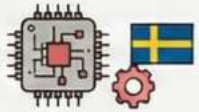
HVDC History
Technology/Leadership

Ludvika Februari 2026

The Power Path: Bo Normark's 38-Year Career at Asea and ABB

Bo Normark dedicated nearly four decades (1971–2009) to Asea and its successor, ABB, becoming a pivotal figure in the power systems sector. His career tracks an evolution from technical development to global executive leadership.

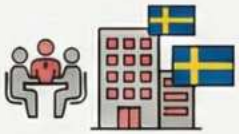
1971–1981: Technical Foundations and Early Management



1971 – 1974
Development Engineer
Focused on control, protection, and semiconductor valves for HVDC and FACTS at Asea Sweden.



1975 – 1978
Lead Engineer, CU 1000MW HVDC Project
Spearheaded control and protection for a major 1000MW project based in the United States.



1978 – 1981
Manager, HVDC Contral and Protection Division
Stepped into his first divisional management role at Asea Sweden.

1982–1990: Escalating Managerial Responsibility



1982 – 1987: Scaling the HVDC Division
Managed the HVDC Division at Axea Sweden, overseeing 350 employees and $100 million in revenue.



1988 – 1990: Transition to Global Manager
Following the formation of ABB, he become Global Manager for HVDC operations, leading 500 employees and $150 million in revenue.

1991–2001: Presidential and Global Business Leadership



1991 – 2000:
Company President, ABB Power Systems AB
Served as President for the HVDC and FACTS business unit, maintaining a team of 500 with $150 million in revenue.



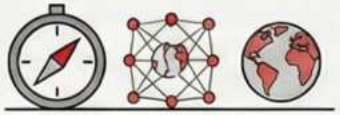
1996 – 2001:
Global Business Area Manager
Reached a massive scale of operations for ABB Power Systems, managing 3,000 employees and $700 million in revenue.



2001–2009: Executive Strategy and Group Vice Presidency



2001 – 2005:
Group Vice President, Business Development
Based in Zurich, Switzerland, focusing on Group-level business development for Power Systems.



2005 – 2009:
Senior Vice President, ABB Grid Systems
Concluded his 38-year tenure with global responsibility for Strategy and Market within the Grid Systems division.

NotebookLM

Uno Lamm, "The Father of HVDC"



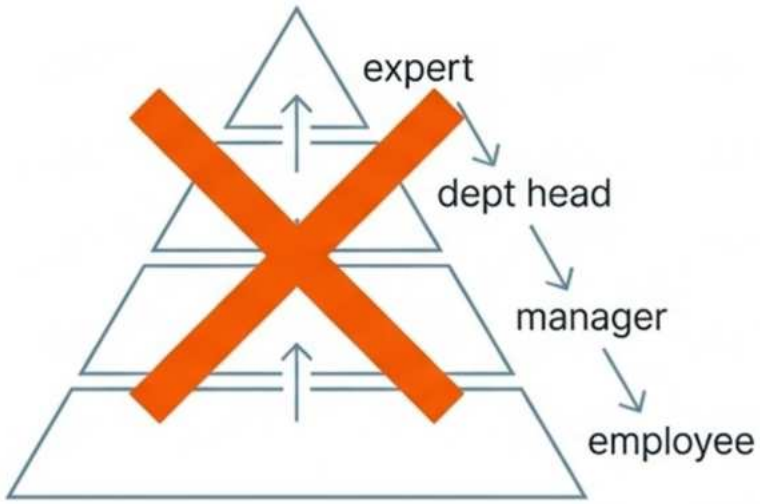
Uno Lamm's legacy, has been crucial in the working life of many of those who, through the years, have worked in the HVDC field after Uno Lamm. Characteristics are:

- The ability to "look into the future"
- Focus on the ultimate usefulness
- Work inclusively with people from other environments
- Embracing new technologies
- Seek strategic collaborations

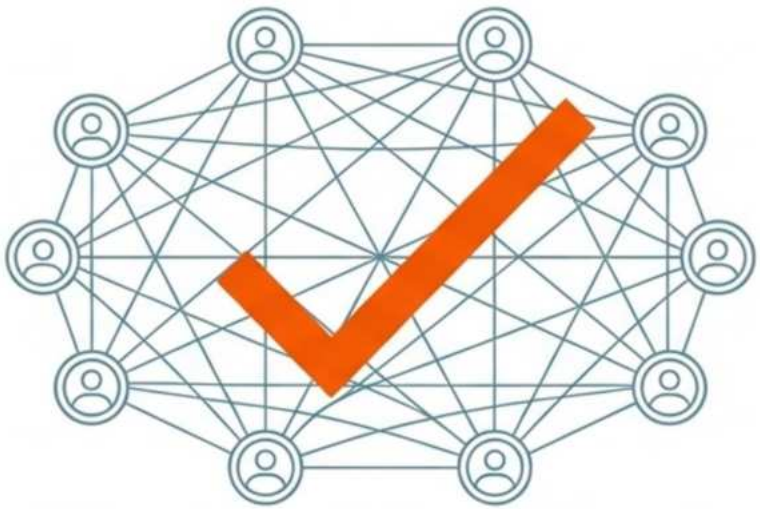
Uno Lamm’s Leadership Legacy

Leadership principle	Practical manifestation	Key quote / concept
Vision-led, market-creating strategy	Sustained R&D for over 20 years by selling the future value of HVDC before the product was ready.	”The world can live without HVDC, but it becomes better with HVDC."
Intrapreneurial culture	Fostered psychological safety where initiative was rewarded over passivity; provided discretionary R&D budgets.	"Initiative is encouraged, even if it does not always turn out right."
Pragmatic execution	Delivered the Gotland project using "Good Enough" technology to gain market entry and real-world experience.	"Good Enough"
Ecosystem building	Licensed core technology to competitors (English Electric, GE) to legitimize the market and build trust.	"Created a competitor… and sparked the first lift in the market."
Values-driven leadership	Actively opposed Nazism; recruited talents such as Dr. Uhlmann based on merit and principles.	Rooted in "the equal value of all people."

HVDC, project driven organization..



The Corporate Chain



The Ludvika Way

The Rule

Free Information Flow. Any individual can approach *any** expert directly to ask for help. No need to go manager-to-manager to allocate resources.

Impact

Status was derived from expertise, not title. If you didn't know the answer, you referred the question to someone who did, regardless of their rank.

Technical heritage, adoption of new technologies

Mercury Arc Valves



Electronic tubes



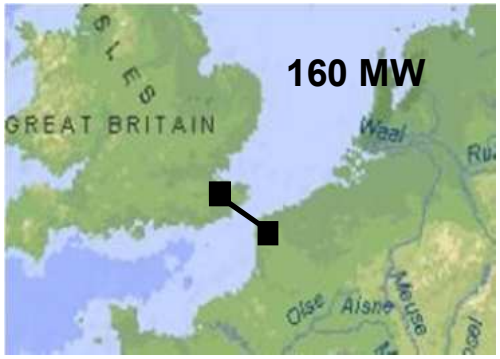
Market heritage, building a global business

A global market was created….

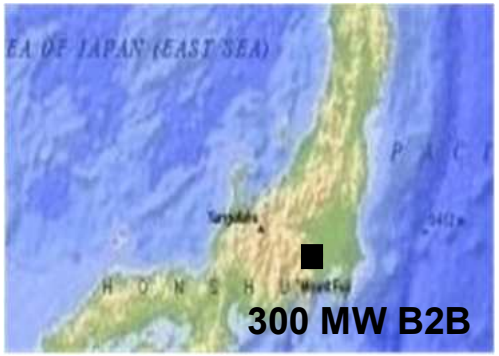
Gotland/Sweden, 1954



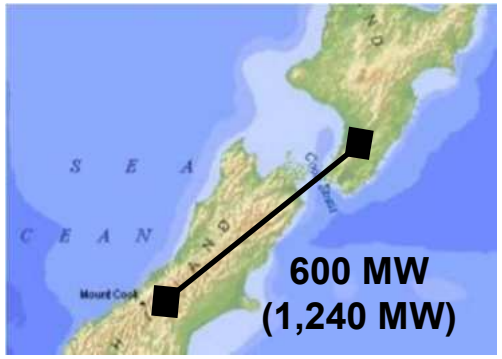
Cross Channel 1961



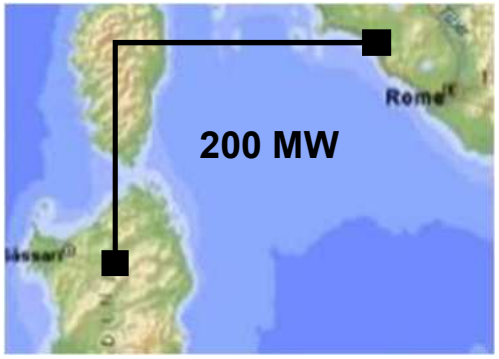
Sakuma/Japan 1965



New Zealand 1965



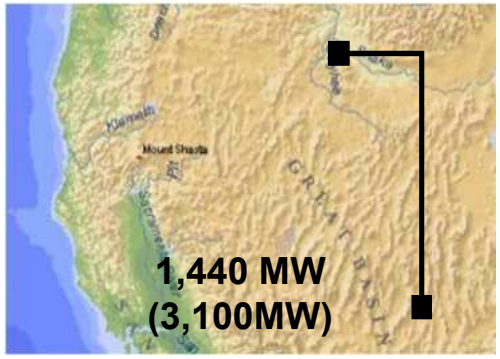
Sardinia/Italien 1967



Nelson River 1968



Pacific Intertie/US 1970



Nelson River 1975

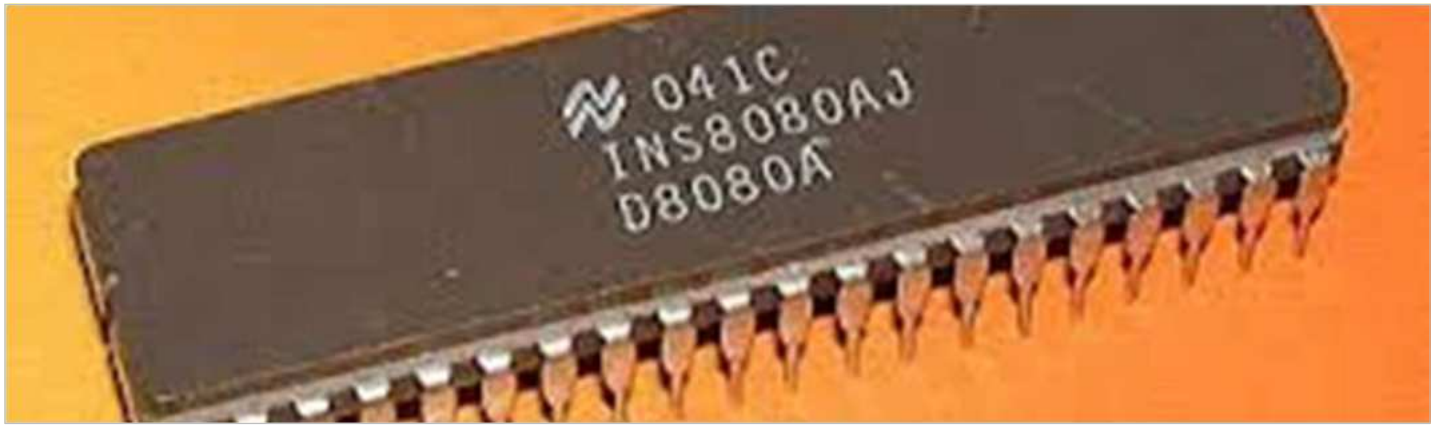


Technical legacy, fast adoption of new technology

Thyristor valves



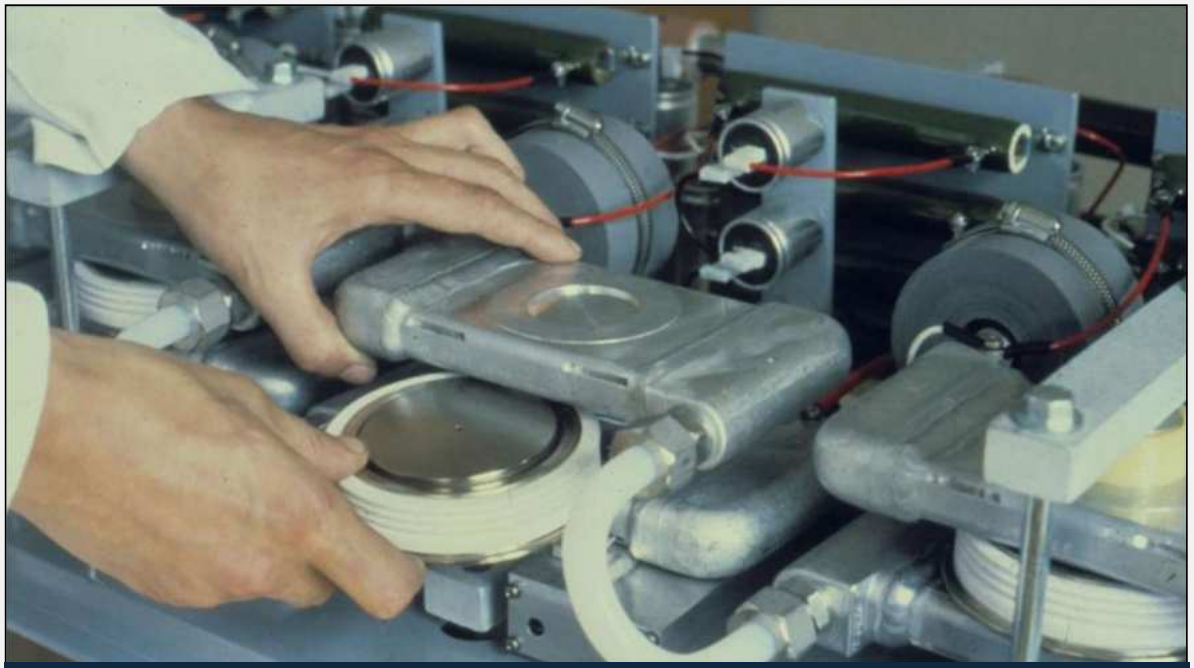
Integrated circuits and flat pack thyristors





Cooperation with customers…

- Partnership with LADWP, new test valve installed in Sylmar 133 kV, 2,000 A (water cooled)

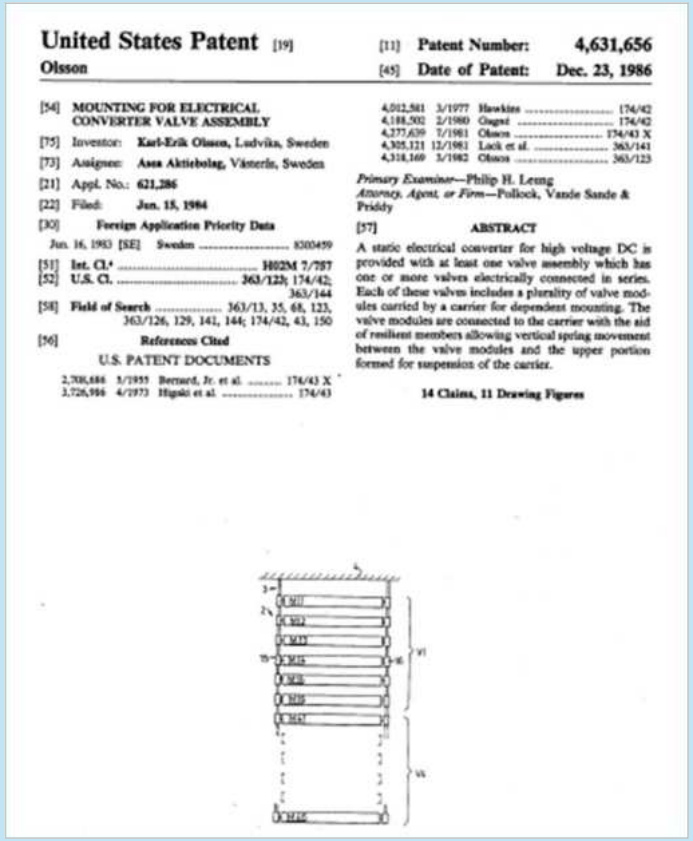


Thyristor replacement without breaking the water circuit



Innovative designs…

1980s hanging thyristor valves, redundant control systems



United States Patent [19]

Olsson

[11] Patent Number: 4,631,656

[45] Date of Patent: Dec. 23, 1986

[54] MOUNTING FOR ELECTRICAL CONVERTER VALVE ASSEMBLY

[75] Inventor: Karl-Erik Olsson, Ludvika, Sweden

[73] Assignee: Asea Aktiebolag, Västerås, Sweden

[21] Appl. No.: 621,286

[22] Filed: Jun. 15, 1984

[30] Foreign Application Priority Data

Jun. 16, 1983 [SE] Sweden 8303459

[51] Int. Cl.⁴ H02M 7/757

[52] U.S. Cl. 363/123; 174/42; 363/144

[58] Field of Search 363/13, 35, 68, 123, 363/126, 129, 141, 144; 174/42, 43, 150

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4,305,121 12/1981 Lack et al. 363/141
4,318,169 3/1982 Olsson 363/123

Primary Examiner—Philip H. Leung
Attorney, Agent, or Firm—Pollock, Vande Sande & Priddy

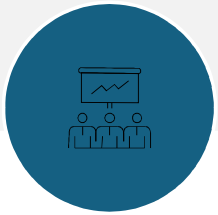
[57] ABSTRACT

A static electrical converter for high voltage DC is provided with at least one valve assembly which has one or more valves electrically connected in series. Each of these valves includes a plurality of valve modules carried by a carrier for dependent mounting. The valve modules are connected to the carrier with the aid of resilient members allowing vertical spring movement between the valve modules and the upper portion formed for suspension of the carrier.

14 Claims, 11 Drawing Figures



Status of HVDC 1978



Global installed capacity increased to 10,400 MW



Only 5 new projects commissioned globally during the 1970:ies

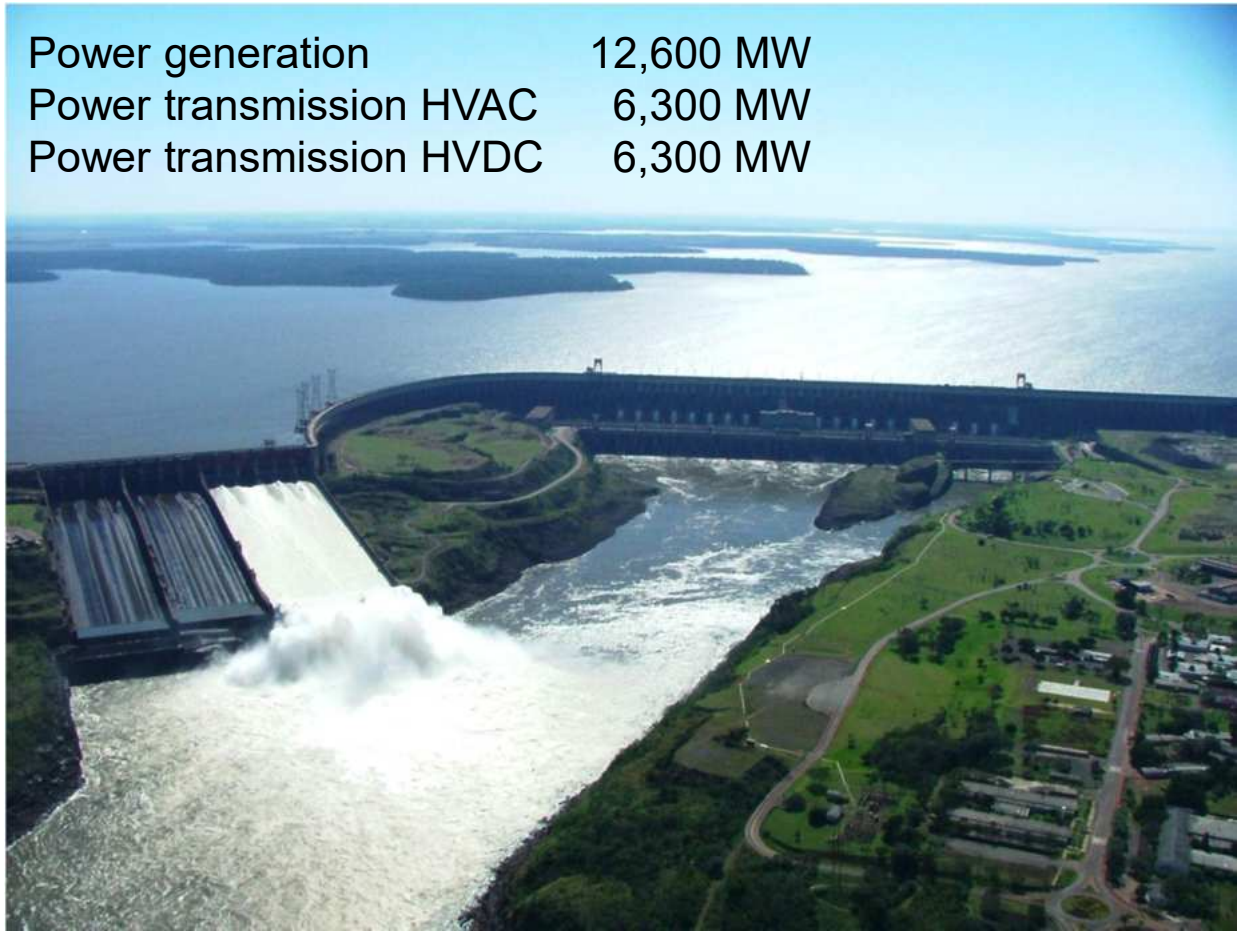


Weak market, downscaling of operations



HVDC organization was scaled down to 40 persons, but the world's largest project was tendered

1978 Itaipu, landmark project with groundbreaking technologies



ITAIPU BINACIONAL

- Water cooled valves
- Single board computers
- New valve concept
- New module concept
- New transformer design…

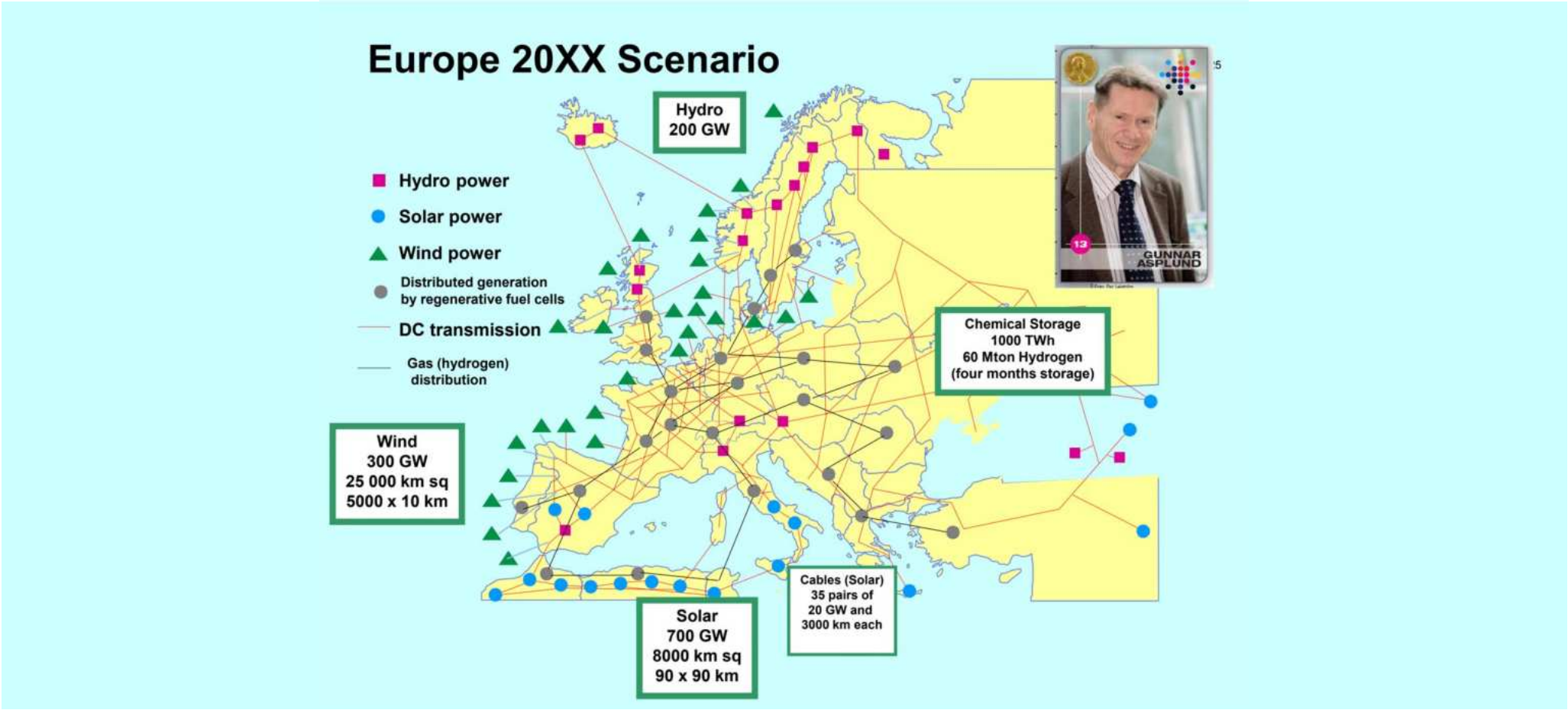
Status of HVDC 1990, Itaipu completed

Global installed capacity 33,000 MW

Market slowing down, increased competition

Market in Europe changing focus
Asia emerging as new market with strong local players

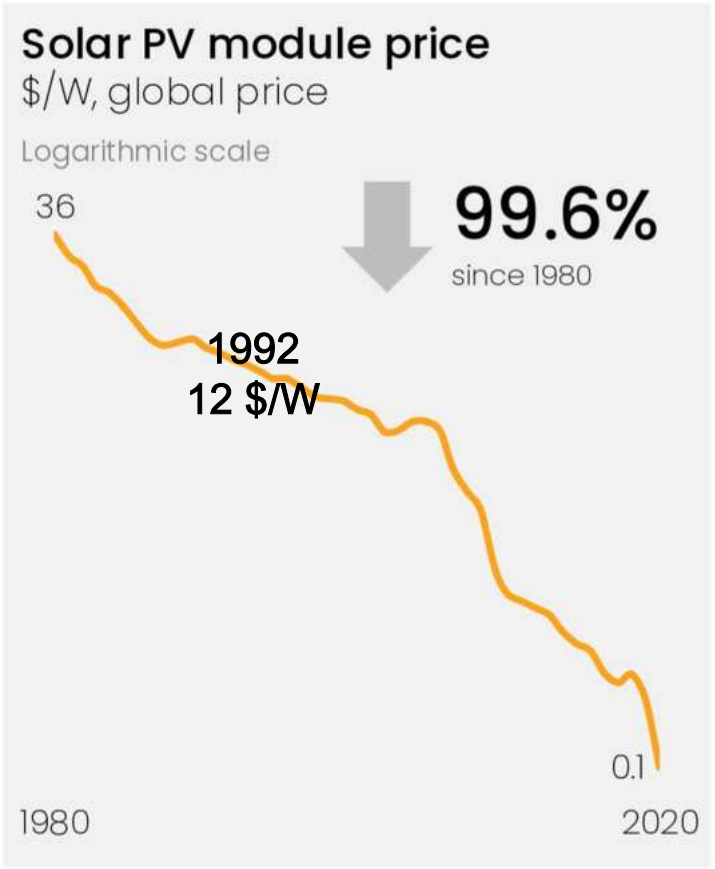
Vision from 1992, 100% renewable power system

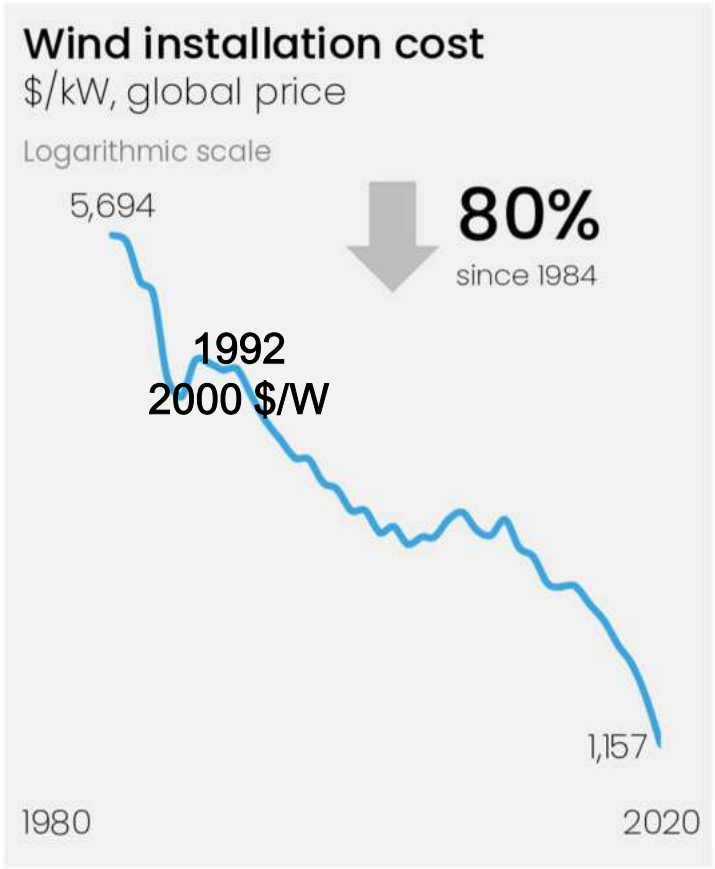


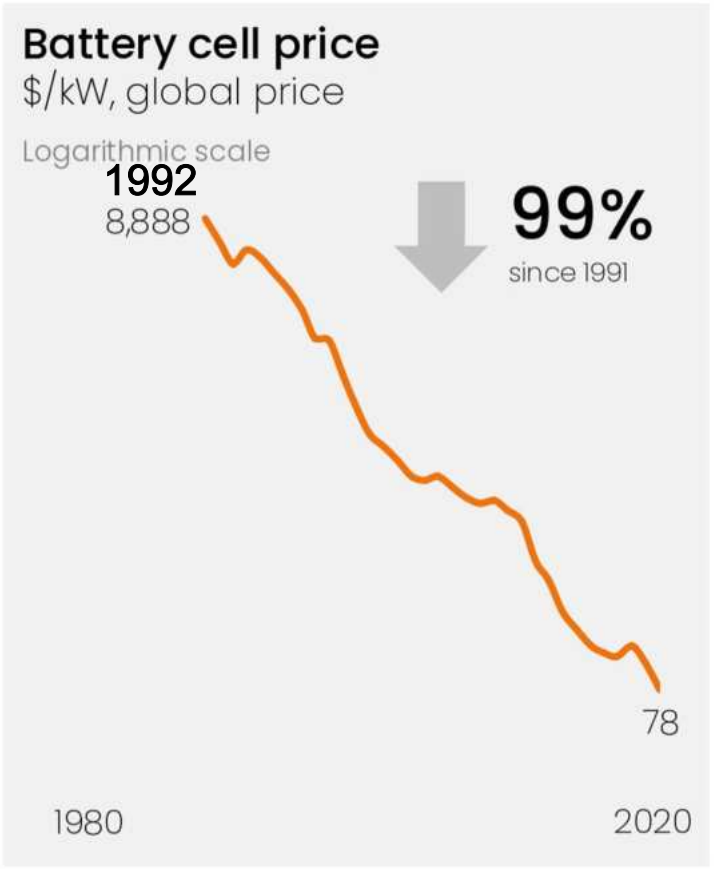
Source: ABB

Costs have been falling for decades on learning curves

Decades of steady cost innovation improved electrotech economics





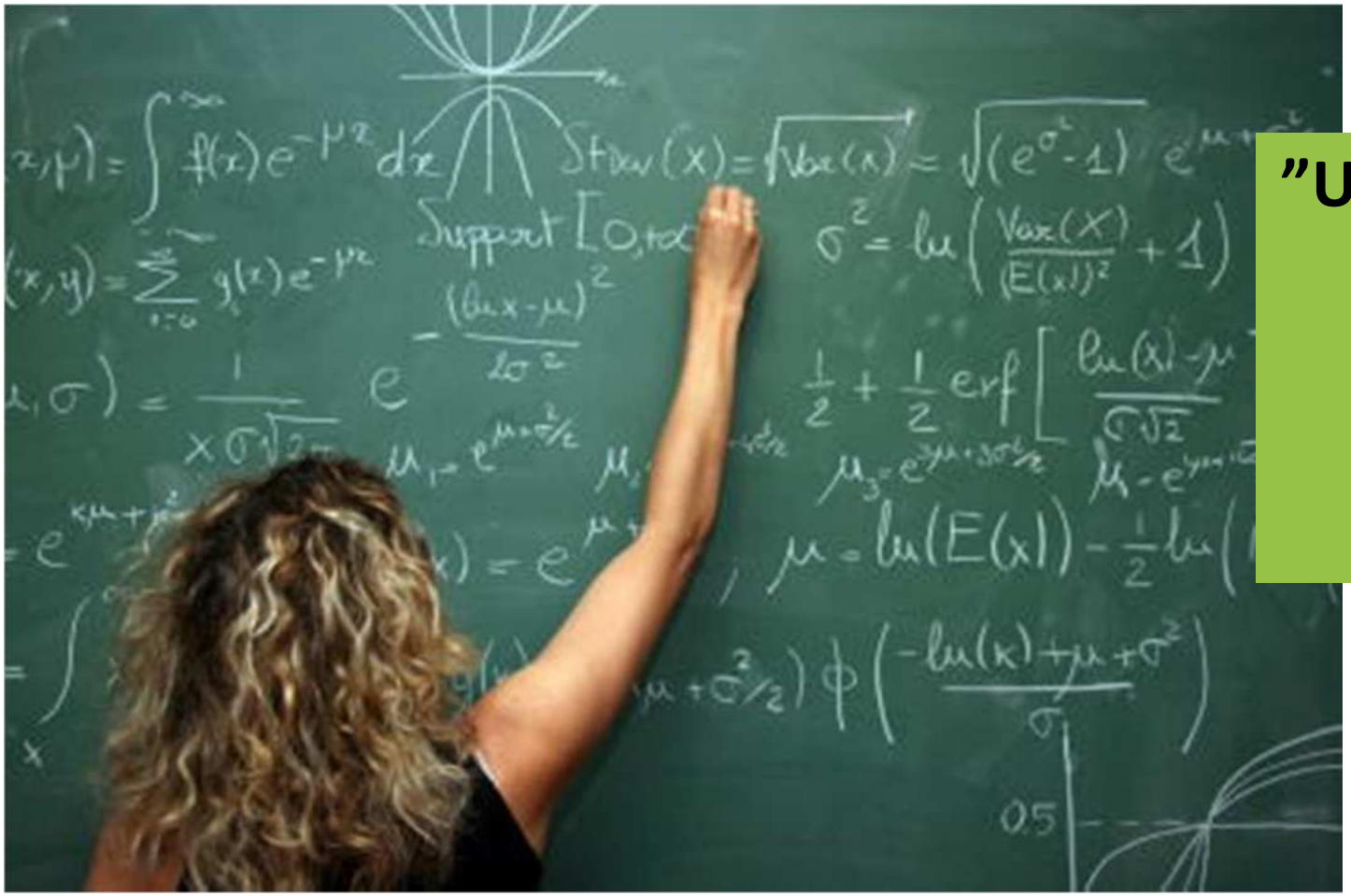


Sources: OWID; IRENA; BNEF/Avicenne

EMBER

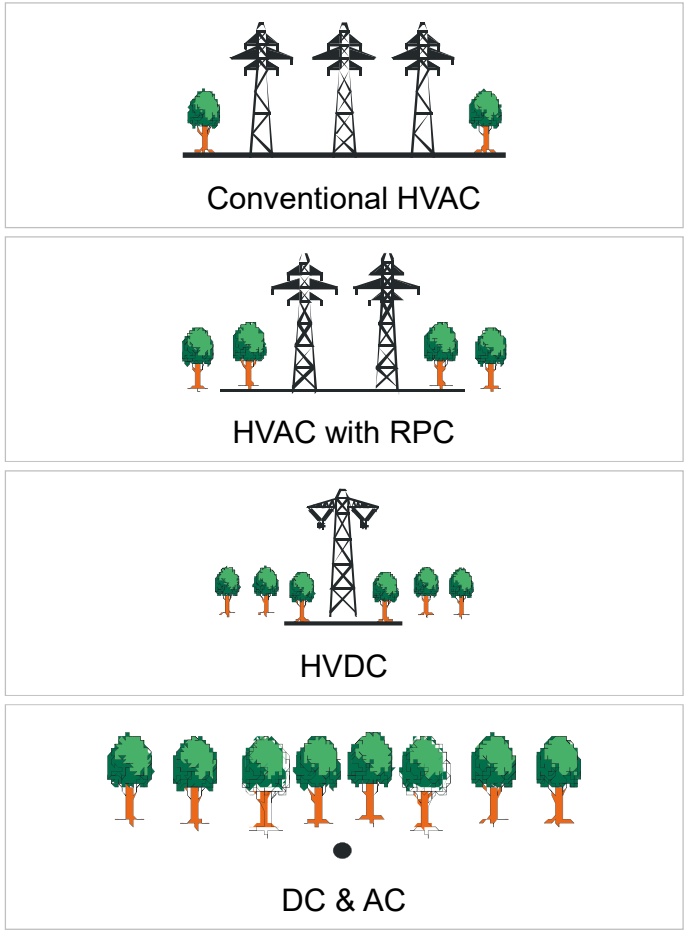
Gunnar, the pragmatic visionary..

How low can the cost go ??

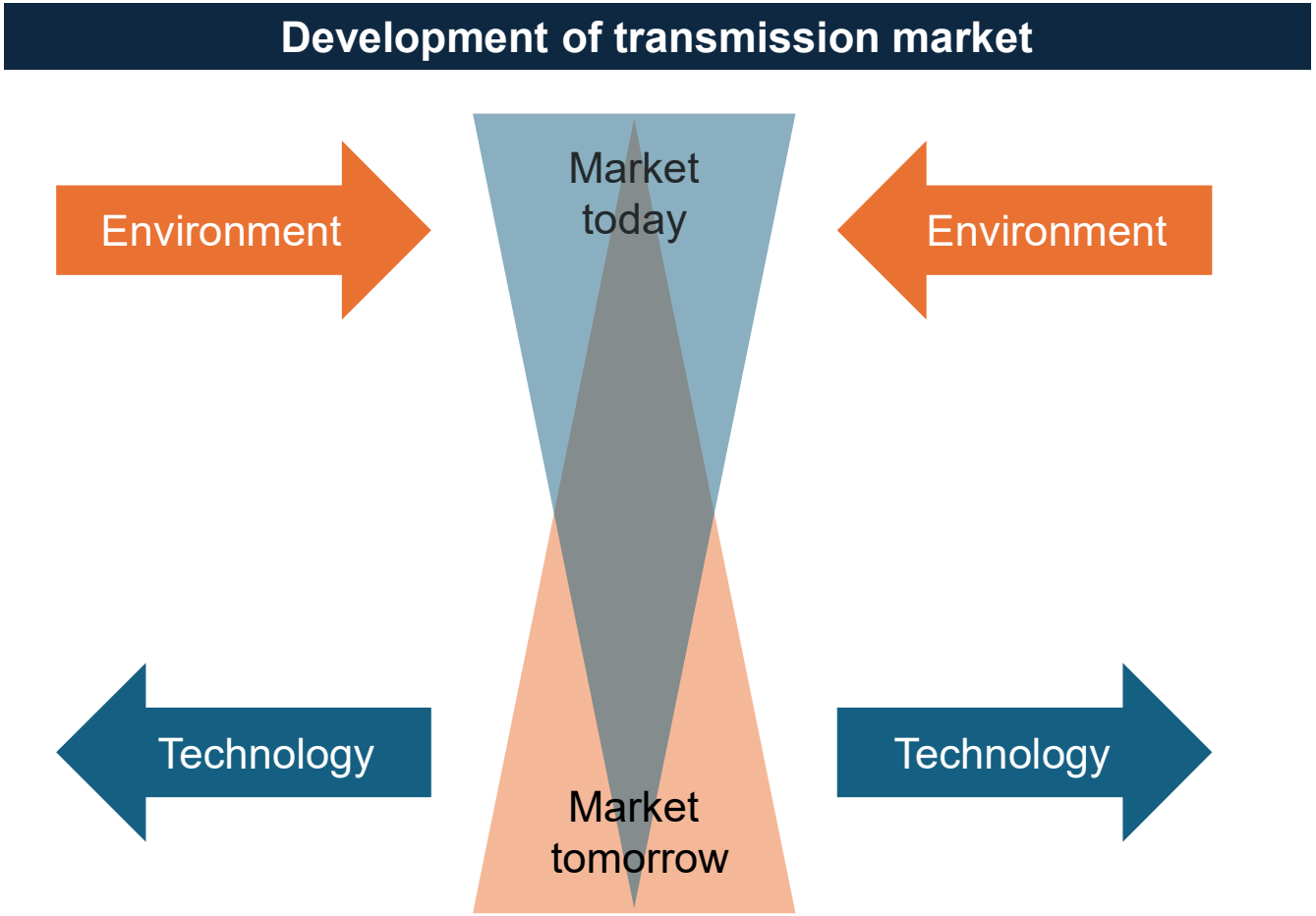


”Unlimited” volume
Cost becomes
1.5 to 2
X
Material Cost

Vision lead to 1994 strategic restart…

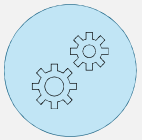


Source: ABB



Strategy summary 1994

New convertor technology (VSC) combined with new cable technology HVDC Light



New applications such as wind power integration



Mainly traditional markets: Europe, US

Conventional technology (LCC) higher voltage, higher power HVDC Classic



Traditional applications with connection of remote centralized production



Main market: Asia

Source: ABB

HVDC Classic, Partnering with customers

From Partner to Pioneer: Co-Developing the World's First 800 kV System

A Landmark Achievement in High-Voltage Direct Current (HVDC) Technology

The Need

For new projects spanning over 2,000 km, a voltage higher than the existing 600 kV world record was needed to minimize losses.

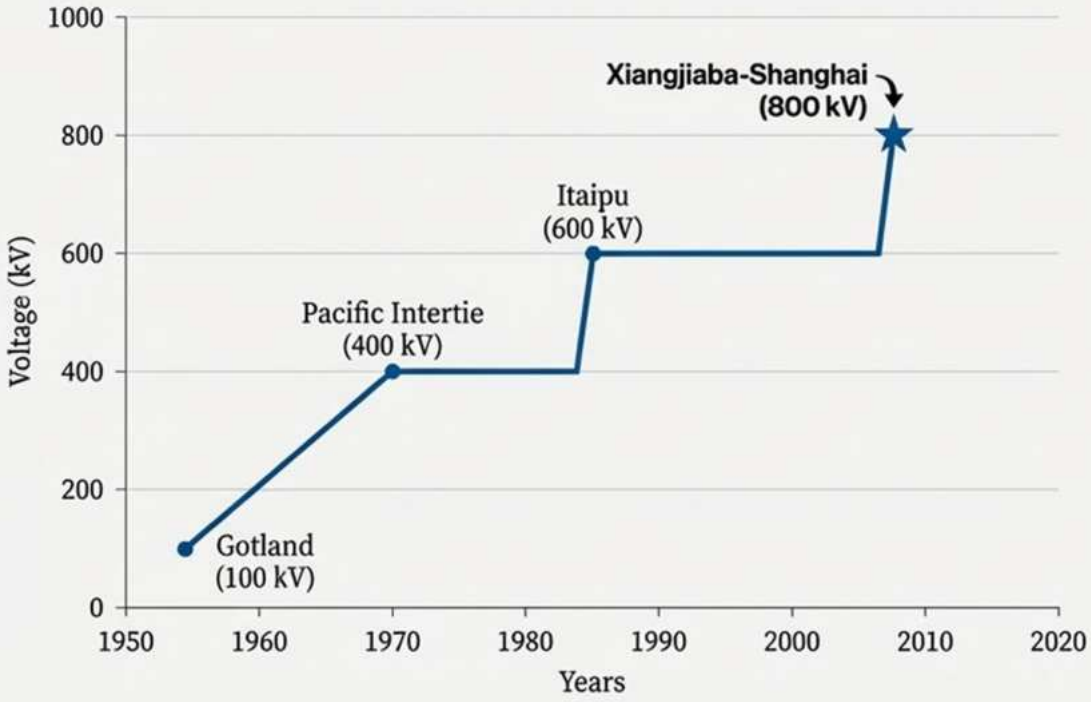
The Process

- **Initial Hesitation:** State Grid was wary of unproven technology.
- **Collaborative R&D:** Over two years, ABB worked closely with the client, investing 200-300 MSEK to develop and prove the feasibility of 800 kV technology.
- **The Geopolitical Trigger:** India's Powergrid, a key rival, decided to build its own 800 kV line. Not wanting to be seen as technologically inferior, China immediately approved the 800 kV plan.

The Result

ABB won the landmark Xiangjiaba-Shanghai project in 2007, a breakthrough that earned the Royal Swedish Academy of Engineering Sciences' Grand Energy Prize in 2008.

The Technological Leap



The HVDC Light® story

The "Innovation Crisis" in ABB 1992



- A mapping in ABB showed that the percentage of new products in the portfolio was going down
- New program HIP "High Impact" prioritized potential before cost
- Global call for projects funded from central R&D budget
- Responce from ABB Ludvika Gunnar Asplund "Hällsjöprojektet"

Source:ABB

The 1994 vision guided the R&D roadmap

Consequences for the technology roadmap



New Voltage Source Technology (HVDC Light)



New semiconductor technology



New cable technology



New high-speed computers

The HVDC Light project, corporate culture preserved

Attribute	Uno Lamm (The visionary founder)	Gunnar Asplund (The modern successor)
Primary technological focus	Mercury-arc valves; establishing the fundamental feasibility of HVDC.	Voltage source converters (VSC); perfecting HVDC for modern grid challenges.
Core leadership style	Charismatic visionary, culture builder, intrapreneur, and strategic diplomat.	Visionary technically grounded R&D leader and hands-on inventor.
Market strategy	Market creation: convincing the world to adopt a new, unproven technology over a 20-year period.	Market enabling: providing the key technology (HVDC Light) to unlock the potential of the emerging renewable energy market.
Key innovation	The concept and first commercial implementation of HVDC transmission (the Gotland link).	HVDC Light, enabling efficient underground transmission and integration of renewable energy.
View on collaboration	Pioneering strategic alliances with competitors (English Electric, GE) to grow the entire market.	Extensive strategic alliances with R&D centers, subsuppliers and customers
Primary legacy	"Father of HVDC"; created a new industry and a resilient corporate culture of innovation.	"Father of HVDC Light"; modernized HVDC and made the technology a cornerstone of the sustainable energy transition.

New technology for new markets HVDC Light®

- Connection of remote loads
- Connection of wind power
- Connection of off-shore platforms
- Underground/subsea transmission
- Power quality

First pilote in Gotland 1997, 60 MW

"Classic" cooperation project
1/3 ABB
1/3 Vattenfall
1/3 Energimyndigheten



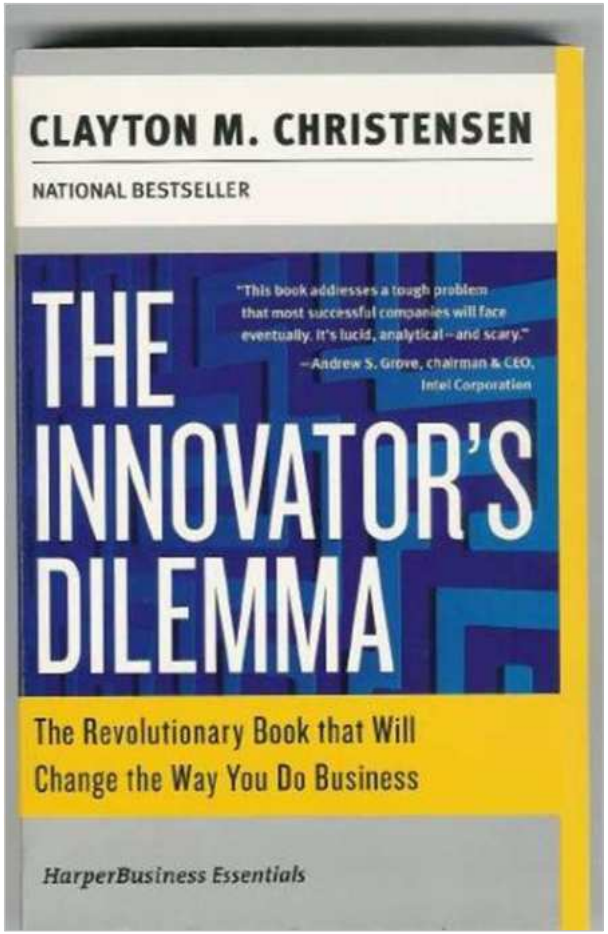




But bringing disruptive technologies to the market is a challenge

Disruptive transformation

- Perceived lower performance
- Initially lower profitability
- Traditional customers not interested!
- Gradual increase in market and eventually dramatic shift in market
- First commercialized in niche market in untraditional applications and with untraditional customers



Partnership with a Canadian owned US project developer…



Untraditional applications with untraditional partner…





TransÉnergieUS

Member of the Hydro-Québec group

1998 Directlink, underground cable
80 km; 3 X 60 MW



2001 Murraylink, worlds longest
underground cable 170 km; 220 MW

Innovative solutions
for power transmission

Third HVDC Light project run into problems…





- 330 MW, 45 km
- Contract June 2000
- Ready for operation June 2002

While burying the cable below the sound, ABB struck rock in the seabed, which kept short sections of the cable shy of the minimum depths specified in the transmission company's permits. Cable buried 6 feet instead of 8 feet for 100 m. **So, for the next year and a half, TransÉnergie was trapped: it couldn't operate without new permits, and it couldn't get new permits with the moratorium in place.**

2005 Troll, first offshore project also in partnership

Troll A Precompression Project, TPK
Key success factors

Planning and decision phase

- High focus on finding environmental attractive solution in Statoil management and among the Troll partners
- Early selection of one potential electrical solution (HVDC light technology)
- Sufficient time to study, mature and qualify the technical solution and establish confidence in Statoil and among the Troll partners to the HVDC light technology and to ABB's ability to deliver
- Building trust through open, close and good cooperation between top expertise in Statoil, the Troll partners and ABB during engineering and qualification of technical solutions

STATOIL



ABB “Survival Crisis” culminated in October 2002…

THE CRISIS: A PERFECT STORM



Massive Asbestos Legal Liabilities
Over **100,000** personal injury lawsuits from a US subsidiary forced a **Chapter 11 bankruptcy filing** to cap liabilities.



90% Drop in Share Price
Complex overexpansion and **$5.2 billion** in net debt caused shares to plummet from **SFr 50 to under SFr 2.**



The $140 Million Pension Scandal
Former CEOs returned **SFr 137 million** in unapproved benefits following a massive public governance scandal.

1988–1996	Percy Barnevik (SE)
1997–2000	Göran Lindahl (SE)
2001–2002	Jörgen Centerman (SE)
2002–2005	Jürgen Dormann (DE)

cut **45,000 jobs**

- Sold non-core assets
- Refocused strictly on **Power** and **Automation.**

Cross Sound Cable opening, the turning point…





August 14, 2003, was a dark day for many people in the United States—though not for officials at TransÉnergie. Just after 4:00 p.m., cascading outages starting in Ohio knocked out power to 50 million people in Canada and the U.S., including many in Connecticut and Long Island.

"Within 12 hours we were transferring power to Long Island, helping customers get energy—and most importantly, helping provide stabilization to the grid while the generators on Long Island were coming back on."

Grateful politicians



The idea of an offshore supergrid 2005





Eddie O´Connor

CEO Airtricity

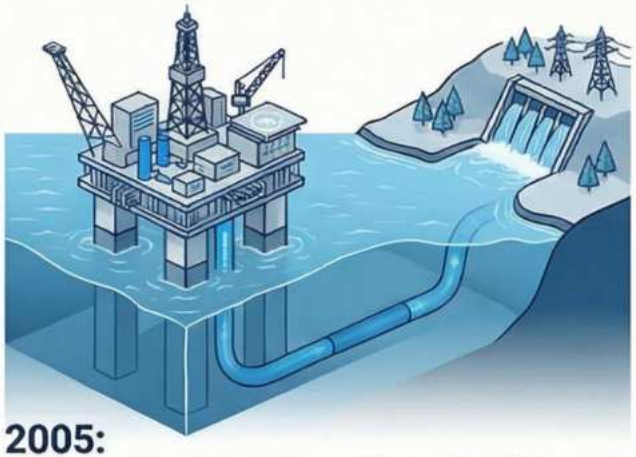
“The Supergrid is based on the combination of two recent but proven technologies, large offshore wind turbines and voltage source converter HVDC transmission.”

“ABB - Power and productivity for a better world

We have today established an advanced transmission technology, HVDC Light, for demanding offshore applications to feed electricity to platforms but also to connect and support integration of electrical networks. We have worked very closely with Airtricity on the technology aspects of their concept for an EU Supergrid Project and have concluded that this European technology fits well with their plans to construct an offshore grid.”

Bo Normark, Senior Vice President Marketing and Sales, ABB Grid Systems

2005–2010: The Offshore Frontier & Generation 3



2005:
Troll A — The Power-from-Shore Breakthrough

First Power-from-Shore Project: HVDC Light powered two 40 MW gas compressors on Troll A from the mainland.

EXAMPLE:
Eliminating 230,000 Tons of CO_2 Annually
By replacing offshore gas turbines with clean hydroelectric grid power.

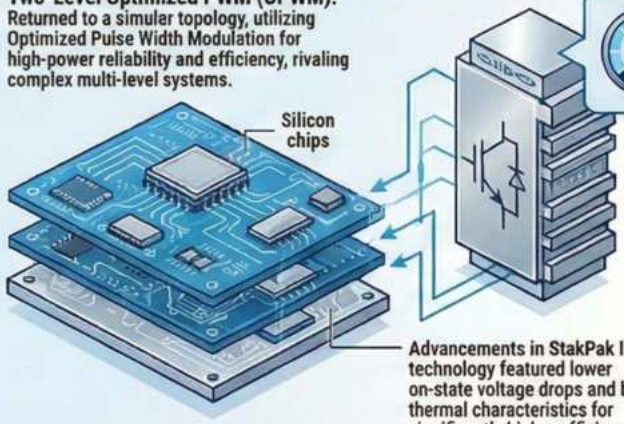
EXAMPLE:
Eliminating 230,000 Tons of CO_2 Annually
By replacing offehore gas turbines with clean hydroelectric grid power.



Integrated Variable Speed Drives:
Platform-side converters acted as Variable Speed Drives (0–60 Hz), eliminating heavy offshore gearboves.

GENERATION 3 TECHNOLOGY: THE SHIFT TO HIGH POWER

Two-Level Optimized PWM (OPWM):
Returned to a simuler topology, utilizing Optimized Pulse Width Modulation for high-power reliability and efficiency, rivaling complex multi-level systems.



STATISTIC:
1.4%–1.7%
Station Losses

Advancements in StakPak IGBT technology featured lower on-state voltage drops and better thermal characteristics for significantly higher efficiency.

Shift to Bulk Power Applications





2006:
Estlink — Crossing the Baltic Sea

Connecting Estonia and Finland:
A critical subsea interconnector providing 350 MW of power at ±150 kV, enhancing security of supply.

KEY FINDING:
Proving Subsea Beliability.
Estlink demonstrated fron 3 technology could handle long-distance subsea transmission rigors and provide vital voltage support.



2009:
BorWin1 — The Offshore Wind Frontier

World's First Offshore Wind HVDC Connection:
BorWin1 connected the BARD Offshore 1 wind form to the German grid across 200 km (125 km subsee).

KEY FINDING:
Bypassing the "AC Wall"
AC cables hit a physical distance limit (~80-100km) due to capacitive charging BorWin1 proved VSC-HVDC could high power over longer distances.

Grid-Forming Reference:
The HVDC system provided the stable frequency reference required for offshore wind turbines to synchronize.

2005–2010 Project Summary

Project Name	Year	Power (MW)	Voltage (kV)	Application
Troll A 1 & 2	2005	2 x 40 MW	±60 kV	Power-from-Shore
Estlink	2006	550 MW	±150 kV	Subsea Interconnector
BorWin1	2009	400 MW	±150 kV	Offshore Wind
Valhall	2011	78 MW	150 kV	Power-from-Shore

NotebookLM

Siemens launches VSC technology HVDC Plus in 2007

The Smart Way

HVDC PLUS – One Step Ahead

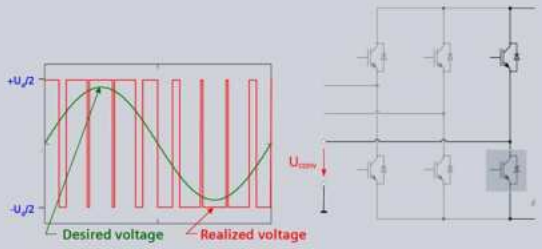
SIEMENS

HVDC PLUS –
Technology, Be
Power Transmission
and Distribution

London, 4th October 2007
J. Dorn; joerg.dorn@siemens.

SIEMENS

VSC Technology – A look back



High harmonic distortion

High transient stresses resulting in HF noise

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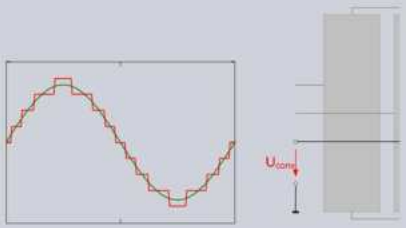
SIEMENS

Modular Multilevel Converter - MMC



Low generation of harm

Low HF noise

Low switching losses

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SIEMENS

Siemens will be
Market-Leader in VSC-based
HVDC Technology!

Thank you very much for your attention.

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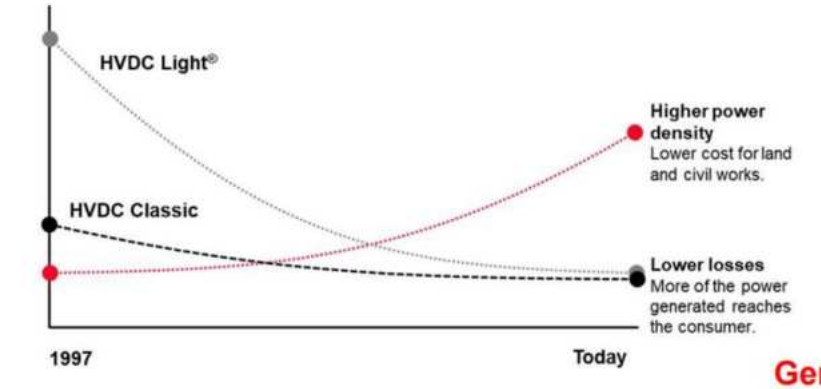
News | October 19, 2007

Trans Bay Cable To Build Undersea Link To San Francisco

Trans Bay Cable, LLC has awarded Siemens Power Transmission & Distribution, Inc. a contract worth more than US$150M to construct a 53-mile undersea high voltage direct current (HVDC) transmission link between San Francisco's City Center electrical power grid and a Pacific Gas & Electric substation near Pittsburg, California. The HVDC PLUS system will transmit up to 400 MW at a direct current (DC) voltage of 200 kV and is the first order for Siemens using its HVDC PLUS technology. The main advantages of the new HVDC PLUS link are the increased network security and reliability due to network upgrades and reduced system losses.

TenneT 2 GW Program – HE's HVDC Technical Solution

HITACHI
Inspire the Next



Gen 1


Hällsjön
3 MW
± 10 kV


Gotland
50 MW
± 80 kV

Gen 2


Cross Sound
330 MW
± 150 kV


Estlink
350 MW
± 150 kV

Gen 3


BorWin1
400 MW
± 150 kV


Caprivi
300 MW
+ 350 kV


East-West Interconnect
500 MW
± 200 kV

2010


DolWin1
800 MW
± 320 kV

Gen 4

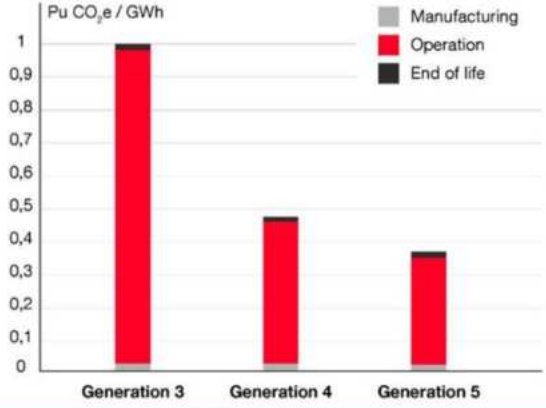

Skagerrak 4
700 MW
500 kV


NordLink
1400 MW
525 kV


Dogger Bank
1200 MW
320 kV

Gen 5


DC4 / SunZia /
2GW Program
2-3000 MW
525 kV



Baseline for the 2GW HVDC design is Hitachi Energy's HVDC Light® Gen 5 and its extensive experience into the industry

Public
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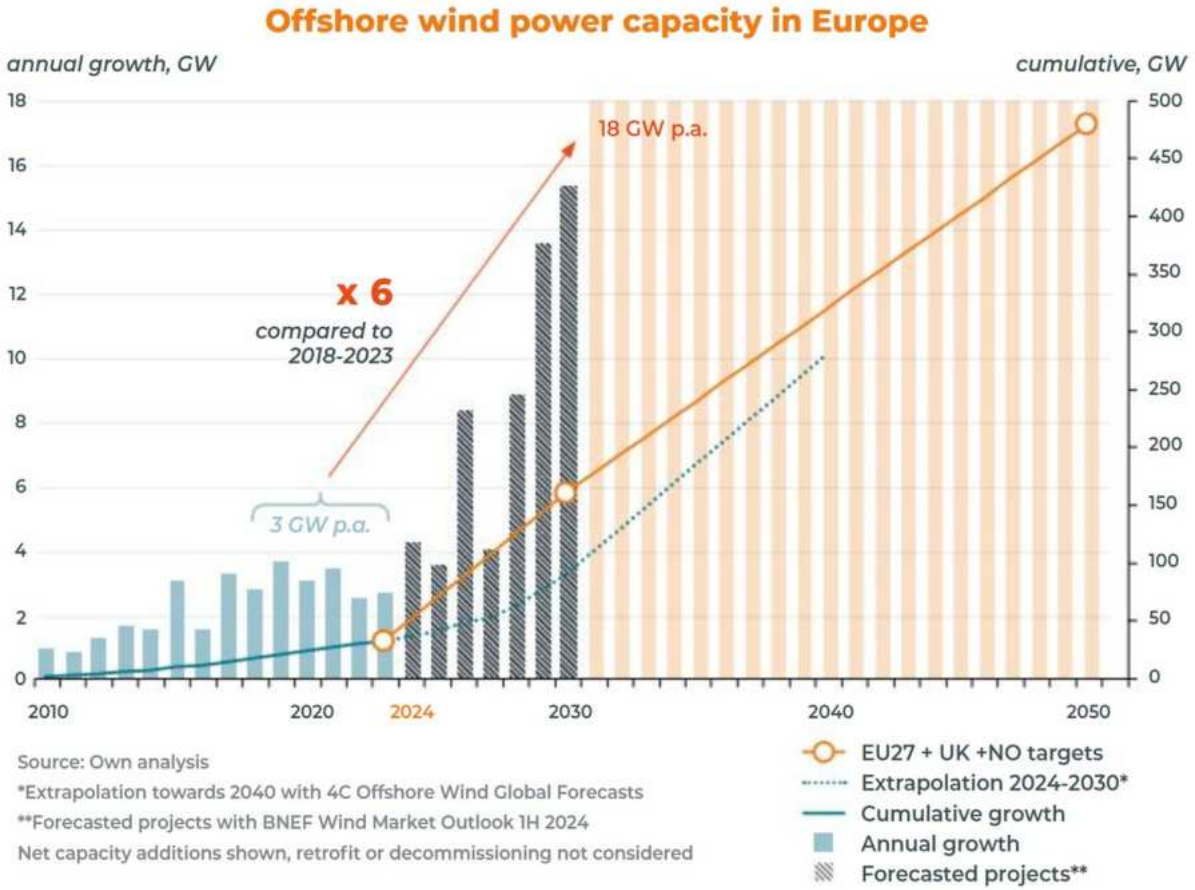
Hitachi Energy

12 countries signed North Sea Off Shore Grid agreement 2010



The buildout has just started

- **HVDC is taking off – 50% of Grid investments in Europe are HVDC**



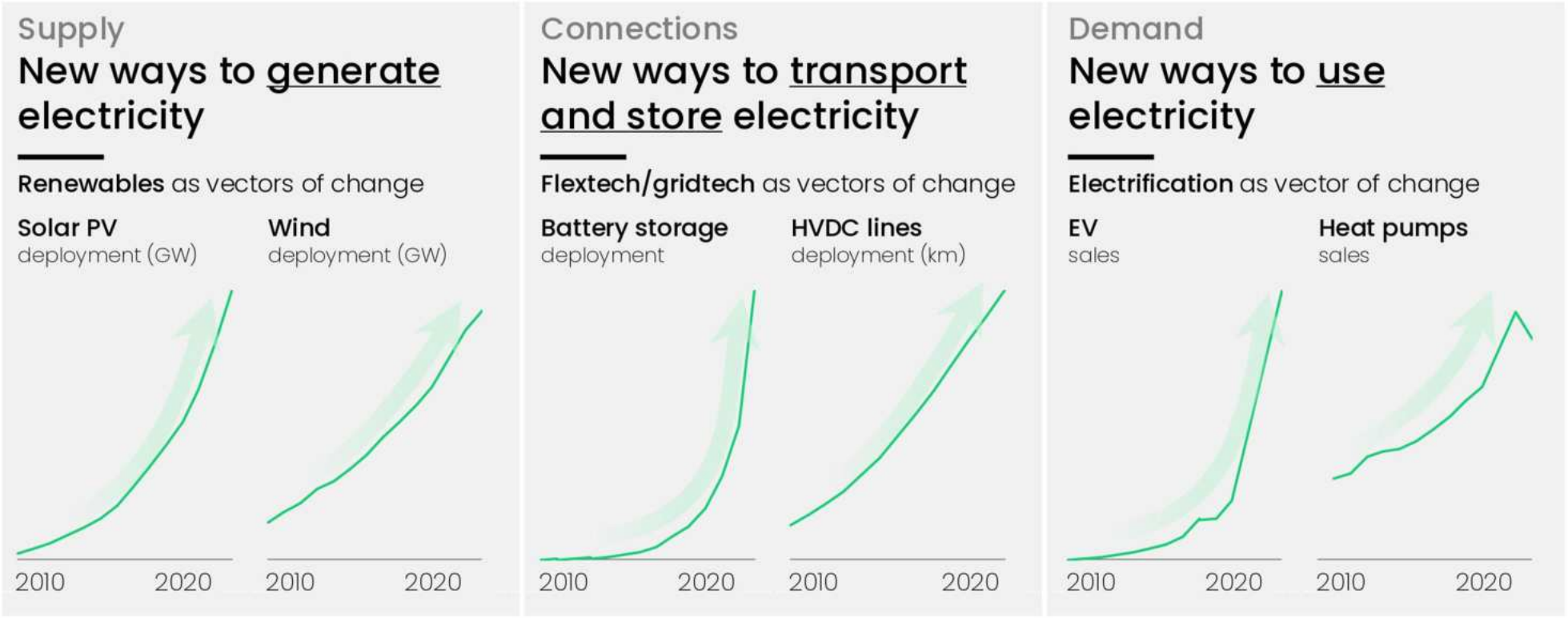


Source: https://issuu.com/eliagroup/docs/5387_241015_elia_book_uk_bd_double_page

HVDC in the technology revolution in energy

This is a technology revolution in energy

Electrotech is technology that revolutionises the supply, connection and demand of electricity



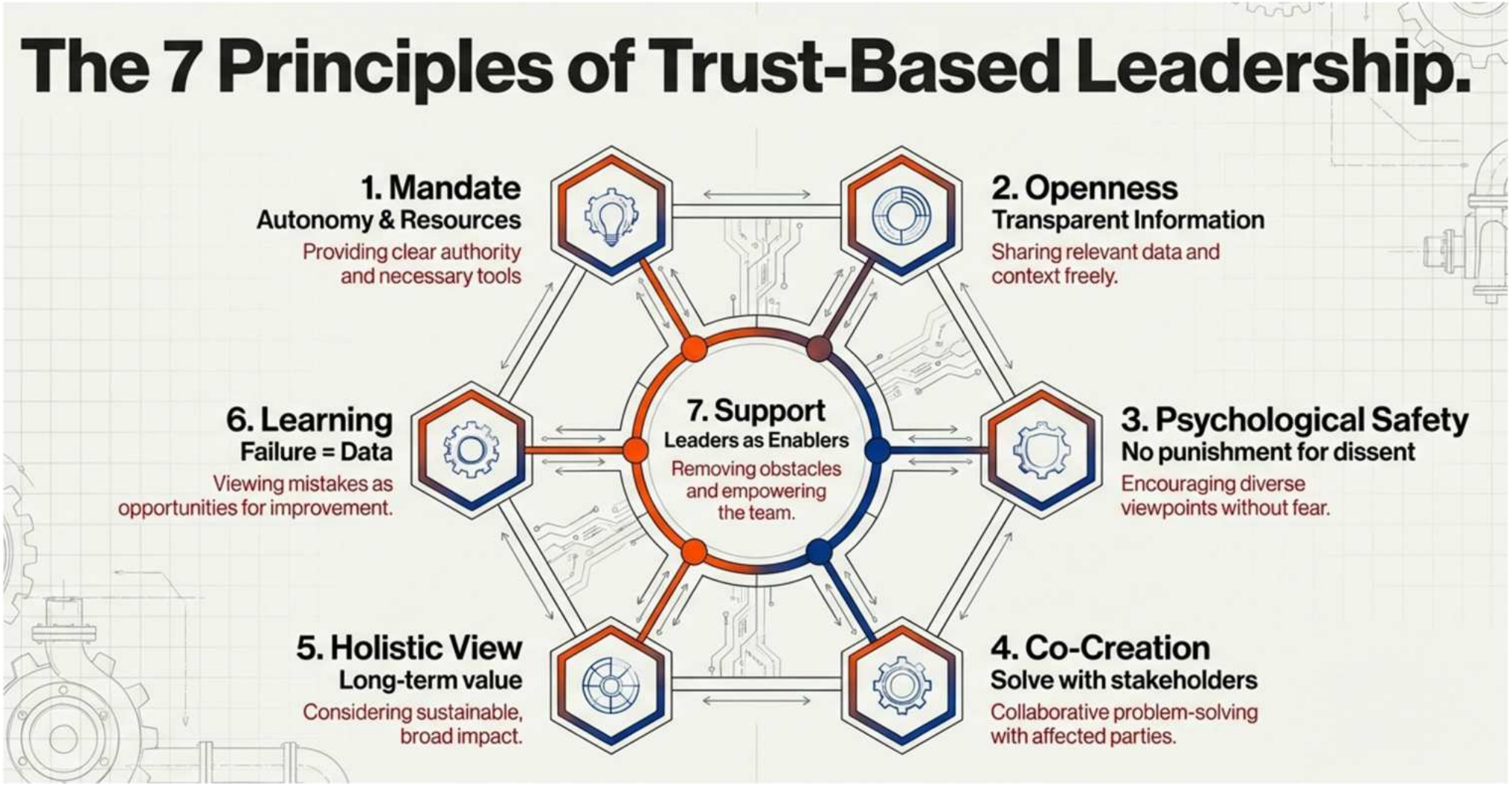
Sources: Ember, IEA, RMI, Thunder Said

EMBER

HVDC Light project success factors

- **Creating “Protected Environment" for Innovation:** Just as ABB did with its HIP projects, leaders must consciously create protected zones for high-risk projects. This is about more than just allocating a budget; It is about providing genuine autonomy and acting as a shield against the organizational "immune system" that instinctively rejects disruptive ideas. This requires financial and political courage on the part of the leadership.
- **Ritualizing Constructive Conflict:** Innovation Breeds Tension. Instead of hoping it will go away, leaders need to design processes to channel it productively. The "HVDC Light meetings" are an excellent template: create regular, disciplined forums that distinguish between fact-based information sharing and open, psychologically safe debate. This builds a collective ability to handle difficult conversations and turn disagreements into better solutions.
- **Led with Questions, Not Answers:** The breakthrough for HVDC Light did not come from a top-down directive, but from a mid-level manager asking a crucial question: "What if we listen to a real customer problem?". A trust-based leader's primary role in an innovation process is not to have all the answers, but to create an environment where the right questions can be asked and explored by the team closest to the problem. This requires humility and a willingness to let go of control of the solution.
- **Demonstrating Resilience in Crisis:** The ABB case shows that external crises will inevitably test an organization's commitment to innovation. During these periods, the leader's most critical function is to act as a "shock absorber," protecting long-term strategic projects from short-term panic. This requires courage and a deep-rooted trust in the team and vision, even when financial metrics are pointing in the wrong direction. The story of the power outage on Long Island shows the importance of being ready to seize the opportunities that may arise from a crisis to confirm and justify the trust that has been shown

Generic leadership model



My personal view on leadership from 1994

Ludvika-model: A Guide to Trust-based Leadership and Knowledge Transfer

The company is its people



Ground leadership in insight that an organization consists of competent employees, not hierarcttical systems; when empl-overs thrive and develop, the company's growth happens natu-

Encourage generosit with ideas



Create a culture where experienced employees share knowledge and ideas with others (mentorshipl), effective and natural knowledge transfer as a way of everyday life.

Handle uncertainty through flexibility



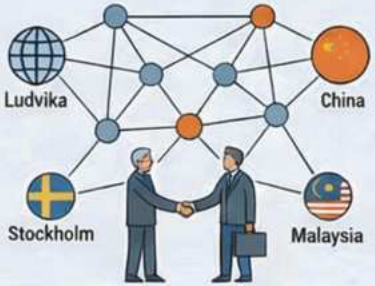
Instead of controlling change, let the organization's forms adapt to environments, like a river that is able to cultivate and accelerate technical shifts through accessibility.

Solutions before blame



In cases of technical errors or failure, solving things to prevent further damage is prioritized; it lays the foundation for psychological safety which is- the innovation.

Openness to the surroundings



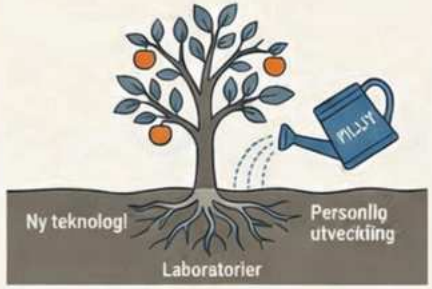
Have an "**enlightened**" organization travel and establish global connections - from In Stockholm to China and Malaysia.

Leadership that reflects the organization



Leadership goals allow members to recognize that the organization represents, and to mirror the organization in the form of diverse groups of citizens.

"Investing is the lifeblood"



Trust may grow and expertise can develop faster through new technology, laborato-ries and investments in personal development create relevant growth.

Notebookl