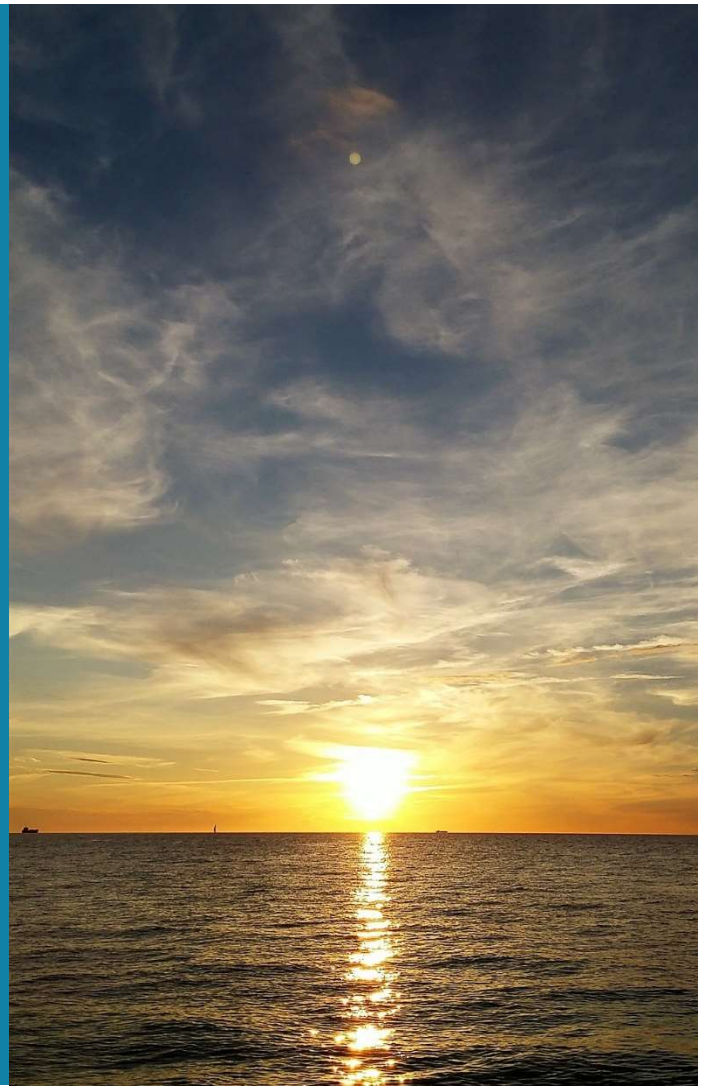
TRIZ SUMMIT 2019

RESEARCHING FUTURE

Technology Forecasting (GETTING PRESCIENT KNOWLEDGE)

Supported by



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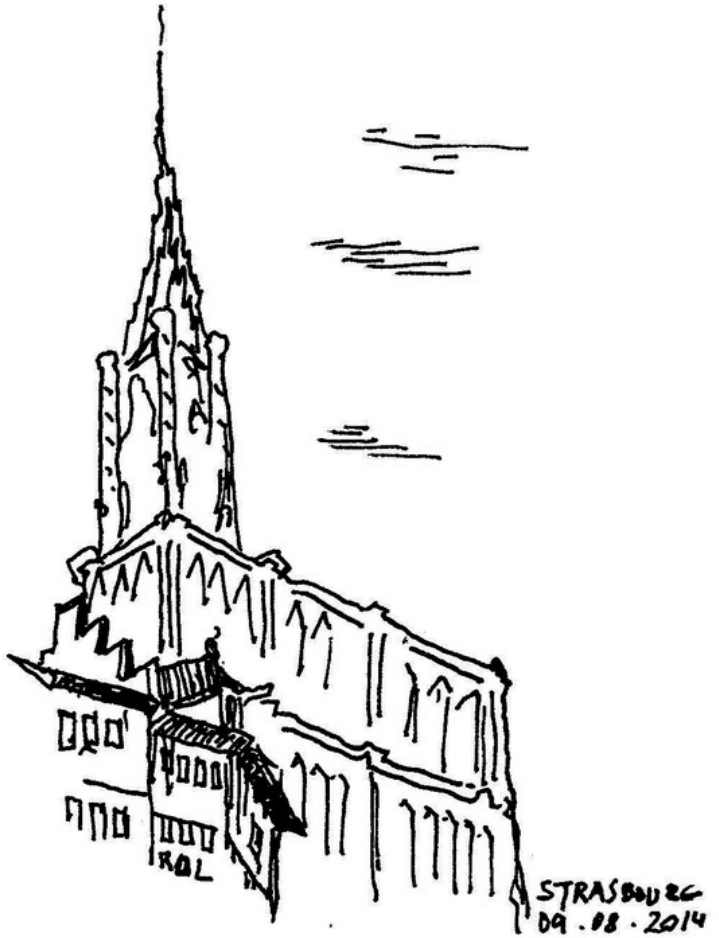


ОТСМ-ТРИЗ

...- Г-голубчики, - сказал Федор Симеонович озадаченно, разобравшись в почерках.
- Это же п-проблема Бен Б-бецалая. К-калиостро же доказал, что она н-не имеет р-решения.

- Мы сами знаем, что она не имеет решения, - сказал Хунта, немедленно ощетиниваясь.
- Мы хотим знать, как ее решать.

- К-как-то ты странно рассуждаешь, К-кристо... К-как же искать решение, к-когда его нет?
Б-бесмыслица какая-то...

- Извини, Теодор, но это ты странно рассуждаешь.
Бессмыслица – искать решение, если оно и так есть.
Речь идет о том, как поступать с задачей, которая решения не имеет...

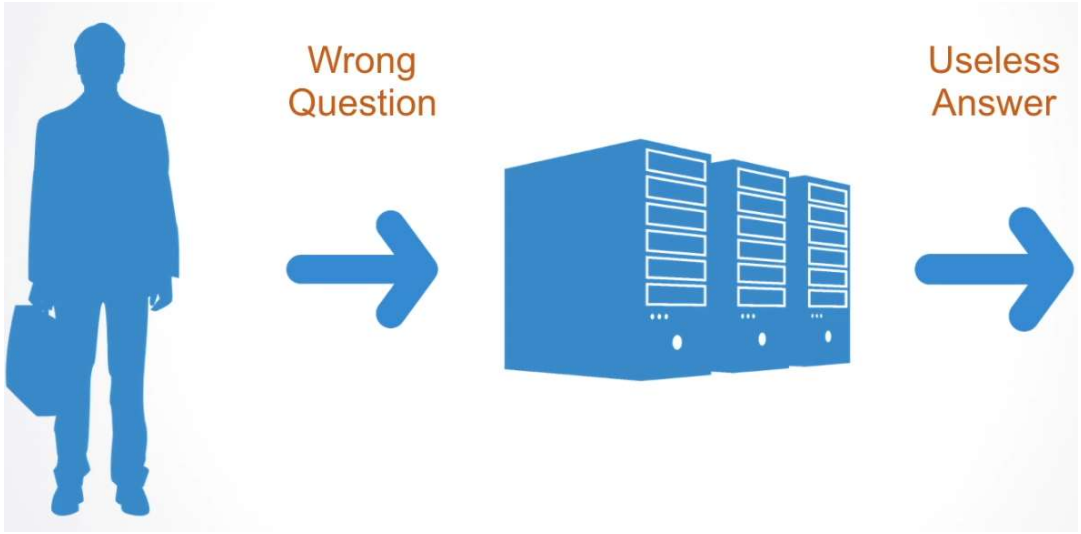
А.Стругацкий, Б.Стругацкий. *Понедельник начинается в субботу.*

* www.trizminsk.org (1997-2004)

We fail more often because we solve the ***wrong problem*** *than because we get the wrong solution to the right problem*

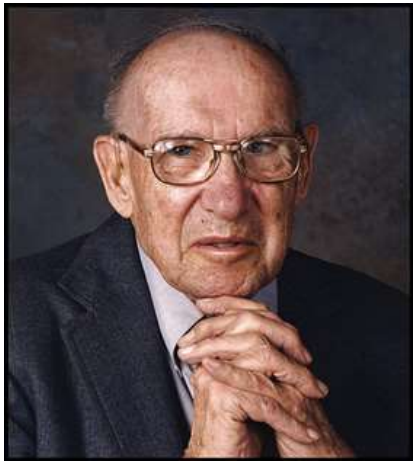
Russel Ackoff (1919 –2009)
was an American organizational theorist, consultant, and Anheuser-Busch Professor Emeritus of Management Science at the Wharton School, University of Pennsylvania.
Ackoff was a pioneer in the field of operations research, systems thinking and management science.

*If you ask the wrong **question**, it doesn't mater how good your **answer** is, it will lead you into wrong direction.*



*. https://www.youtube.com/watch?v=snOnTFBkRB0&list=PLsJWgOB5mIMC8qFrlhr5qAIutMivDe4vs&index=3

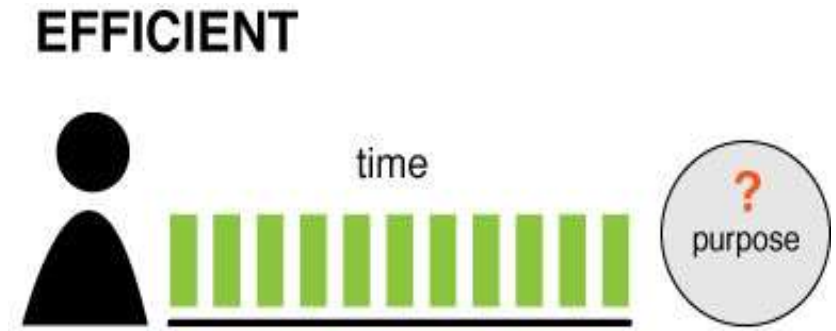
efficiency is doing things right;
effectiveness is doing the right things…

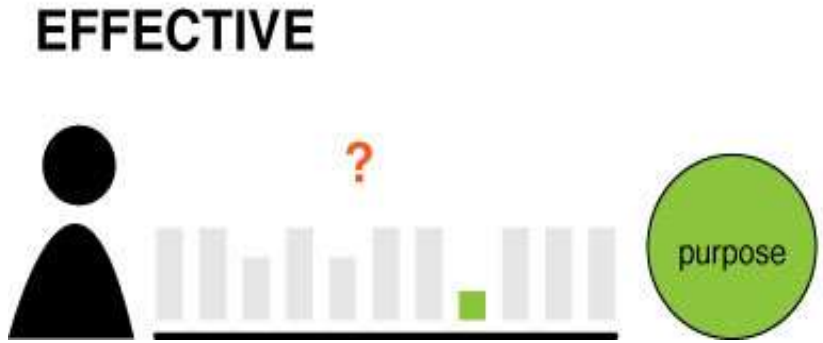


Peter Drucker (1909 –2005)

was an Austrian-born American management consultant, educator, and author, whose writings contributed to the philosophical and practical foundations of the modern business corporation. He was also a leader in the development of management education, he invented the concept known as management by objectives and self-control, and he has been described as "the founder of modern management".

efficient vs. effective





source: http://blog.jackvinson.com

How do we decide?

What is the right target?

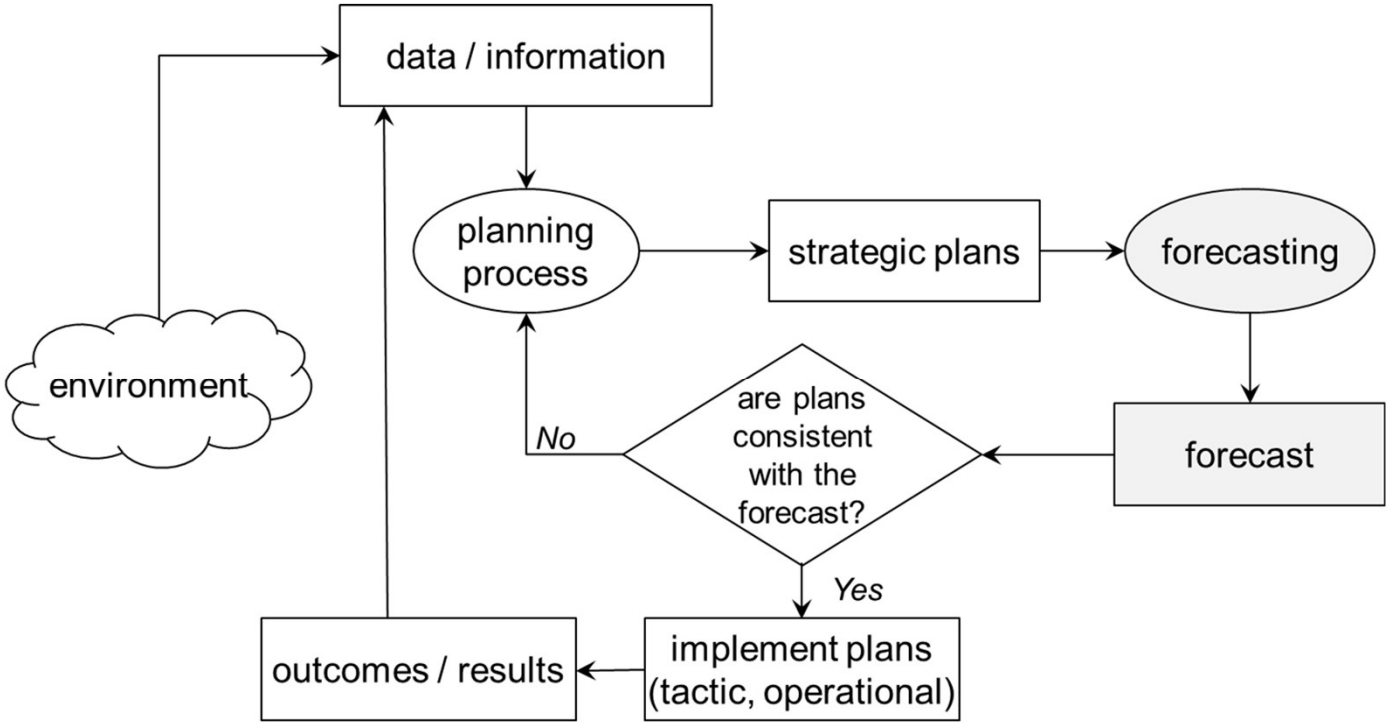
WHY
RESEARCHING FUTURE

INVENTION and INNOVATION

WHAT IS THE FUTURE OF EMERGING TECHNOLOGIES?

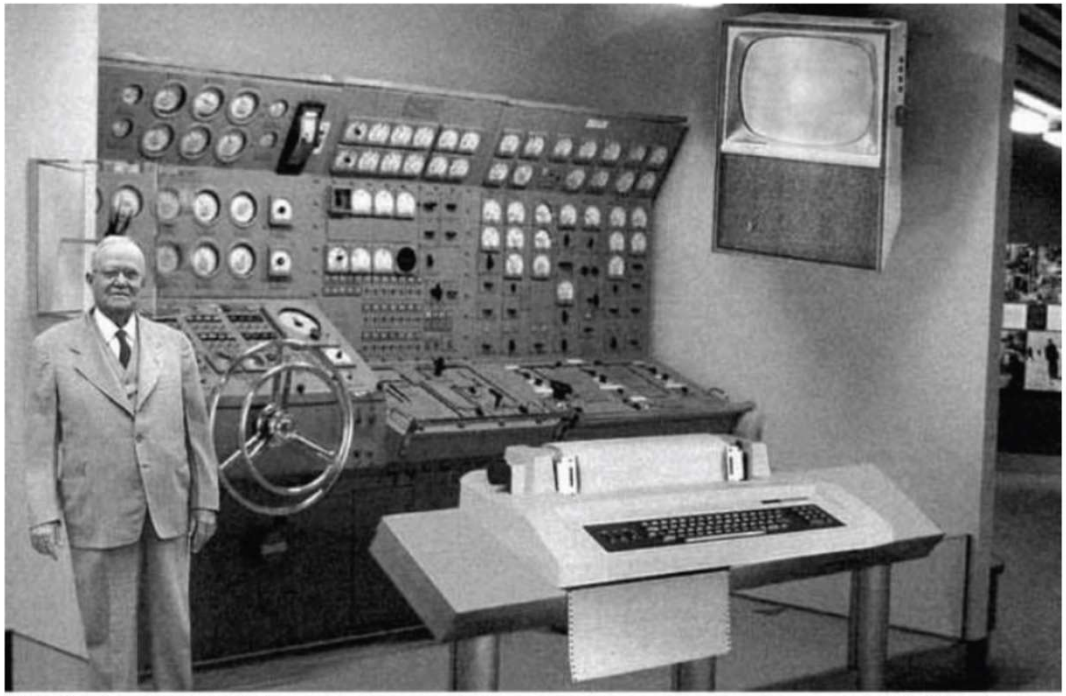
Feasibility and Performance (e.g. km/kWh) ⟷ Production and profitability (€, £, ¥, $)

framework for planning and forecasting



* J. S. Armstrong, Principles of Forecasting: A Handbook for Researchers and Practitioner, 1st ed. Boston / Dordrecht / London: Kluwer Academic Publishers, 2002.

home computer in 2004: forecast of 1954



Scientists from the RAND Corporation have created this model to illustrate how a "home computer" could look like in the year 2004. However the needed technology will not be economically feasible for the average home. Also the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems. With teletype interface and the Fortran language, the computer will be easy to use.

Source: Umberto Cugini, (2014) KAEMaRT, Politecnico di Milano

WHAT? *will be state of cooper mining technology*

WHEN? the next 35 years

WHERE? in Chile

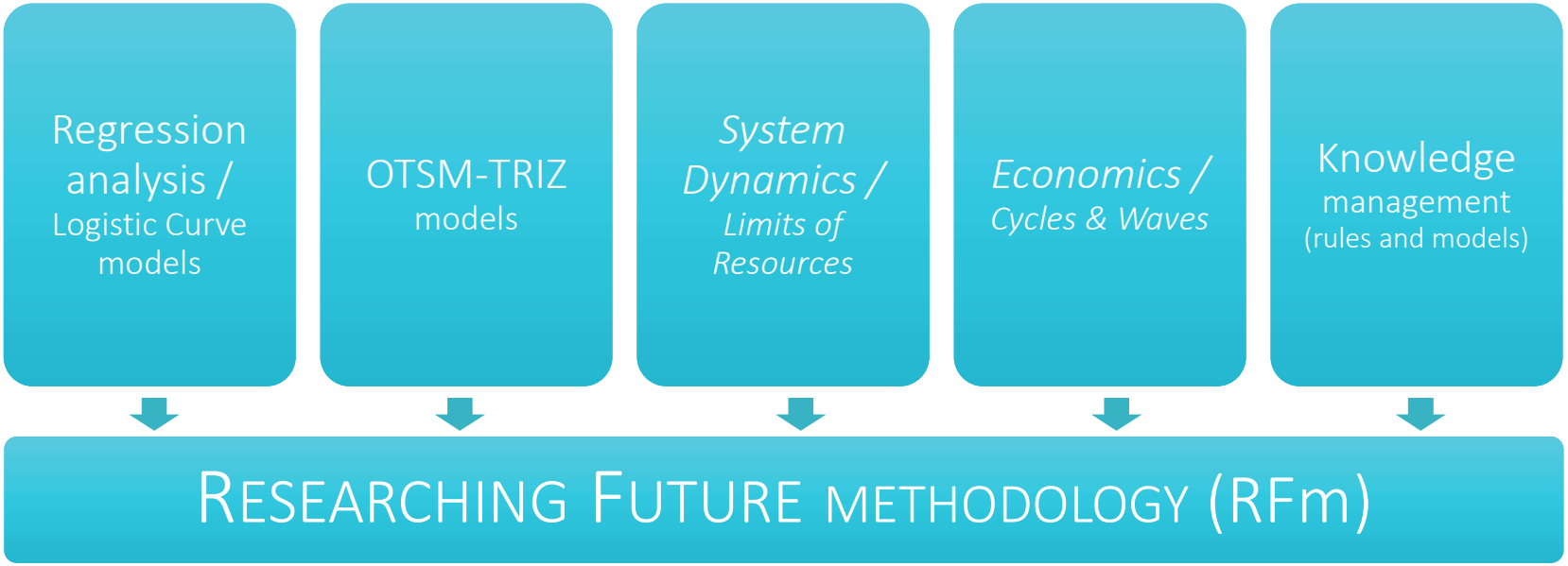
WHY?

HOW?

Problems are more important than solutions. Solutions can become obsolete when PROBLEMS remain

Niels Bohr (1985-1962)
a Danish physicist who made foundational contributions to understanding atomic structure and quantum theory, for which he received the Nobel Prize in Physics in 1922

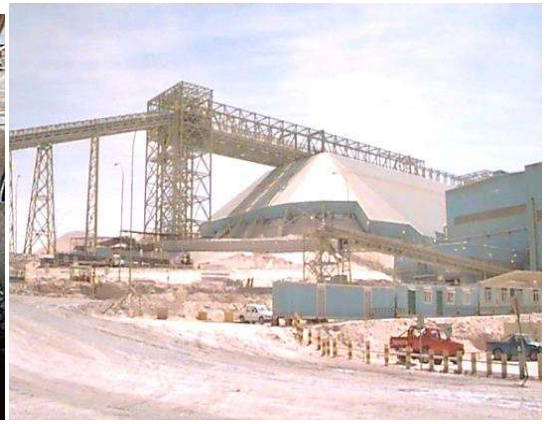
Researching Future methodology / basic components



size reduction technology

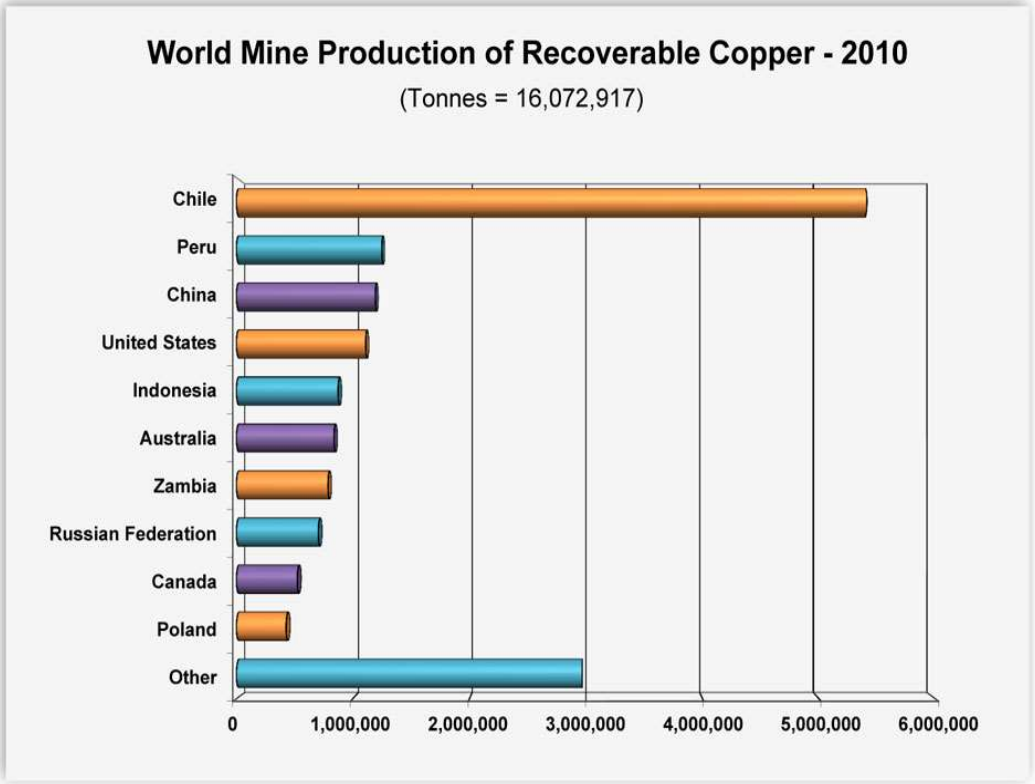
- cooper ore size-reduction technologies (until 2045 in Chile)
- size-reduction technologies life-cycle?
- neXt technology?
- gaps of knowledge and path from today → neXt ?





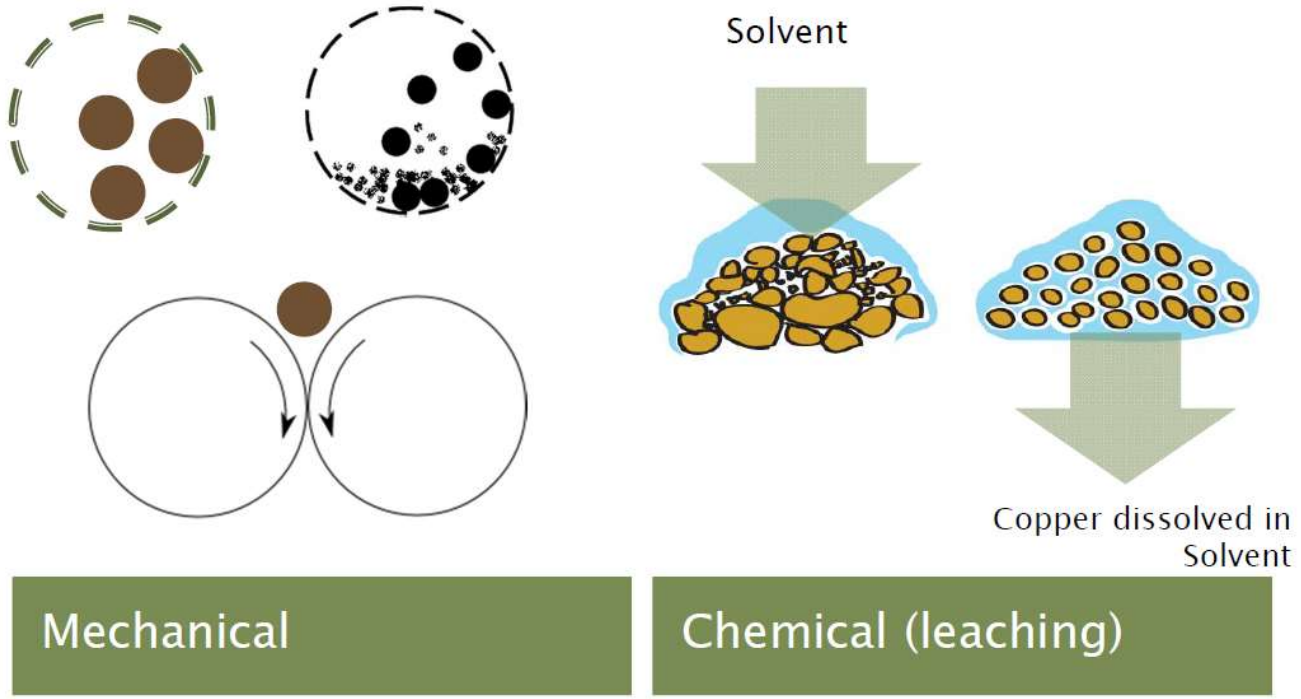
* 2011-2012 : Project - Forecasting the parameters of the technological dynamics of a technological core area of Chilean mining industry, CBC, Santiago, Chile

cooper production by country

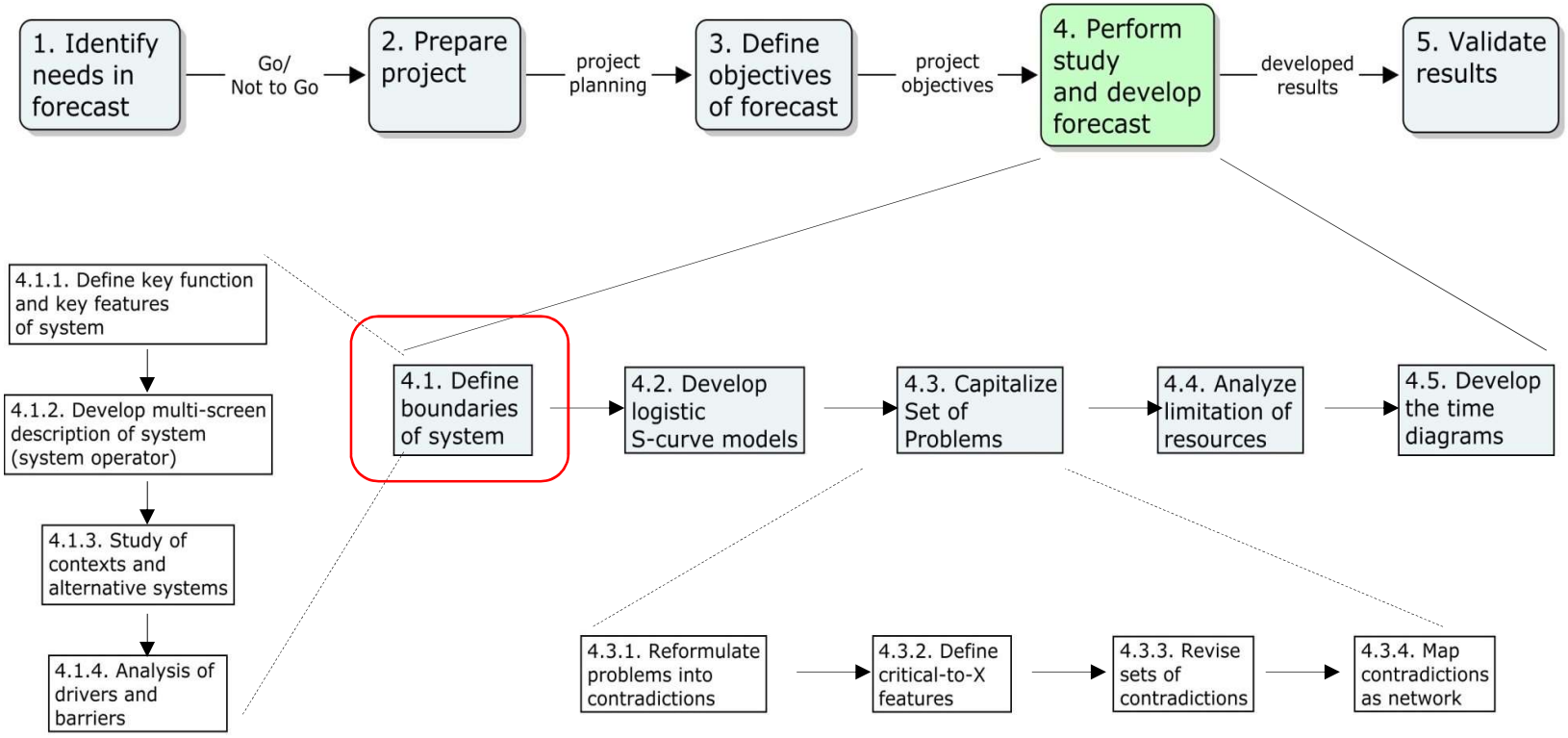


Source: International Copper Study Group

existing technologies



researching future flowchart

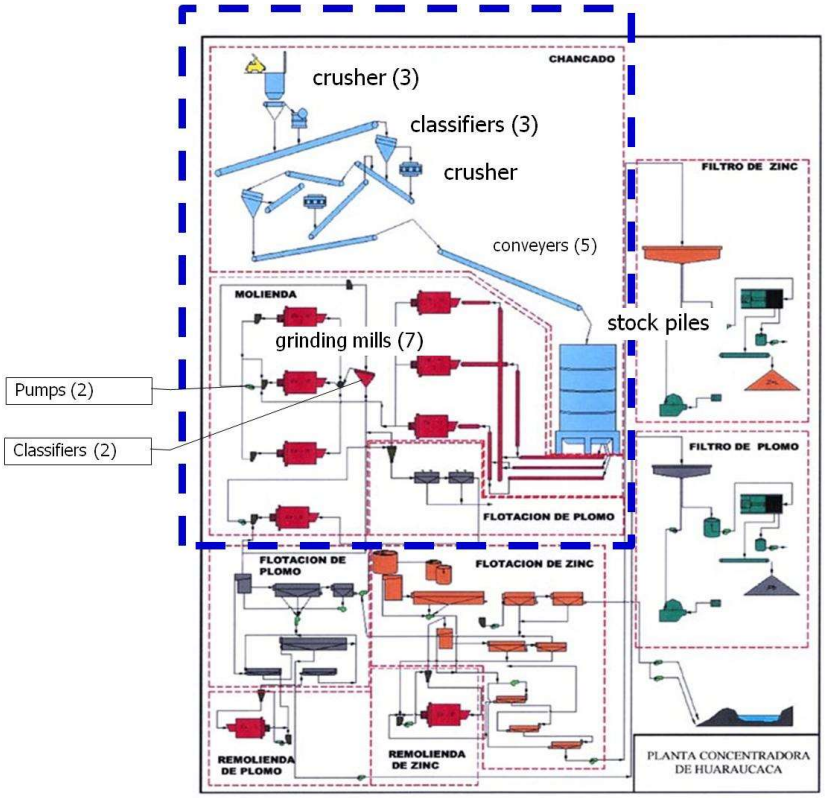


boundaries of system

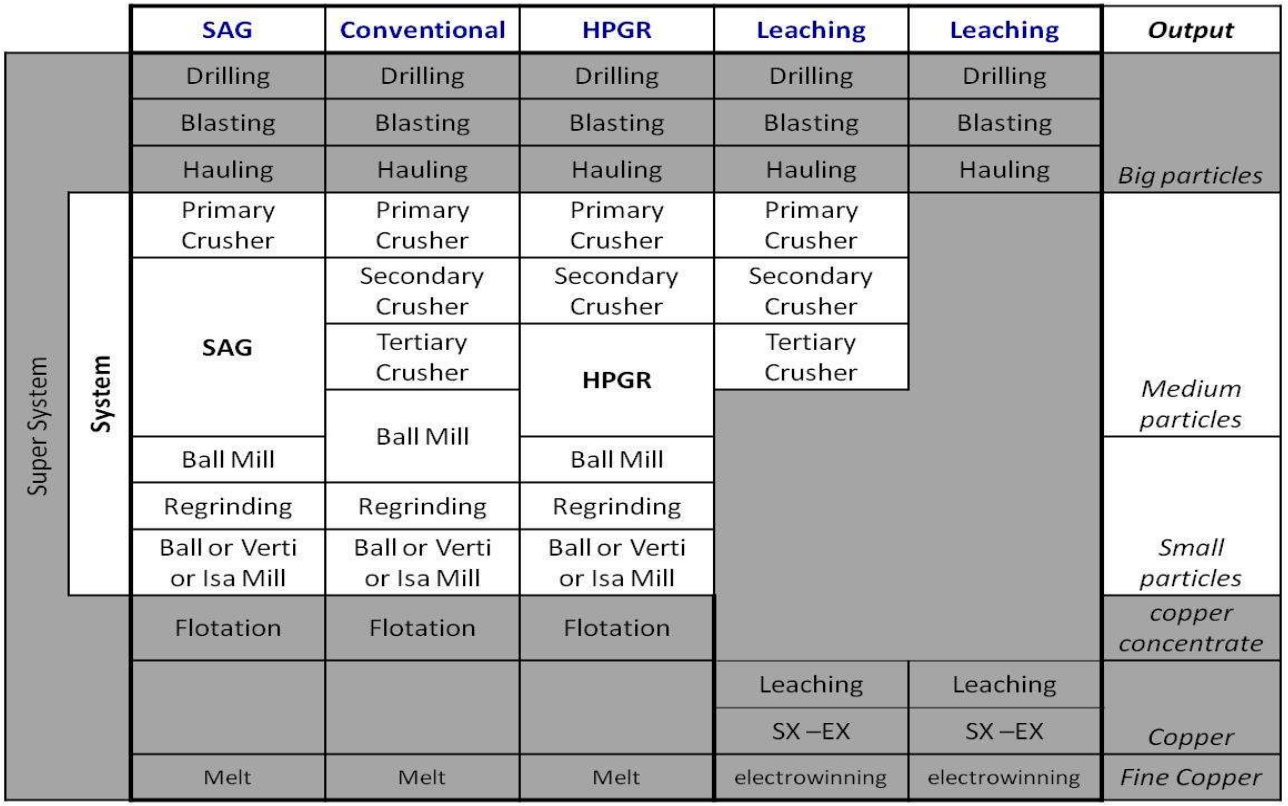
PROCESS:
to <reduce> <size> of ore lumps

to <expose> the surface of mineral particles

as a part of process
to <increase> <concentration> of copper

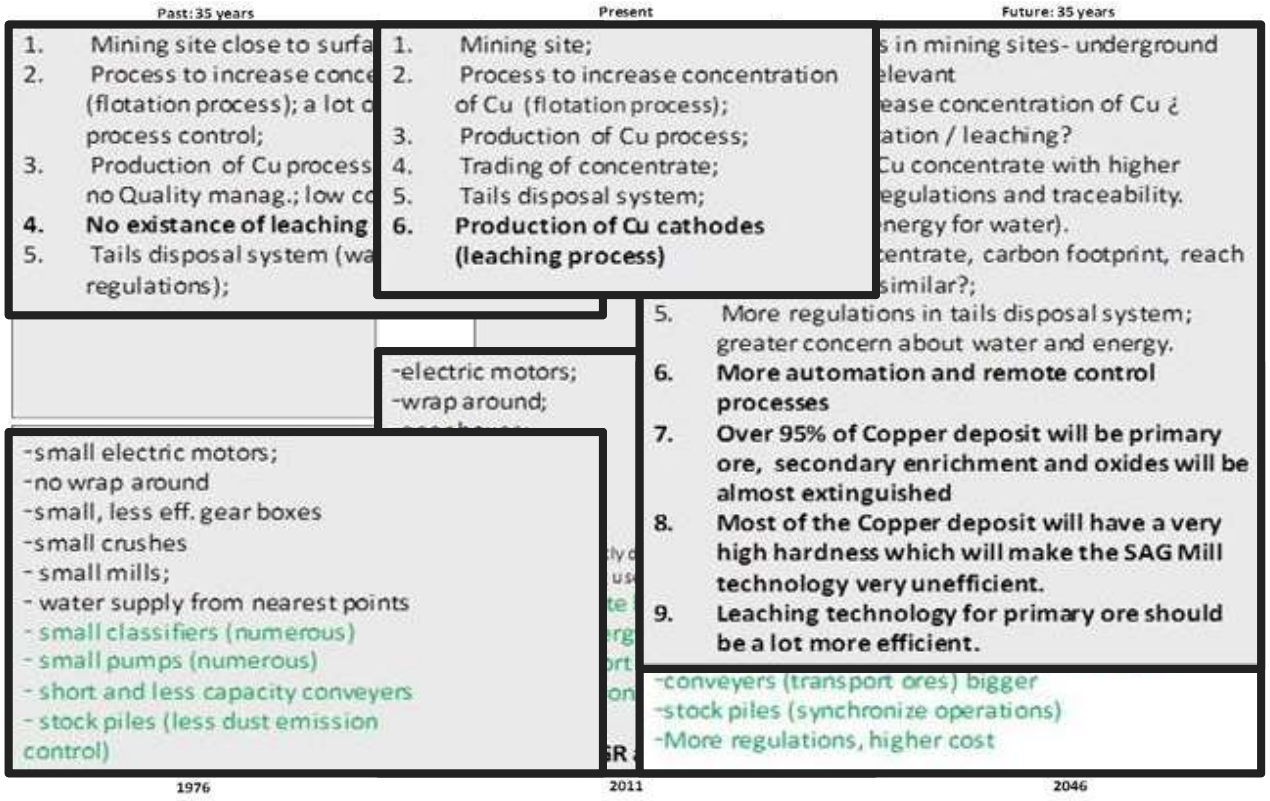


alternative technologies

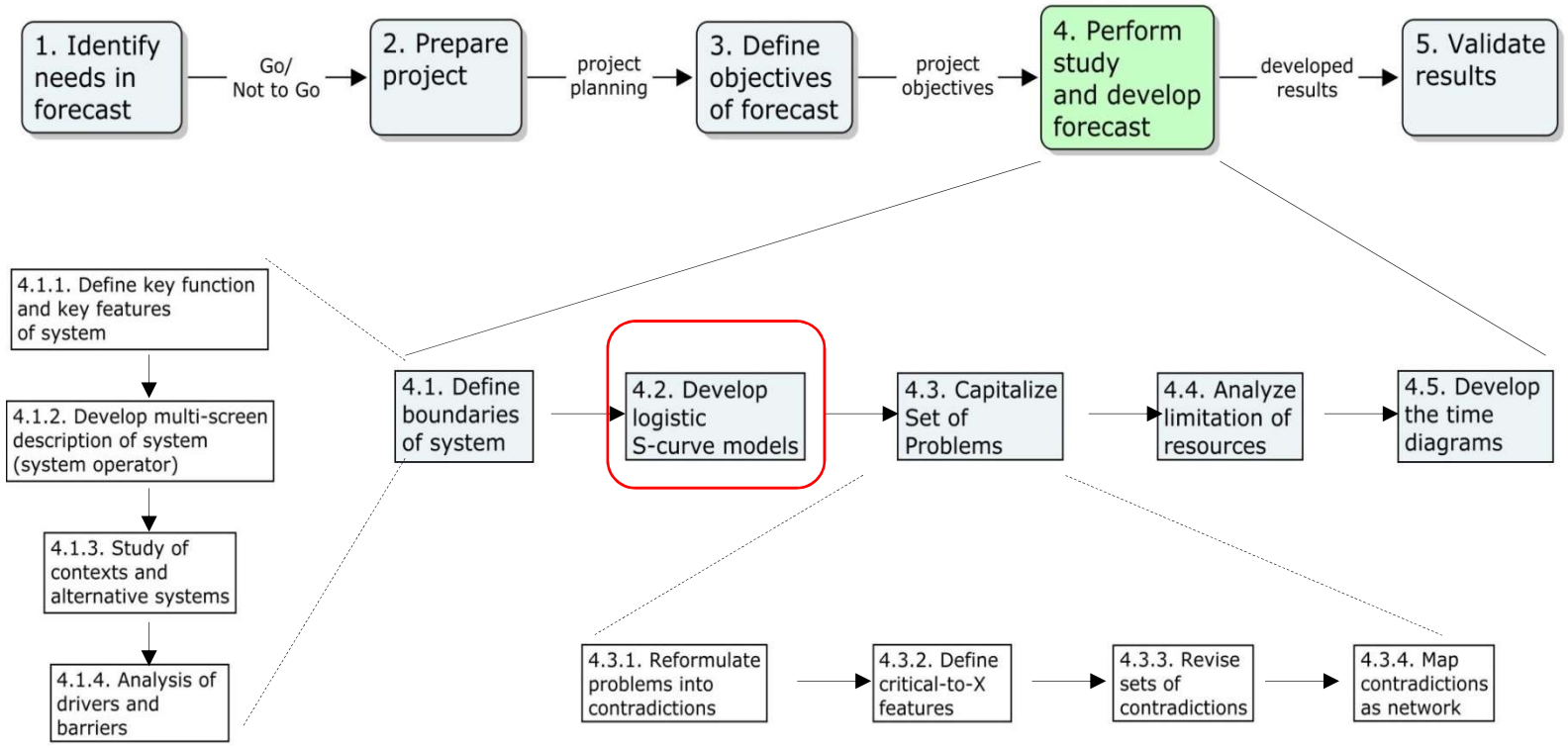


		SAG	Conventional	HPGR	Leaching	Leaching	Output
Super System		Drilling	Drilling	Drilling	Drilling	Drilling	
		Blasting	Blasting	Blasting	Blasting	Blasting	
		Hauling	Hauling	Hauling	Hauling	Hauling	*Big particles*
	System	Primary Crusher	Primary Crusher	Primary Crusher	Primary Crusher		
		SAG	Secondary Crusher	Secondary Crusher	Secondary Crusher		
			Tertiary Crusher	**HPGR**	Tertiary Crusher		*Medium particles*
			Ball Mill				
		Ball Mill		Ball Mill			
		Regrinding	Regrinding	Regrinding			
		Ball or Verti or Isa Mill	Ball or Verti or Isa Mill	Ball or Verti or Isa Mill			*Small particles*
		Flotation	Flotation	Flotation			*copper concentrate*
					Leaching	Leaching	
					SX –EX	SX –EX	*Copper*
		Melt	Melt	Melt	electrowinning	electrowinning	*Fine Copper*

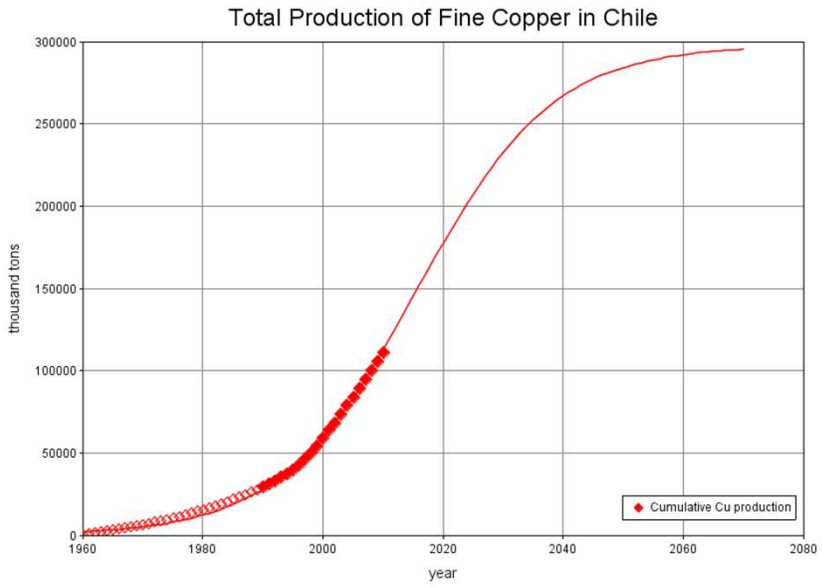
multiscreen view

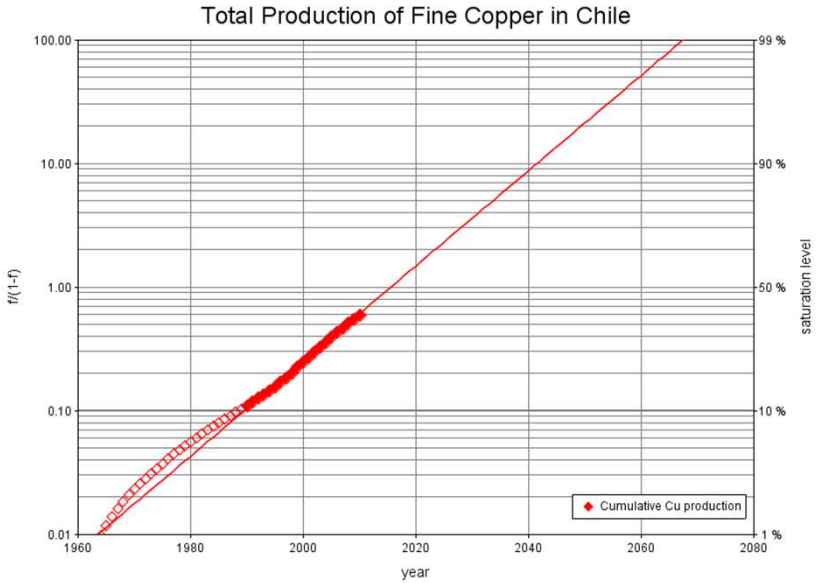


researching future flowchart



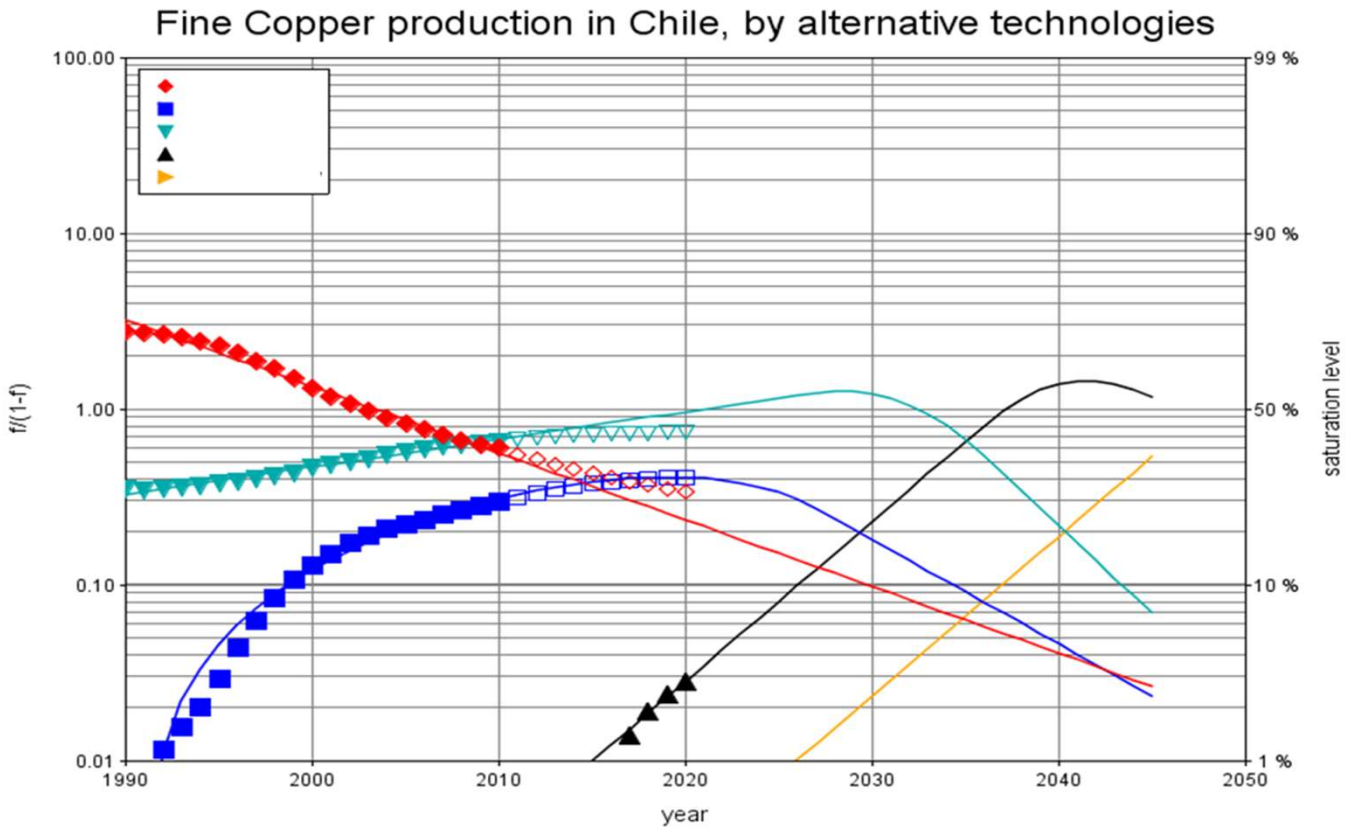
cumulative production of fine copper (99.99%) in Chile



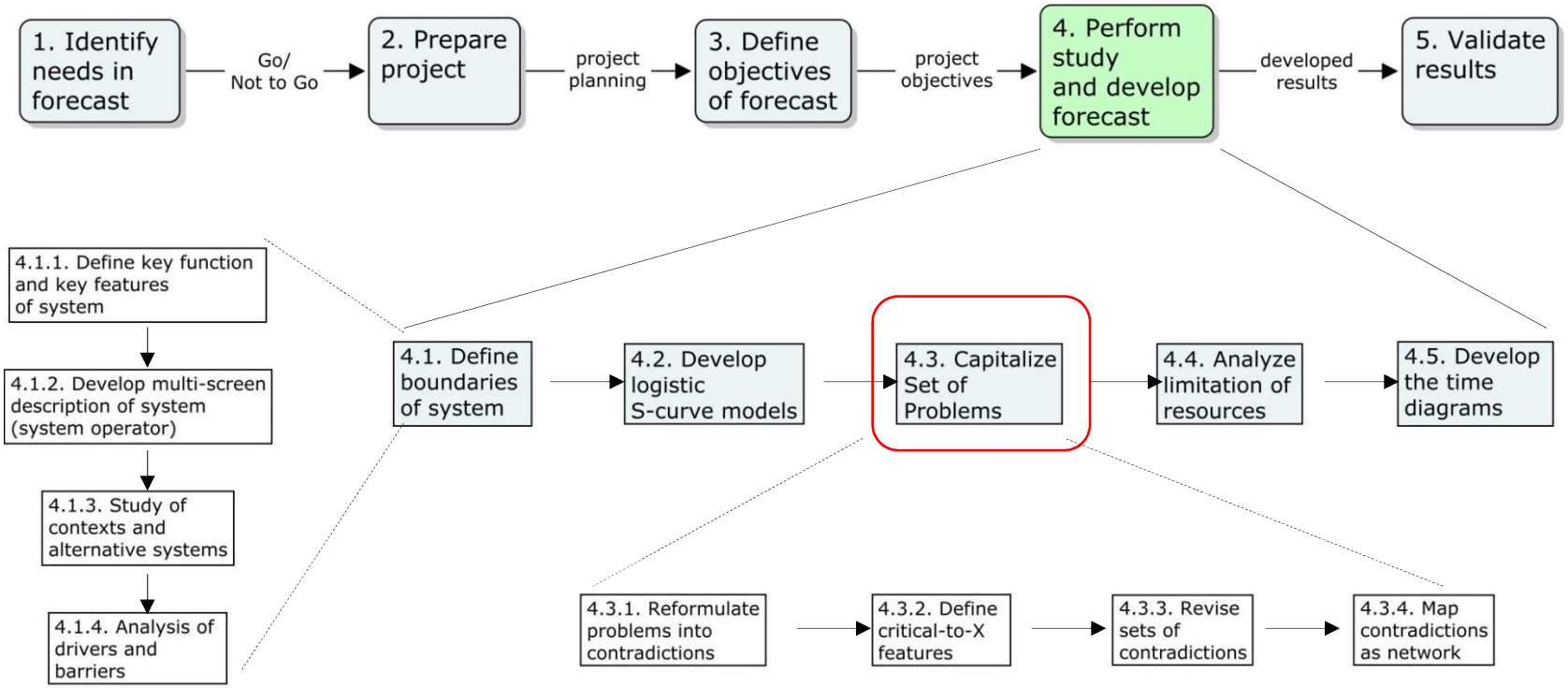


Applied data series are for period 1991-2010.
Estimated upper limit of growth (K) is about 297,750.4 kt;
midpoint of growth trajectory (tm) is about 2015.6 year;
characteristic duration of growth (Δt) is about 49.5 years.
Rsq=0.99

what will be the lifecycle of size-reduction technology?



researching future flowchart



Problems are more important than solutions. Solutions can become obsolete when PROBLEMS remain

Niels Bohr (1985-1962)
a Danish physicist who made foundational contributions to understanding atomic structure and quantum theory, for which he received the Nobel Prize in Physics in 1922

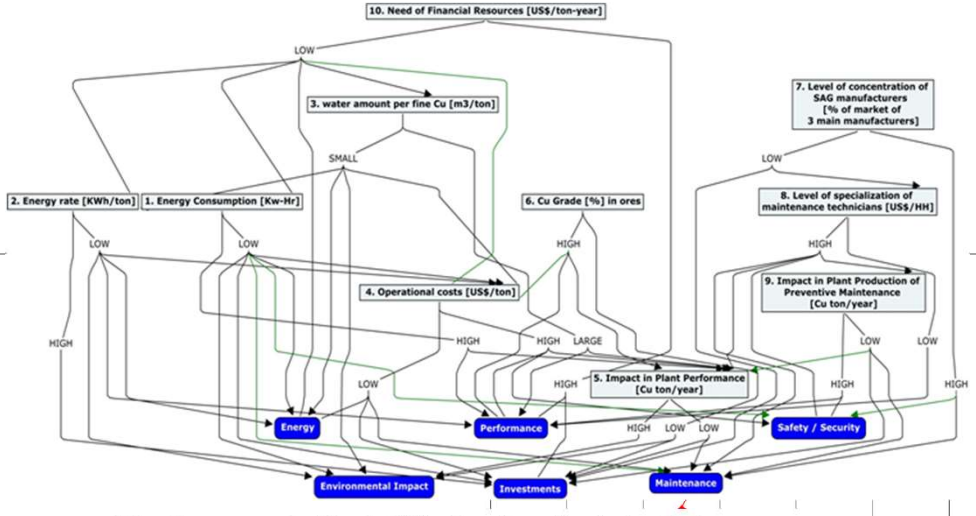
WHAT?

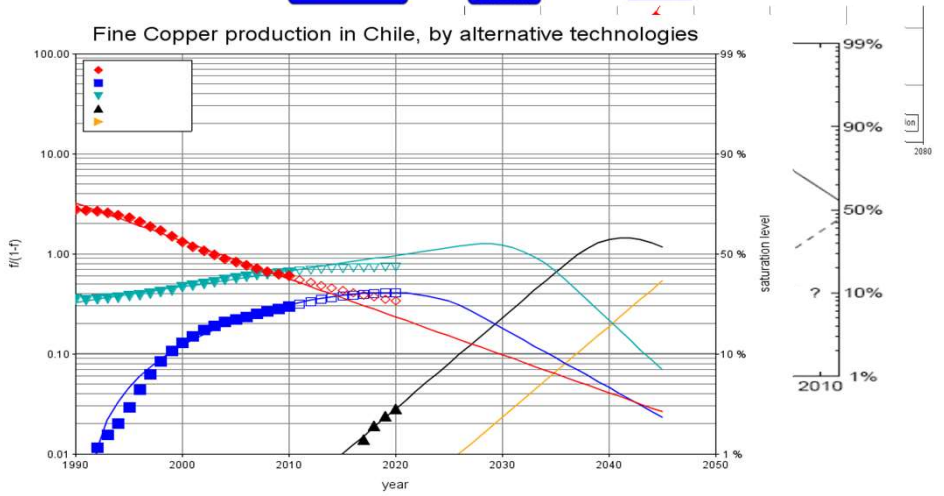
WHEN?

WHERE?

WHY?

HOW?

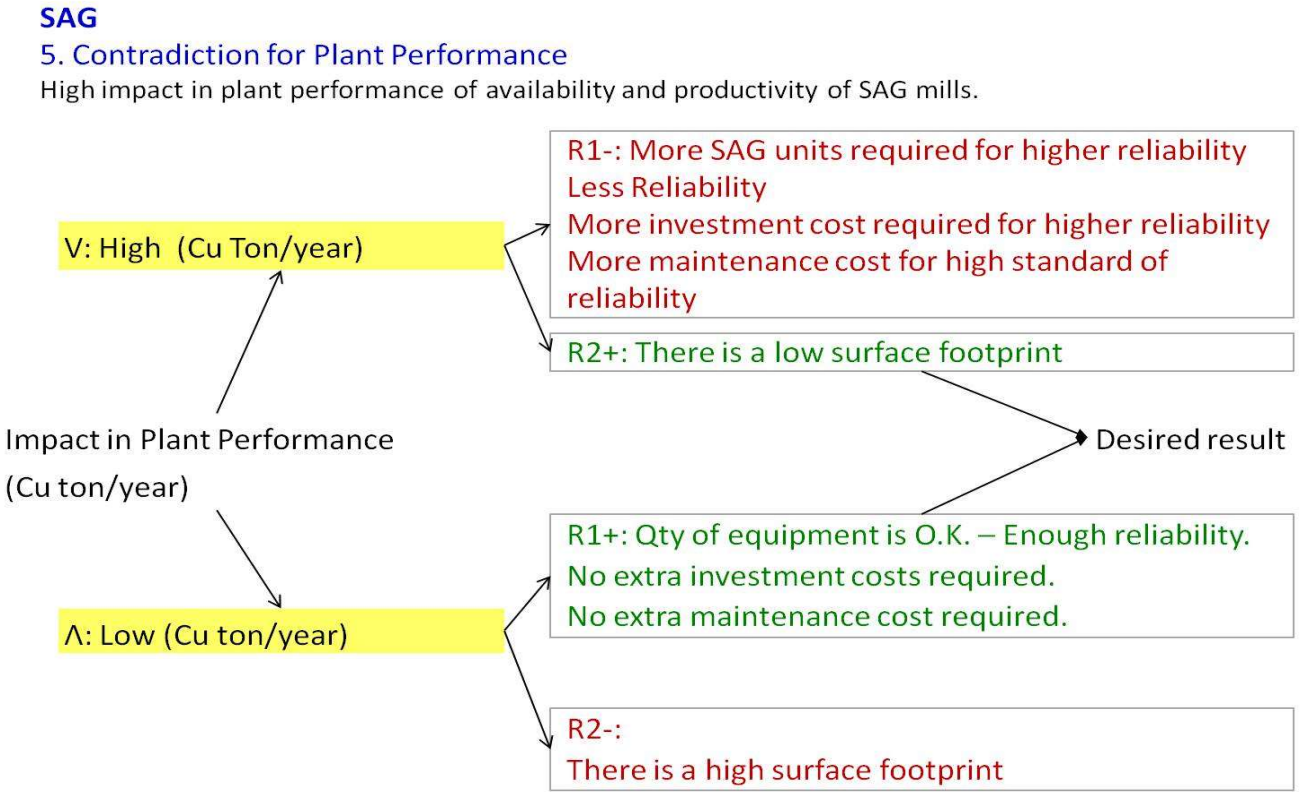




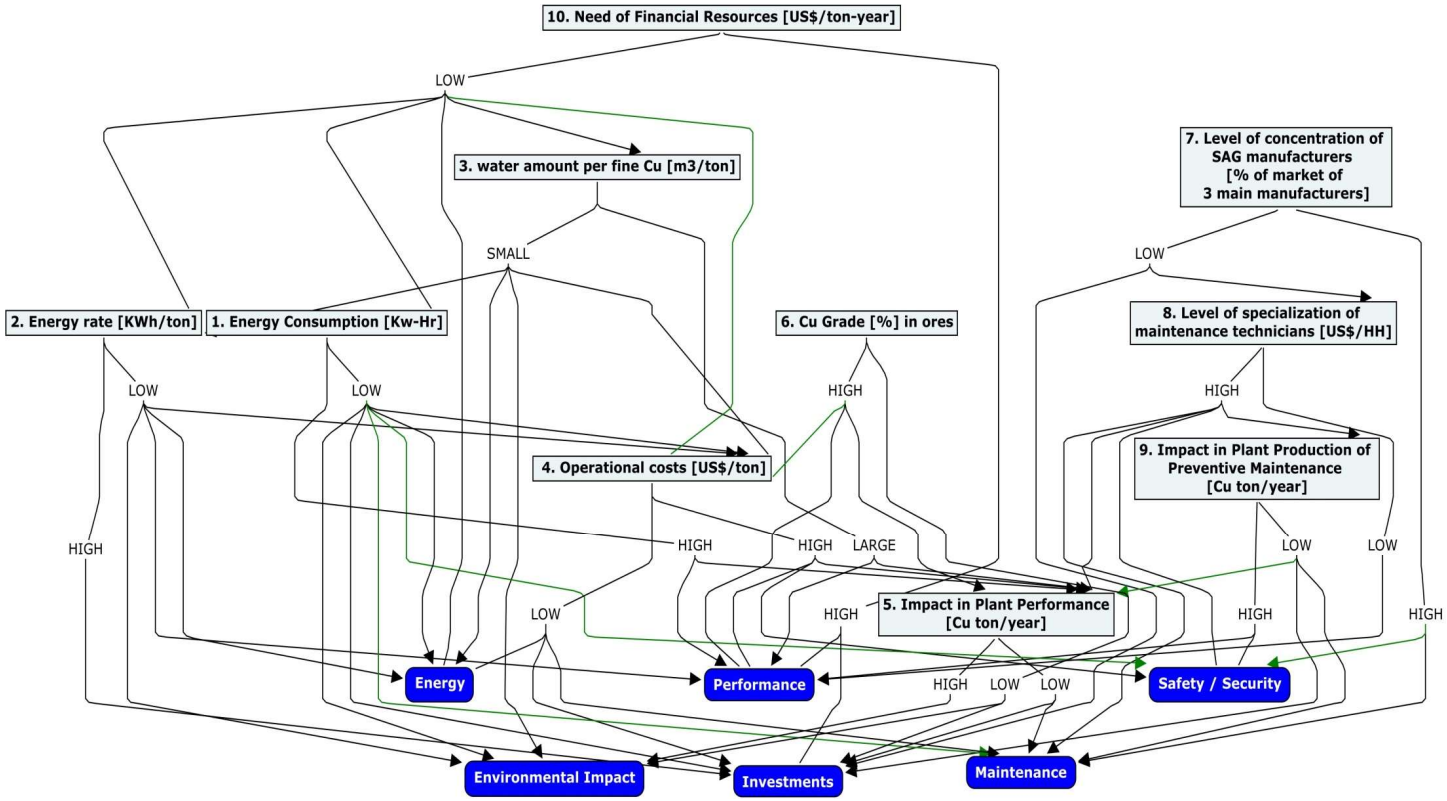
lists of problems

#	Conventional	SAG	HPGR	LEACHING
1	High energy consumption and number of equipment generates a high carbon footprint.	Highest energy consumption generates de highest carbon footprint.	No problem with water.	Not well controlled process.
2	Lack of energy efficiency because of high number of electric equipment with low efficiency electric motors and distribution systems.	Lowest energy efficiency because of high energy consumption of SAG mills.	No problem with financial resources .	Need of a large surface available.
3	There is a lot of water losses during the process.	There is a lot of water losses during the process.	Lack of experience in Copper application.	Low Copper recovery.
4	High number of equipment and interconnection systems makes very complex engineering facilities.	High operational costs because of complex control systems and maintenance costs for SAG mills.	No problem with maintenance costs	Poor safety conditions for operators.
5	Energy consumption and higher number of operators due to higher number of equipment and less automation control makes operational costs the highest of four technologies.	High impact in plant performance of availability and productivity of SAG	Higher probabilities of failures in operation because of higher human intervention.	Not a good option for ores with high percentage of Cu.
6	Needs of a large operational period because of high investment costs for pay back.	Not a good option for ores with low percentage of Cu.	Reduced availability of specialized technicians in Chile for HPGR.	Restrictions of special temperature conditions for bacterial leaching.
7	Large footprint because of high number of equipment and large process net.	Concentrated industry of SAG mills manufacturers.	Concentrated industry of HPGR manufacturers.	Largest processing time.
8	Higher probabilities of failures in operation because of higher human intervention.	Highly specialized technicians for maintenance assistance.	Preventive maintenance of HPGR has a high impact in plant production.	
9	Higher maintenance costs because of high number and different kinds of equipment.	Preventive maintenance of SAG mills has a high impact in plant production.		
10		Need of the highest financial resources of the four technologies.		

an example of contradiction



map of contradictions [SAG-technology]



what will be the neXt technology? (list of features)

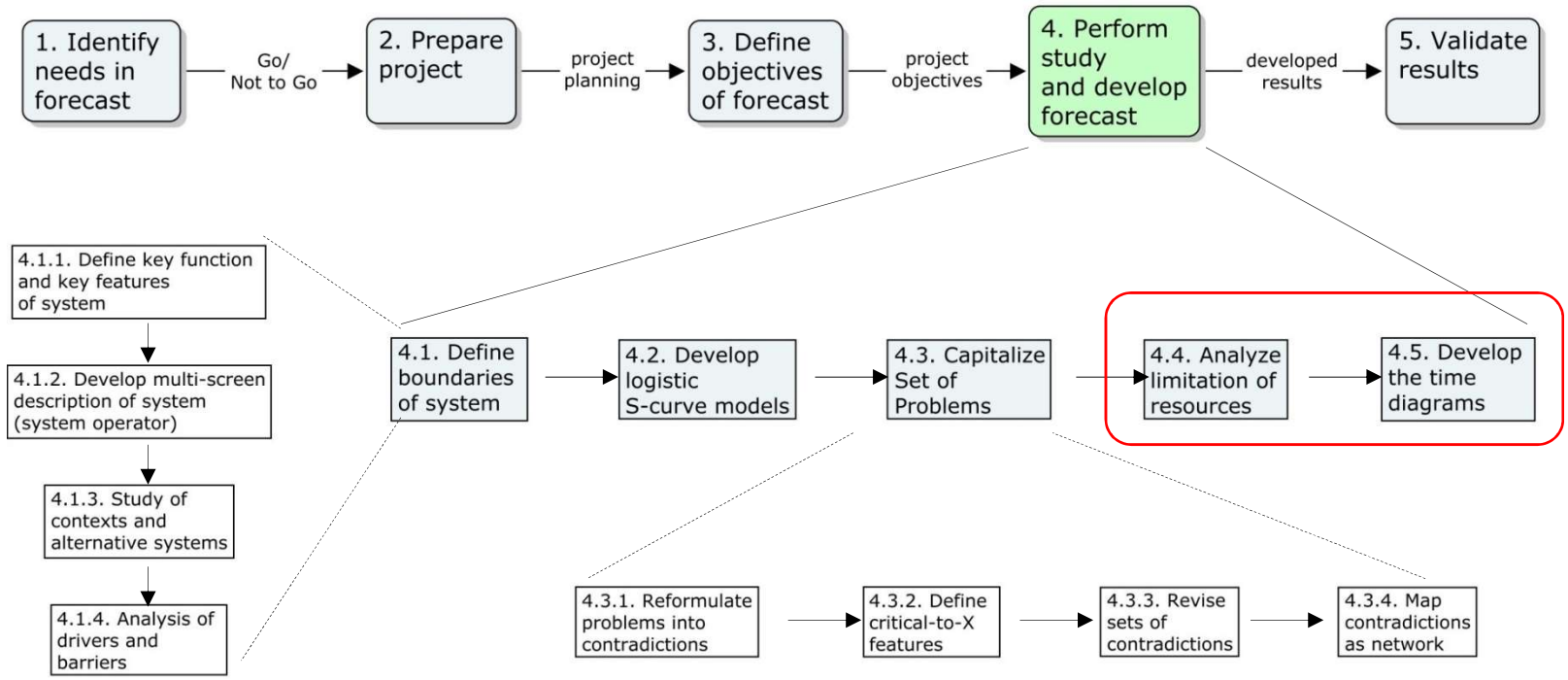
FUNCTION : <EXPOSE> THE SURFACE OF MINERAL PARTICLES

features of future system
1. Operational Availability will be as high as actual values for HPGR;
2. Energy Consumption will be less (or equal) to 8Kwh/ton feed (best of available today)
3.1 Water Consumption will be less that 0.01 m^3/ton feed
3.2 Carbon Footprint will be less (or equal) to 2 TonCO2/Ton Fine Cu
3.3 Surface Footprint will be lower (occupy less area) in m^2, i.e. less than actual values for SAG, or HPGR
4. Accident Rate will go beyond the actual value of HPGR, i.e. it will decrease
5. Investment Costs will be lower, i.e. similar to actual values for LEACHING (US$/ton-year)
6. Maintenance Cost will be similar (or less) to actual values for LEACHING technology today (0,3 US$/ton)

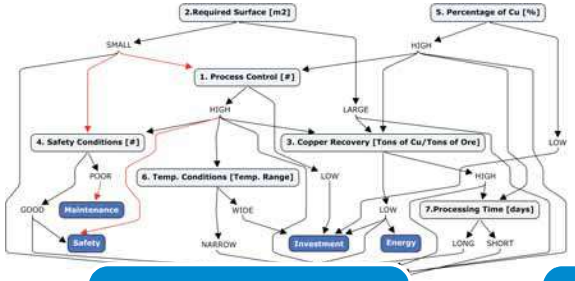
relevant changes in super-systems (system operator for Chile, in 35 years)

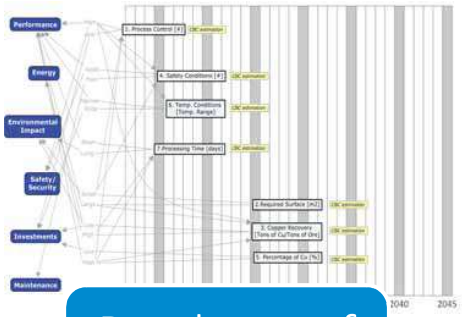
characteristics of future SUPER-SYSTEMS
1. Lower percentage of Cu in ores, near 0,4% (average)
2. Over 95% of Copper deposit will be primary ore, secondary enrichment and oxides will be almost extinguished
3. Greater volume of ore to process will make distances larger and time longer for transportation
4. More automation and remote control processes
5. Increase in operational costs if trading prices increases
6. Most of the Copper deposit will have a high hardness which will make the SAG Mill technology very inefficient
Family of neXt technologies: What will be the conditions in the mining sites in future? Deepness of mining, % of Cu in ores, hardness of ores, size of mining sites (proven reserves)?

researching future flowchart



from maps of problems to roadmaps



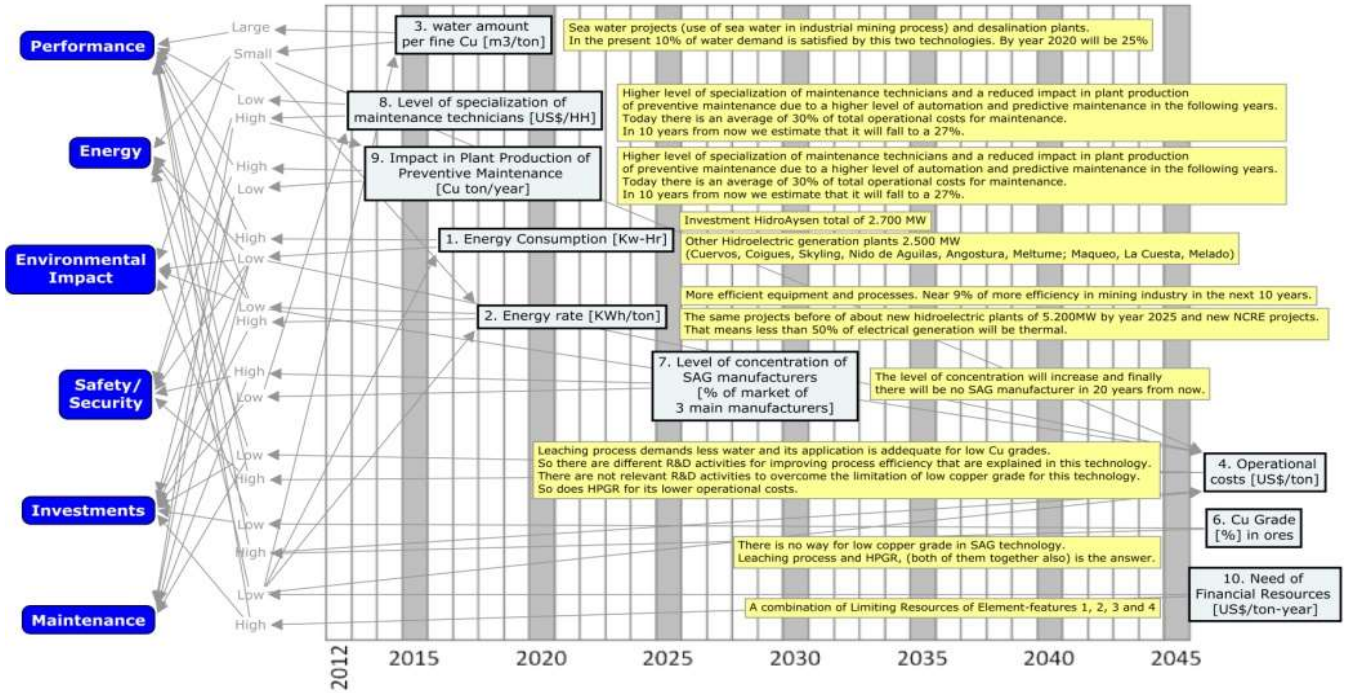


Map of Contradictions → Analysis of Limiting Resources → Roadmap of neXt Technology

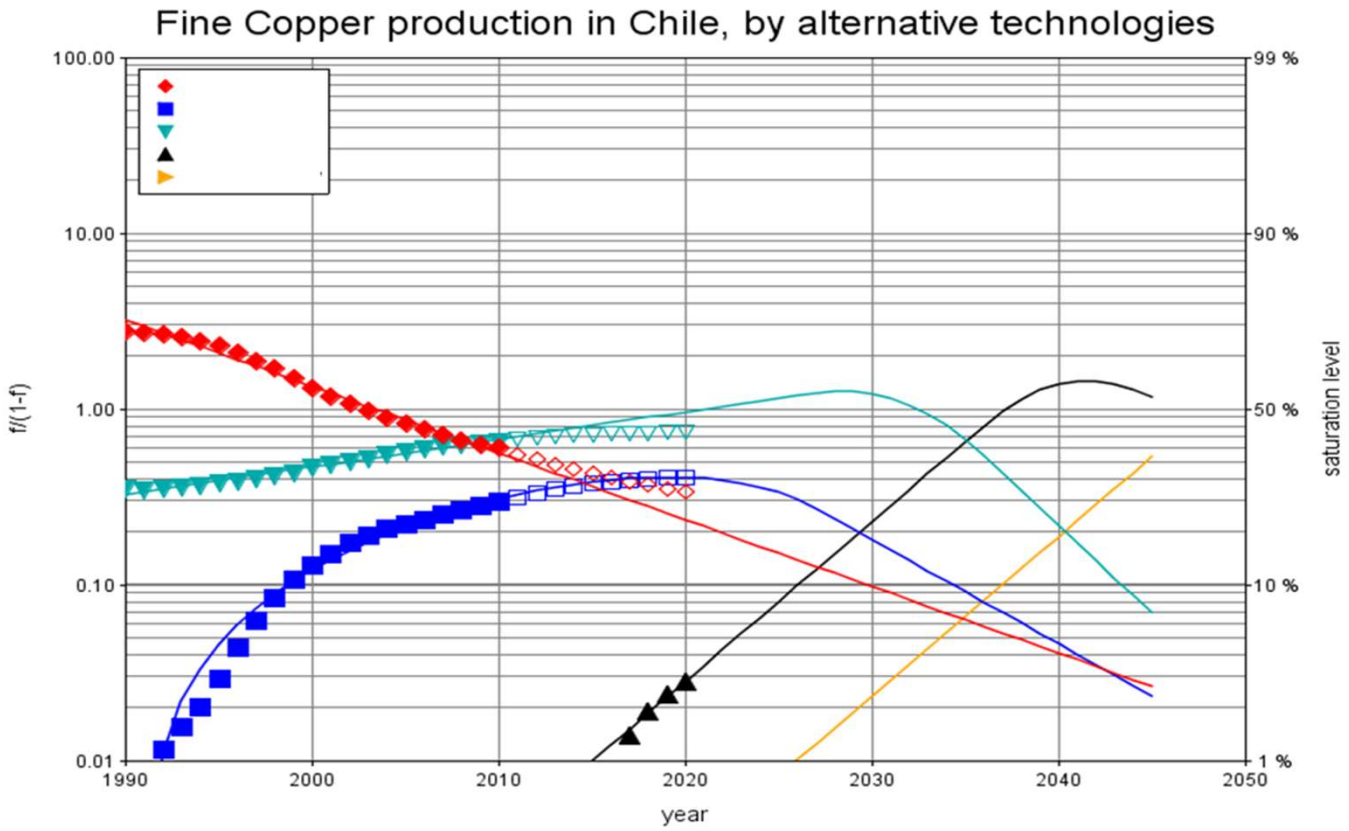
element-feature	demand	cause	Limiting resources	R&D Activities (name of projects)	Exploration time	Implementation time	total time, months	Notes	Source
1. Process Control [#]	High	4. Safety Conditions [#]	1) Skilled workers and 2) Time	The leaching process has a very poor process control in the leaching pile. There are projects in the implementation phase for controlling what happens in the surface of the pile, but the reality of the inside of the pile remains uncontrolled. There is an estimation that in 5 years from now there will be solution for a real improvement in process control.		60	60	Estimation from CBC	
1. Process Control [#]	low	Investment							
1. Process Control [#]	High	6. Temp. Conditions [Temp. Range]							
1. Process Control [#]	High	Performance							
1. Process Control [#]	High	3. Copper Recovery [Tons of Cu/Tons of O							
2.Required Surface [m2]	Large	3. Copper Recovery [Tons of Cu/Tons of O	Space (available surface with industrial aptitude)	There are different projects in the experimentation phase that will be implemented in the following years and that will have as a result an improvement in efficiency (same production for a reduced surface):				Estimation from CBC	
2.Required Surface [m2]	Small	4. Safety Conditions [#]							
2.Required Surface [m2]	Small	Investment							
2.Required Surface [m2]	Small	1. Process Control [#]		Bacteria genetic modification		120	120		
2.Required Surface [m2]	Large	Performance		Bacteria ecosystem modification		60	60		
2.Required Surface [m2]	Small	Environmental Impact		Concentrated ore leaching		240	240		

what is a path for implementation of new technologies?

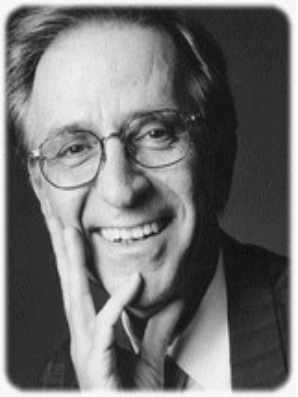
ROADMAP FOR SAG TECHNOLOGY



size-reduction technology substitution



The ultimate test of the forecaster is an accurate and reliable forecast not the elegant or easily applied method



Theodor Modis
Physicist, futurist, strategic analyst,
and international consultant

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MAPPING CONTRADICTIONS

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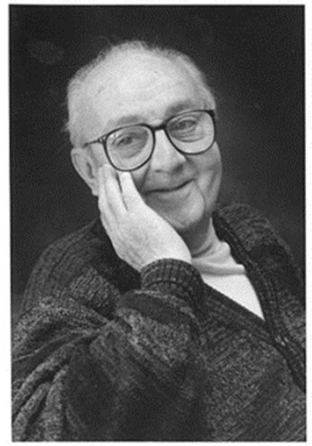
all models are wrong,
but some are useful



George E. P. Box (1919 –2013)

…statistician, who worked in the areas of quality control, time-series analysis, design of experiments, and Bayesian inference. He has been called "one of the great statistical minds of the 20th century…

THANK YOU

Dmitry KUCHARAVY
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