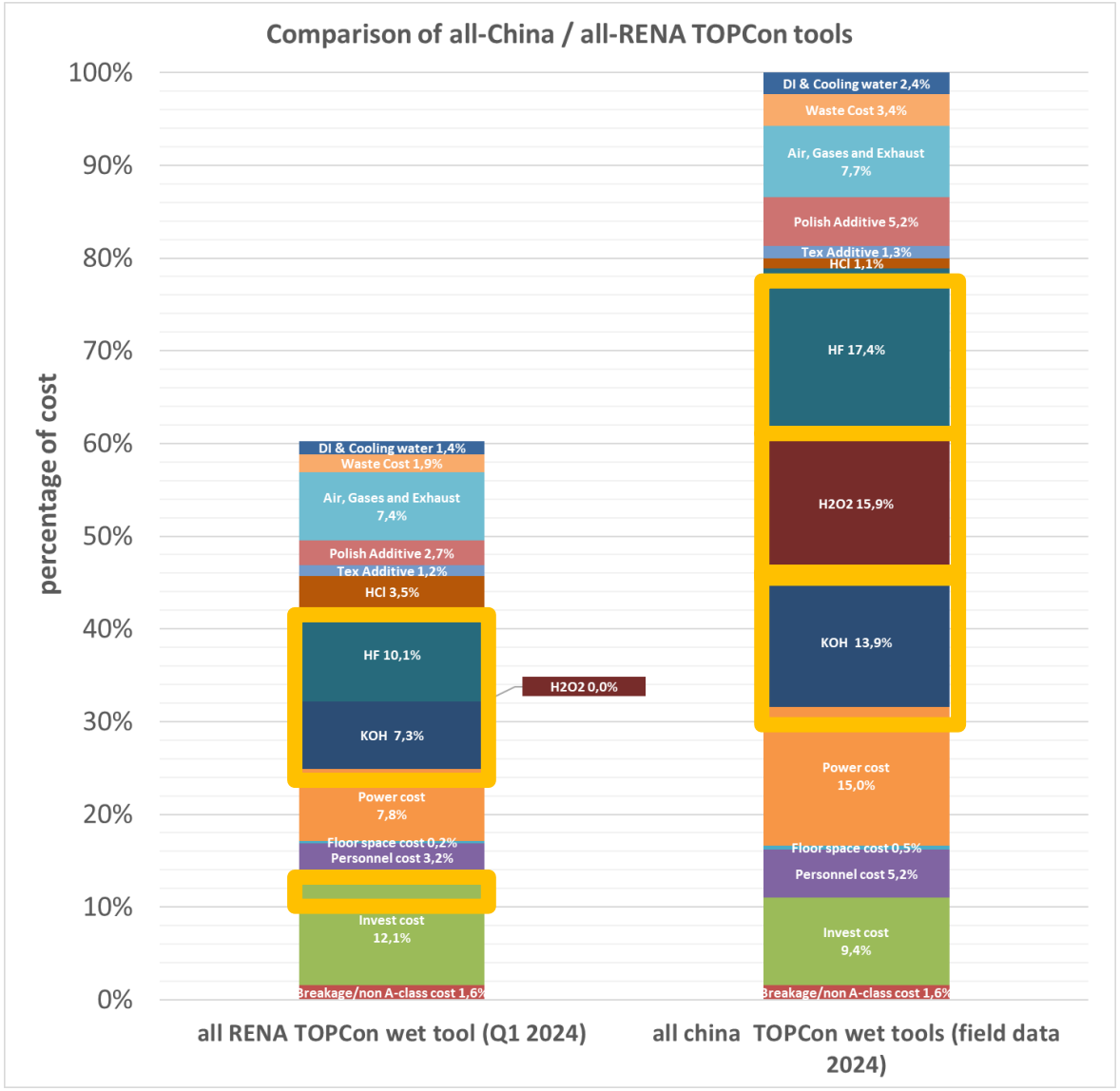
- Very important factor since its applied in
  - Texture
  - Edge isolation
  - Poly wrap around etch

➢ No. of cleans: RENA: 7-O_3 || China: 8-pSC1

- Standard cleaning in China is pSC1
  - KOH and H_2O_2
  - Leads to increase HF consumption

- Ozone clean performs on same level
  - Increased CAPEX
  - Negligible running cost (power, O2)
  - No waste
  - Reduced KOH & HF consumption

- ***Reduction of waste, chemistry usage***
- ***Reduction of OPEX***



O3 vs. pSC1 ← RCA (SC1 + SC2)

- O3/DI-based cleaning:
  - Superior to a full RCA in terms of Performance

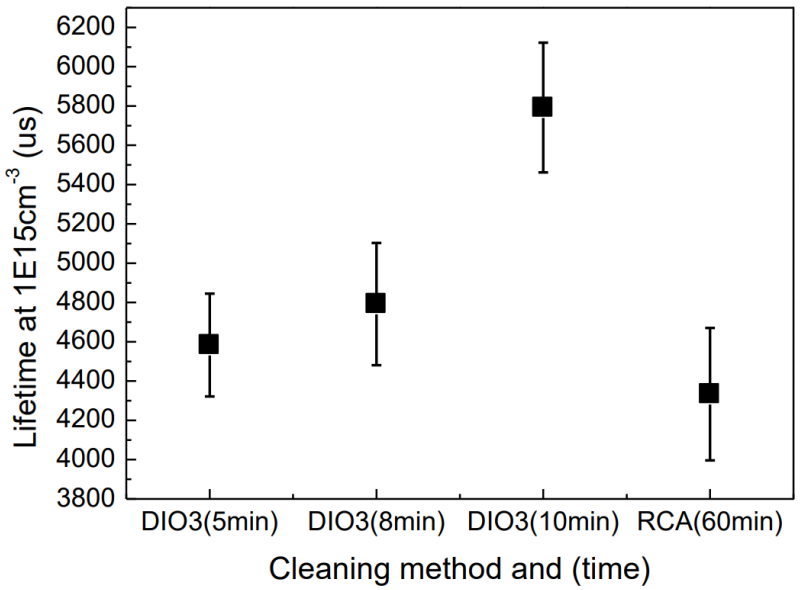
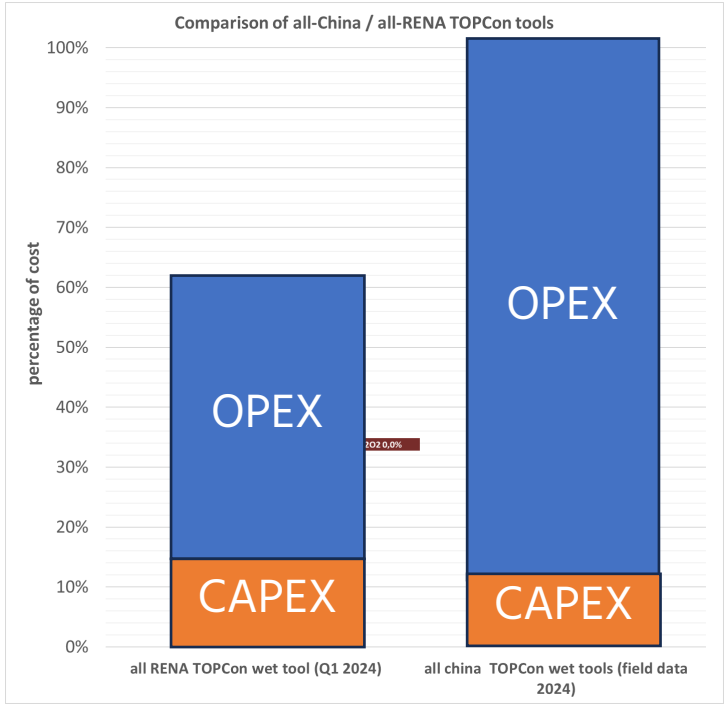


Figure 1: Effective lifetime of wafers with different cleaning time using DIO_3/HF/HCl and RCA solution.

- O3/DI-based cleaning:
  - Basis for advantages in CoO => up to 40% savings



[8 Zhonglan LI et al, HIGH-LIFETIME WAFER CLEANING METHOD USING OZONE DISSOLVED IN DIW/HF/HCL SOLUTION September 2014 - Conference: EUPVSEC 201

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Water Saving now and beyond – RENA Roadmap

No Watersaving:

- **0%** *RENA TOPCon machines with no upgrades.

Watersaving 1.0 (available today)

- **25%** less water*
  Upgrades for existing tools possible!

Watersaving 2.0 (coming soon)

- **50%** less water*
  New RENA-Tools by 2026.

Watersaving 3.0.

- **70%** less water*
  Outlook into the future.

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RENA is saving resources

Water

- RENA Water saving technology
- Less waste-water

Electricity

- Heat recycling: usage of waste heat from thermal processes for DI-Water heating

Chemistry

- No H2O2
- Less KOH and HF

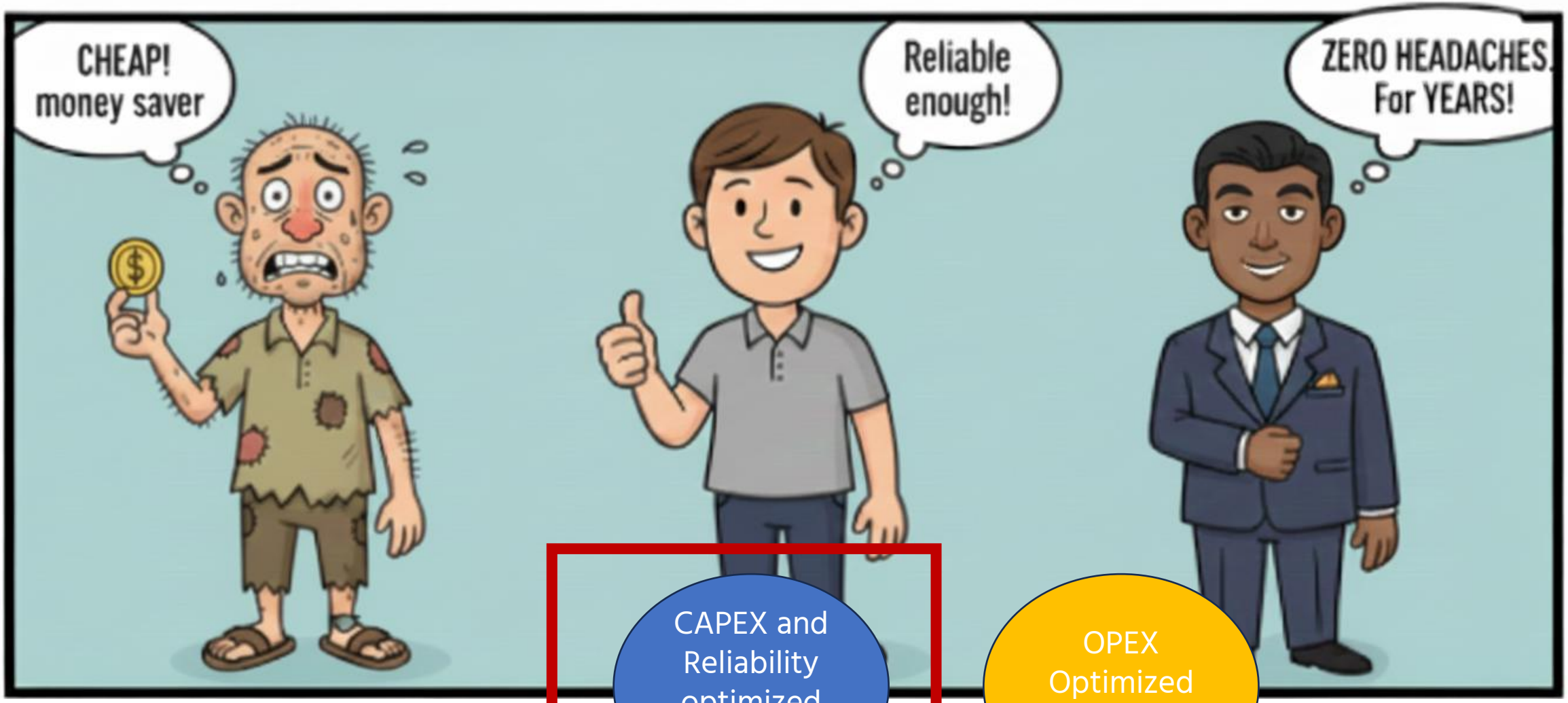
Waste

- Less waste treatment with the reduction of chemicals

The RENA Team optimized the machine design for sustainable savings of consumables, water, electricity and waste!

-> Positive impact on environment and facility cost!

Is your company rich enough... to afford *cheap* things?



Capex and reliability optimized Solution

Capex and reliability optimized Solution

OPEX-Optimized Solution

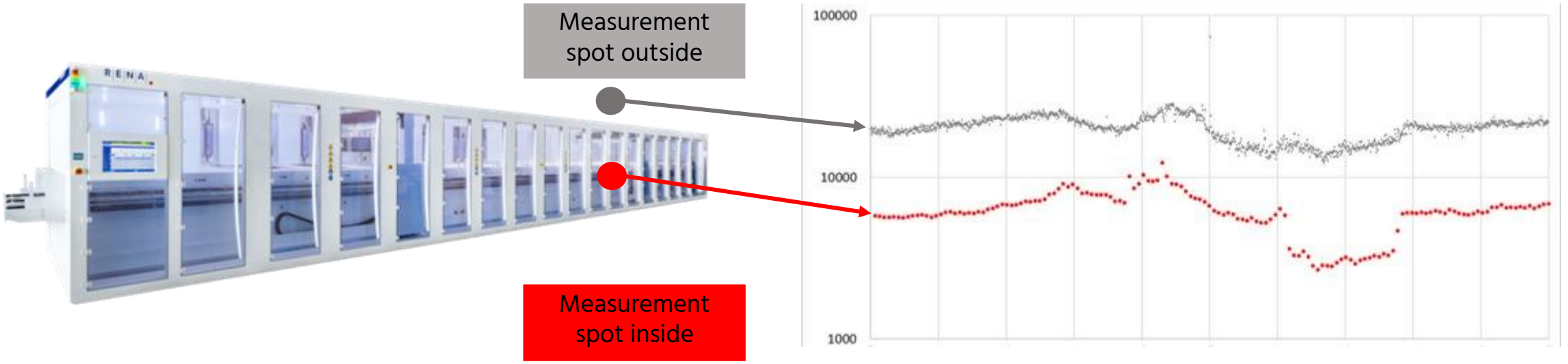
- **Production proven O3-Cleaning process**
  (RENA introduced O3-Cleaning already 20 years ago)
- **No H2O2-usage**
  (available on request for pSC1-process)
- **Low KOH-consumption**
  (no pSC1-process)
- **RENA Watersaving Technology**
  (up to 50% compared to competition)
- **Low Energy consumption**
  (Less KOH- and no pSC1-baths leads to less heating)
- **Reduced waste treatment cost**
  (no H2O2, less KOH, less water, ...)
- **Small footprint**
  (saves expensive clean-room space)

CAPEX-Optimized Solution

- **Mainstream pSC1-process**
  (H2O2 included)
- **No O3-Cleaning processes**
  (no O3-Generators for reduced CAPEX)
- **Comparable OPEX to competitors**
  (similar process parameter)
- **Watersaving Technology**
  (optionally available)
- **Further reduced footprint**
  (approx. 2 sqm)

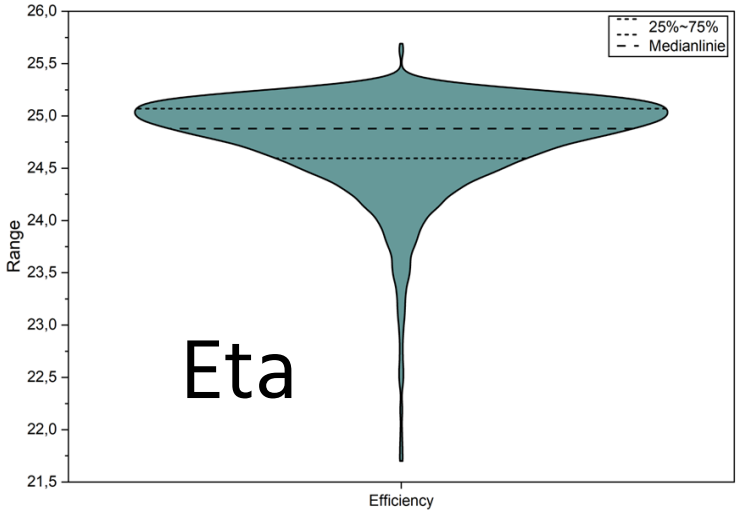
Proven tools and performance TOPCON - Ramp up data

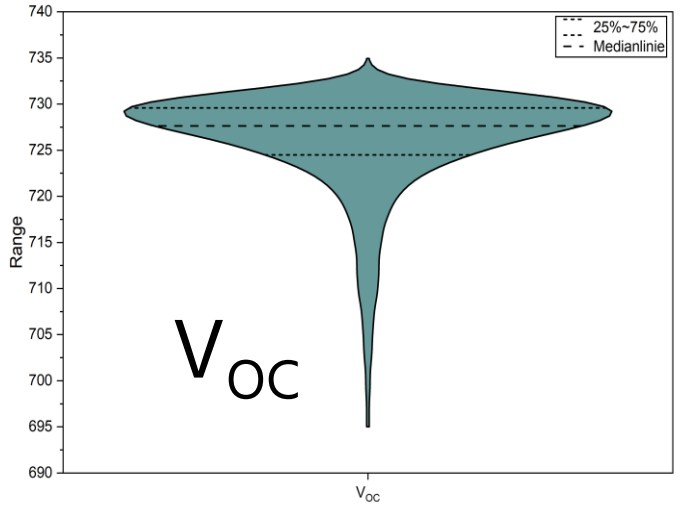
Effective Particle Management

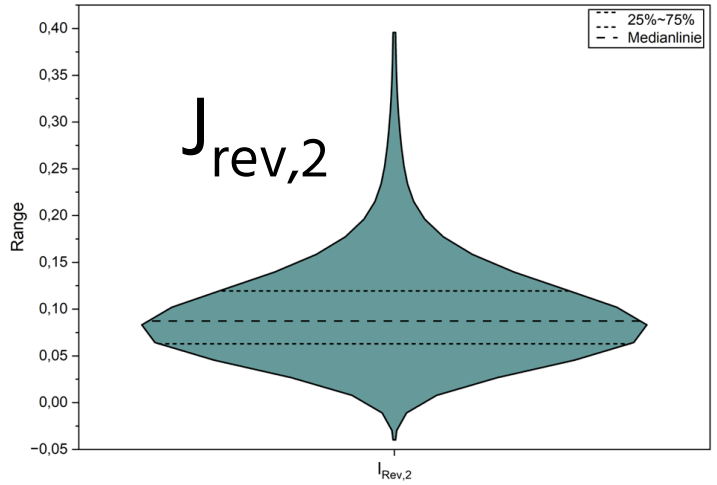


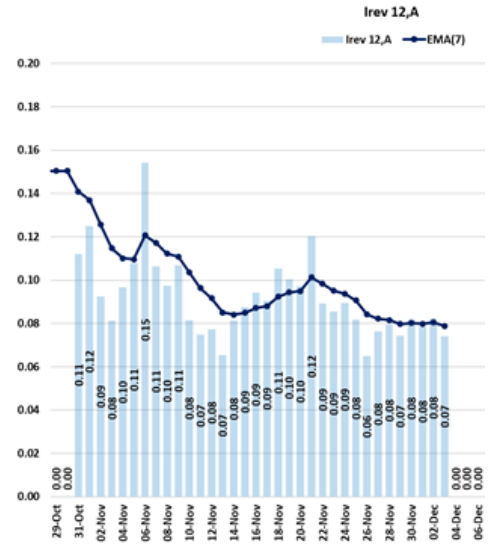
- Up to 3-times lower particle load inside RENA BatchTool
- Proof for effective particle management inside
- V_{oc}>735mV values can be reached after 2 month of 1st cell out (depending in clean room, and entire line)

- $V_{OC,max}$ > 735 mV
- Efficiency,max > 25.5%
- $I_{Rev,2}$ on very low level









Future-Proof Investment: Technology Roadmap

2024-2027

TOPCon

Peak production years

2027-2028

Transition

IBC preparation phase

2028+

IBC/TBC

Next-gen technology

80-90% Equipment Reusability for IBC Technology

Your RENA investment is not just for TOPCon's 3-4 year lifecycle.
When IBC becomes mainstream, most equipment transitions – minimizing additional CAPEX.
Chinese suppliers: Equipment often requires full replacement for technology transitions.

Chinese Supplier Approach

Buy cheap now → Replace entirely for IBC → Pay twice
Will China support you for re-use of tools?

RENA Approach

Invest in quality now → Reuse 80-90% for IBC → Pay once
Full support by RENA for conversion from TOPCon to IBC

Solar-Wafering Solutions

SOLAR WAFER PROCESS STEPS
AND CORRESPONDING PARTNER NETWORK

Graphic by:
Fraunhofer ISE

PVA TePla
Crystal Growing Systems

Potential Partner for Crucibles (from Vietnam)
RAAMS AS

Poly-Silicon

Cz ingot
Cz ingot growth
IngotFab

Ingot cropping
Brick squaring
Grinding/Polishing
BrickFab

Power
Water
Cooling
Warehouse
Services
Utilities and Services

Crucible filling
Reclaim Si
Crushing
Offcuts
Si Reclaim & Si Handling

R|E|N|A

Wafer slicing
Wafer cleaning
Quality control
WaferingFab

LAPMASTER WOLTERS

R|E|N|A

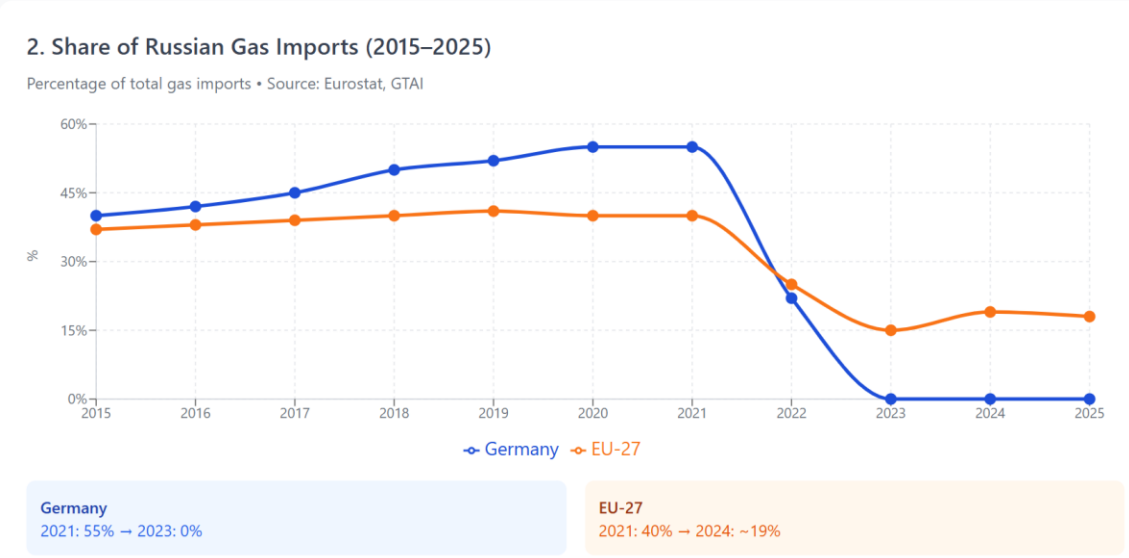
Wafer

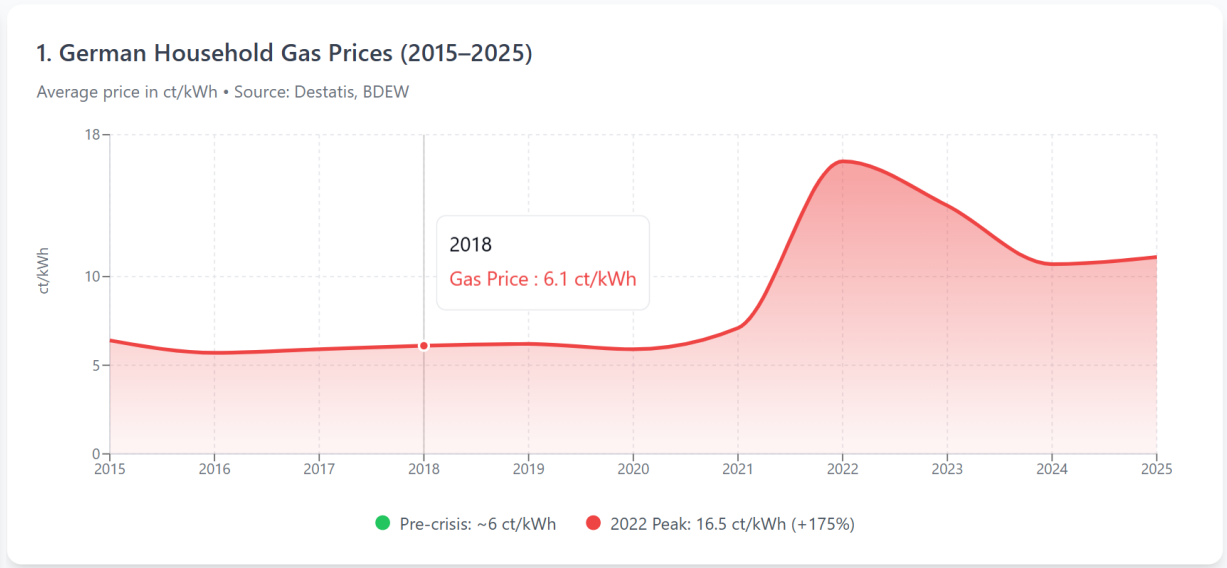
Summary

Summary

- ✓Tools running in production (TOPCon running in India & USA)
- ✓Fast ramp-up time
- ✓Proven for V_{oc}>735mV and efficiencies >25%
- ✓Lowest CoO due to DI/O3 (>15 years of experience)
- ✓NEW: CAPEX optimized alternative
- ✓80 to 100% of the tool can be reused in an IBC line
- ✓Waste and water saving

➢ RENA is ready for smooth TOPCon scaling





- Smart people learn from there mistakes
- VERY smart people learn from mistakes of others

Preserve a second source of:

- Tools
- Innovation
- Competition

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Thank you for your attention

RENA Technologies – your reliable partner

SEVERAL SEGMENTS

- Semiconductor
- Green Energy
- Wafering
- Glass & Advanced Packaging
- MedTech
- Additive Manufacturing

EXTENSIVE EXPERIENCE

- 1993 Foundation of RENA
- Headquarters Gütenbach, Germany
- ~ 1.100 Machines installed

POWERFUL PRODUCTION

- Technology Leader in Wet Process Equipment
- 25,000 sqm Manufacturing Floorspace
- ~ 1.000 Employees

AVAILABILITY ACROSS-THE-GLOBE

- Engineering & manufacturing
- Research & Development
- Sales & service centers
- Representative offices

www.rena.com

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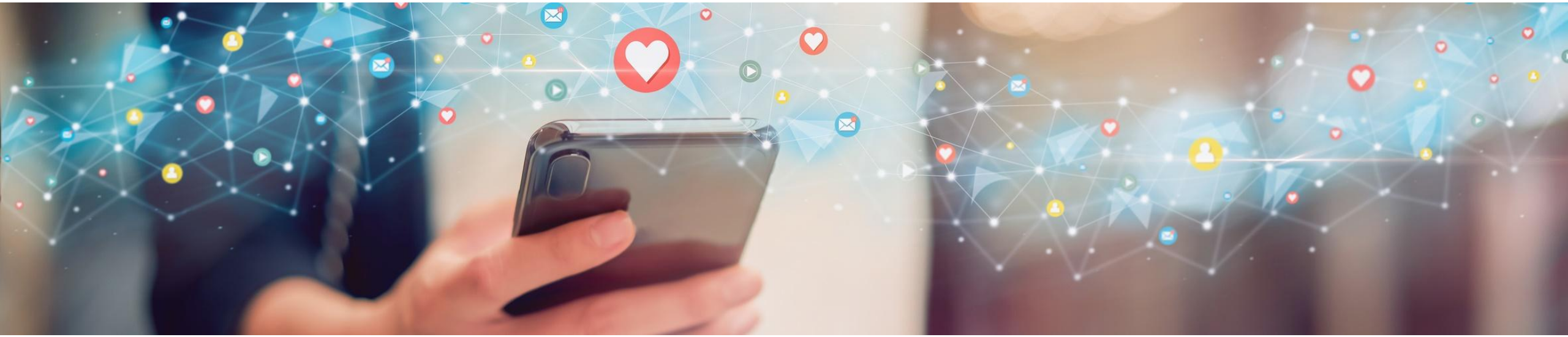
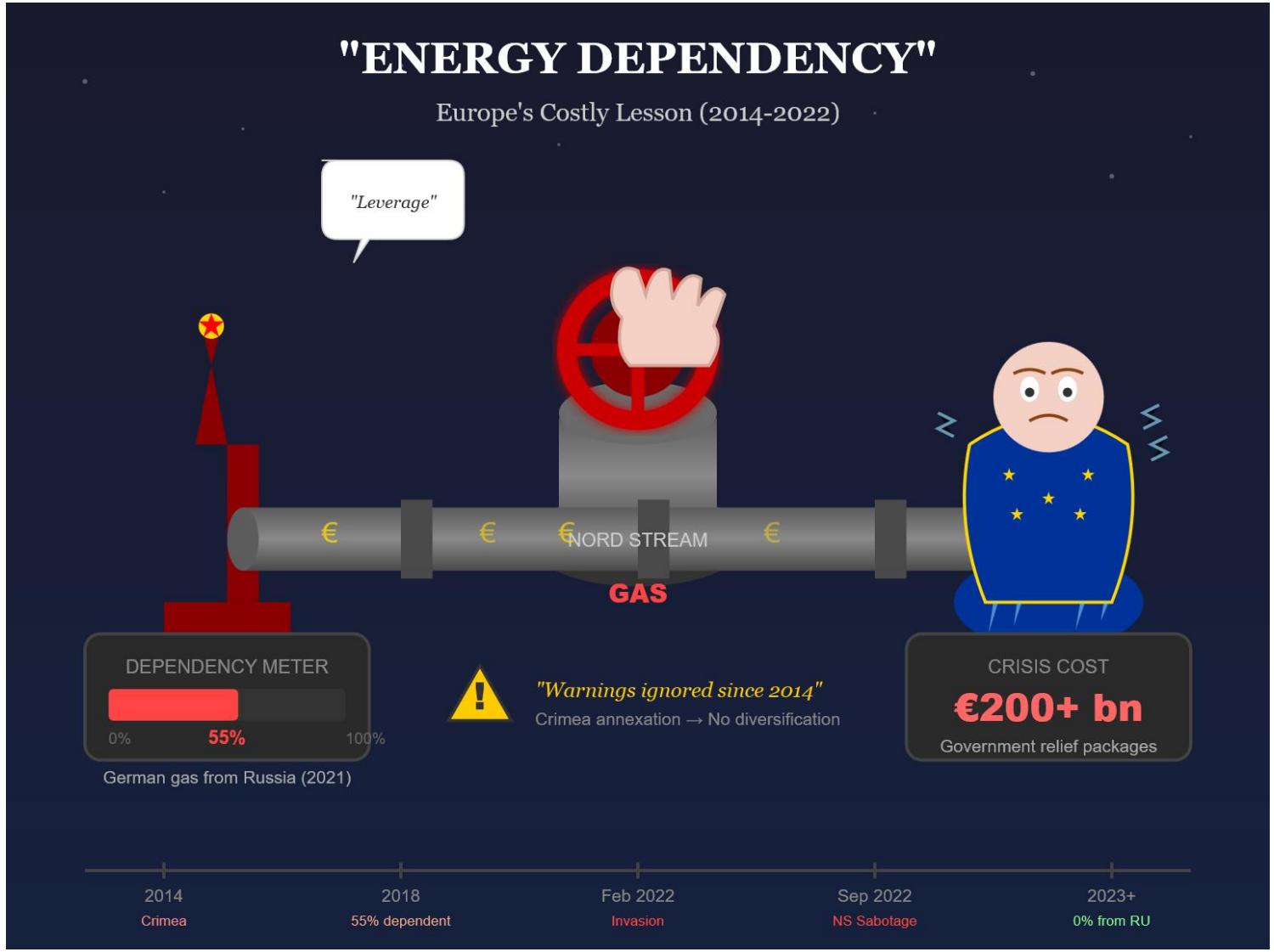
RENA Social Media



Why should we treat a multimillion-dollar factory differently than our private life?



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Preserve a second source of:

- Tools
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Can your production line afford to be 'Type A or B'? Can you afford a machine that is 'good enough' initially, but takes a 'holiday' (breakdown) once a month?

Are you rich enough… to afford *cheap* things?

Why should we treat a multimillion-dollar factory differently than our private life?

"Who among you loves their mechanic so much that they'd like to have him visit every month?"

Low Capex is nice low OPEX keeps you in business

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