Sulfuric Acid Technology – Yesterday, Today, and Tomorrow世界硫酸生产工艺发展历史

15 June 2015, Hefei, Anhui Province合肥，安徽省

Matthew Viergutz 10:35~11:25AM

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Topics目录

- Yesterday: Past 30 Years – Innovation in Technology and Equipment

  昨天：过去的30年-技术和设备的变迁

- Today: Mega Trends and Industry Transformation

  今天：百万吨级趋势和工业化变革

- Tomorrow: Innovation Today for Tomorrow's Needs

  明天：今天创新为明天的需求

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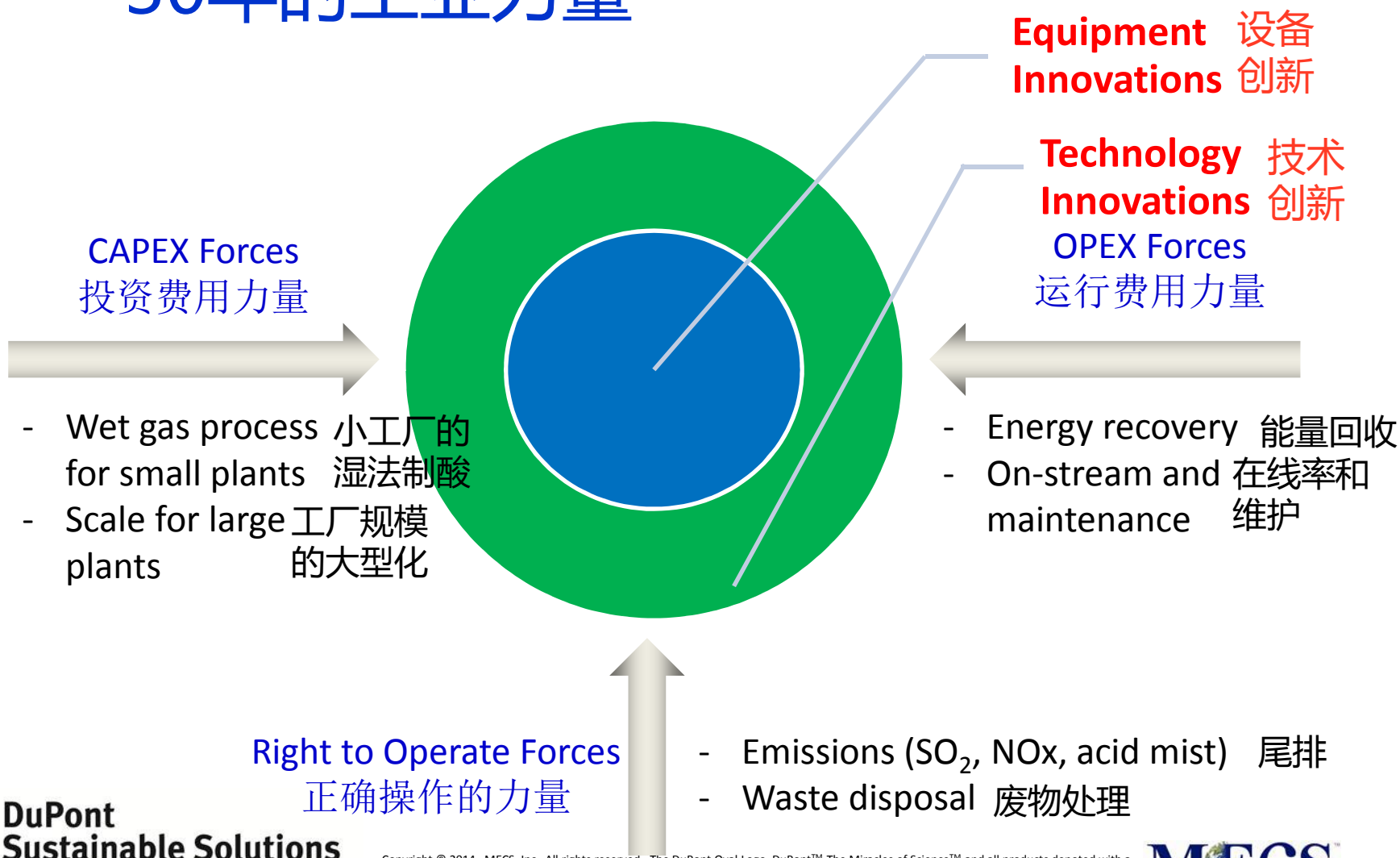
30-Year Industry Forces
30年的工业力量



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30-Year Industry Forces
30年的工业力量

Equipment Innovations 设备创新

Technology Innovations 技术创新

OPEX Forces
运行费用力量

- Energy recovery 能量回收
- On-stream and maintenance 在线率和维护

CAPEX Forces
投资费用力量

- Wet gas process for small plants 小工厂的湿法制酸
- Scale for large plants 工厂规模的大型化

Right to Operate Forces
正确地操作力量

- Emissions (SO_2, NOx, acid mist) 尾排
- Waste disposal 废物处理

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Cost Forces成本力量

- Small Plants – increased demand for small plants across several industries drove need for cost effective flow scheme (wet gas)

小型工厂—跨几个行业的增加的需求量需要小型硫酸工厂驱使成本更有效的工艺流向（湿法制酸）

- Large Plants – global competition drove need to leverage scale at world class fertilizer and non-ferrous metals sites

大型工厂—全球化的竞争驱使采用世界级的化肥厂和有色金属基地

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Wet Gas Summary湿法制酸总结

- 150+ plants in last 30 years在过去30年间有150个以上的工厂
- 120+ plants <100,000 tpy其中120个以上的工厂产能<100,000 吨/年
- Several industries: refining, coking, non-ferrous metals, gasification, fibers, etc.跨越几个行业：炼油、炼焦、有色金属、气化、纤维等等
- Environmental/substitute need环保/替代品的需求
- Trade-off: lower CAPEX versus higher ongoing OPEX (onstream time)
  权衡：更低投资同更高在线运行费用（在线时间）
- Technology drivers:技术驱动因素：
  - Simplified flowscheme简化的工艺流向
  - Market tolerance for low volumes of off-spec acid concentration市场容忍少量的不符合酸浓规格的酸

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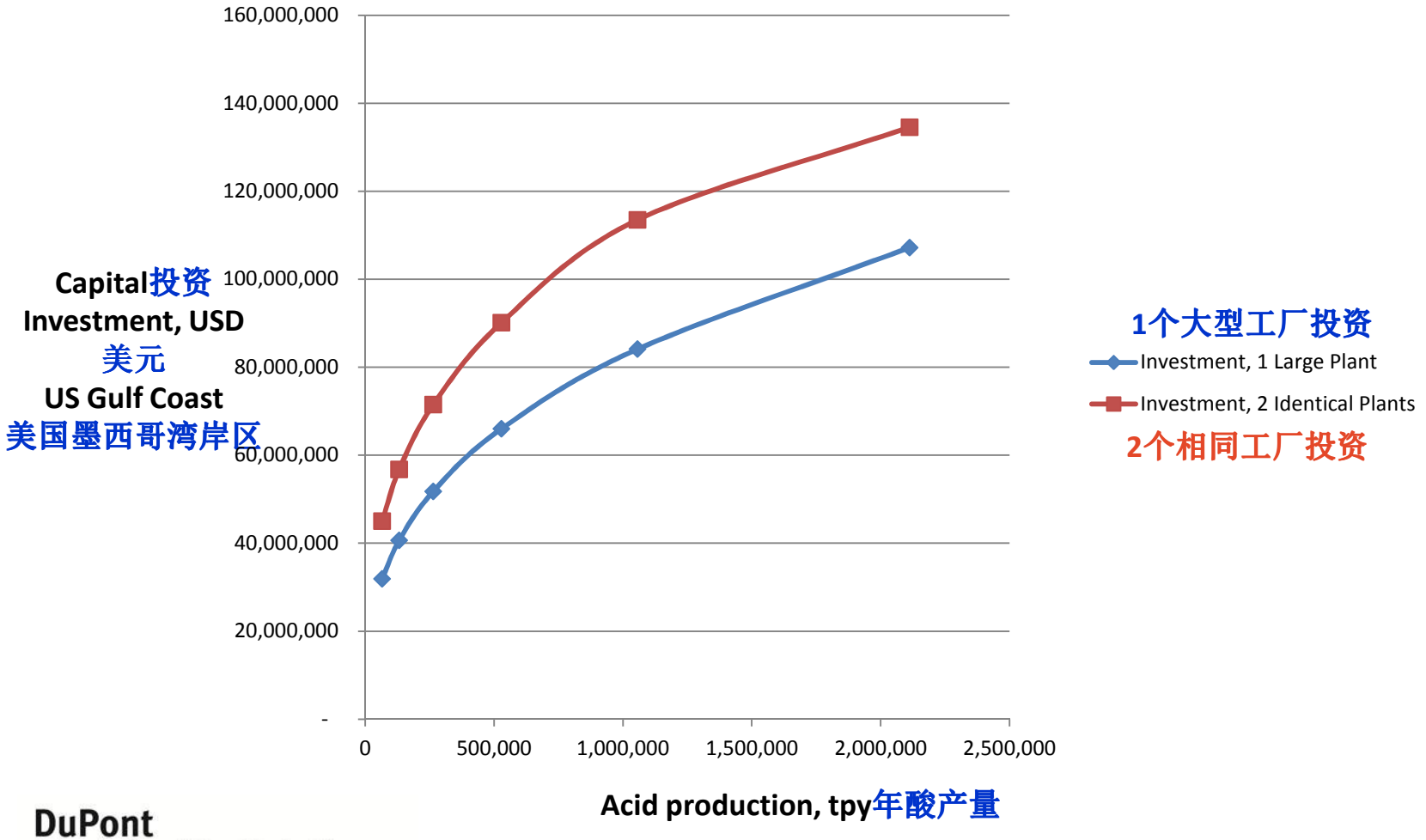
Mega Plant Issues大型工厂问题



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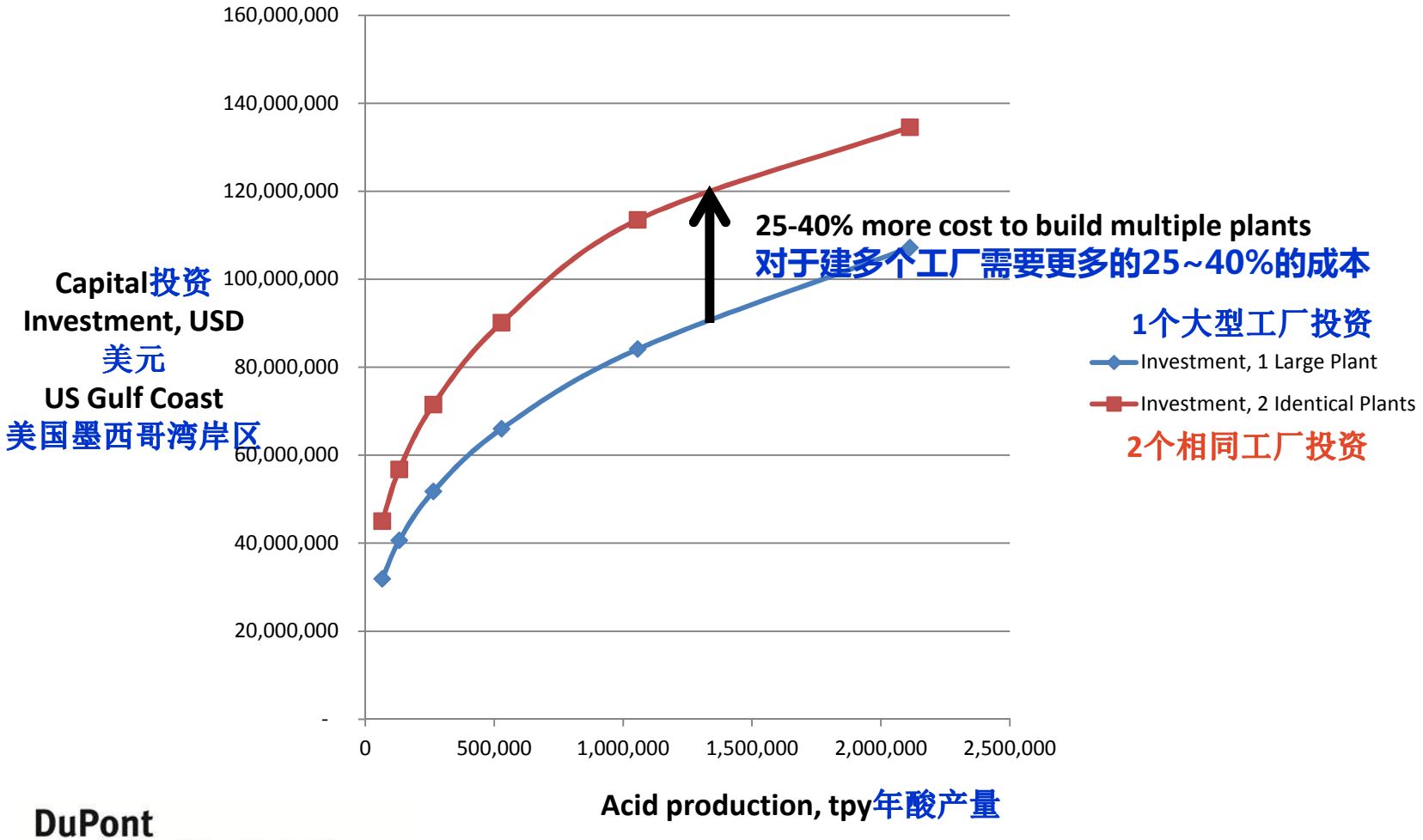
Mega Plant Issues大型工厂问题



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When have Mega Plants been developed?

百万吨级的硫酸厂是什么时候发展起来的？

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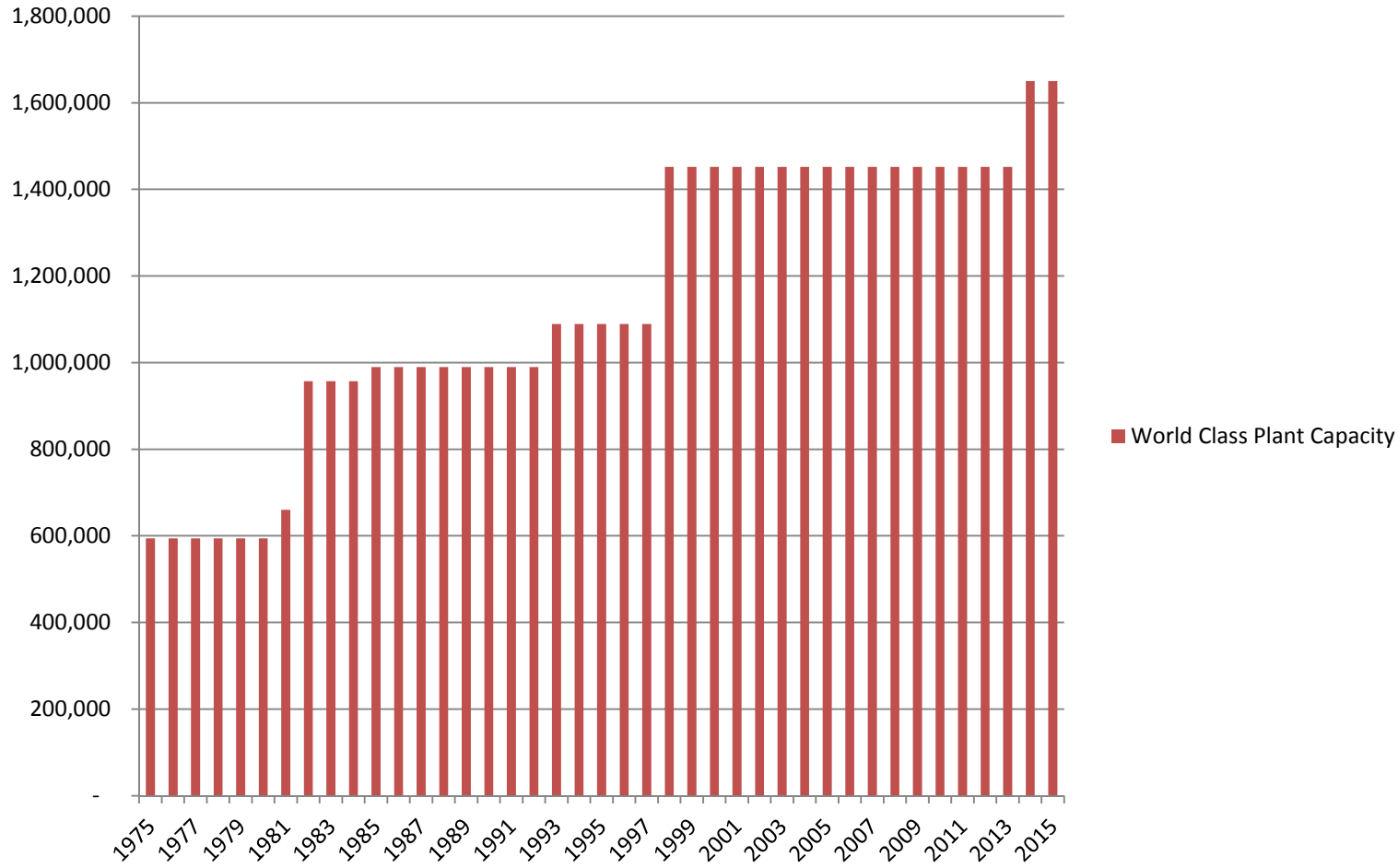
World Class Plant Capacity – 1 Train

世界级硫酸厂产能—单一工厂



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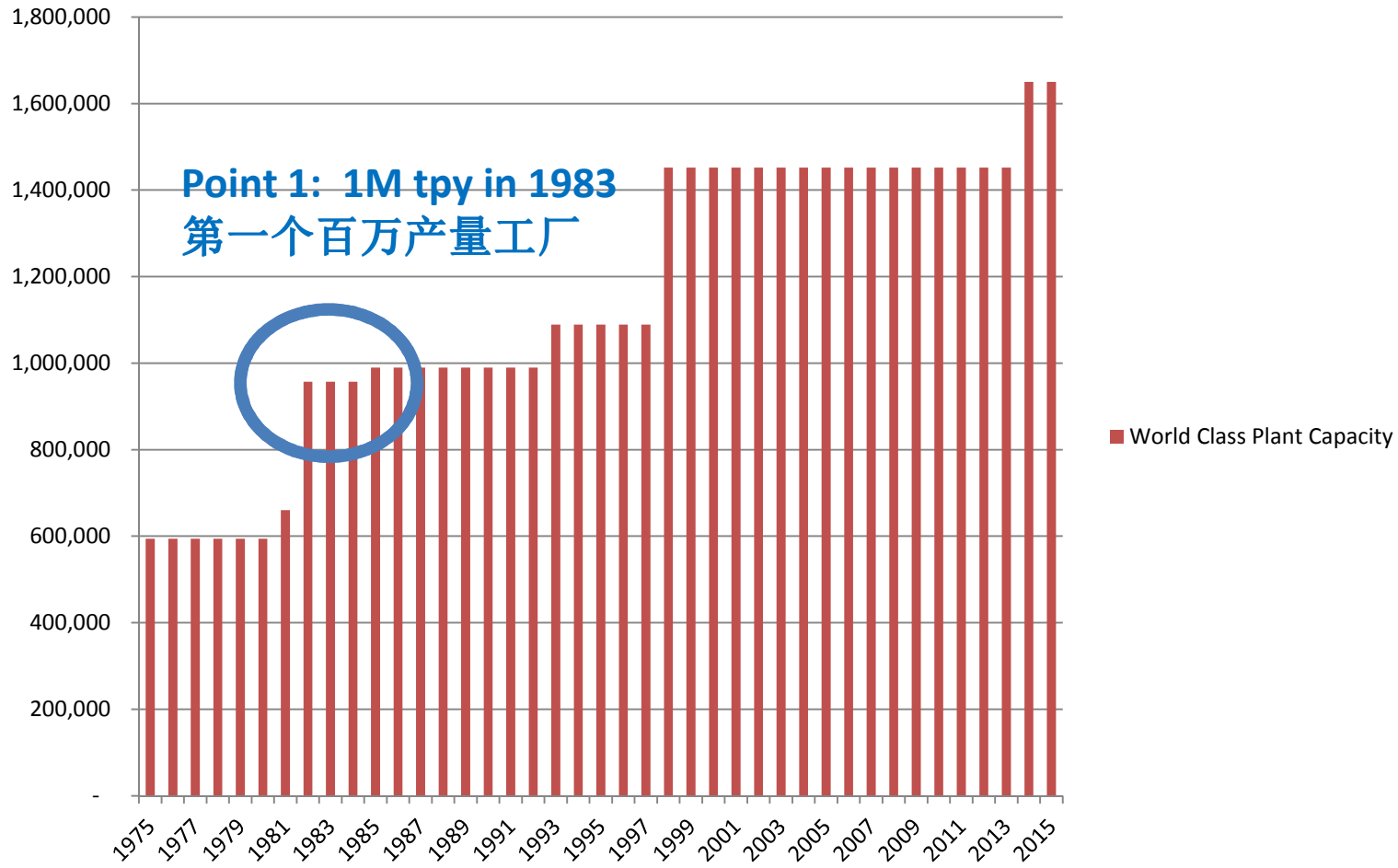
World Class Plant Capacity – 1 Train

世界级硫酸厂产能—单一工厂



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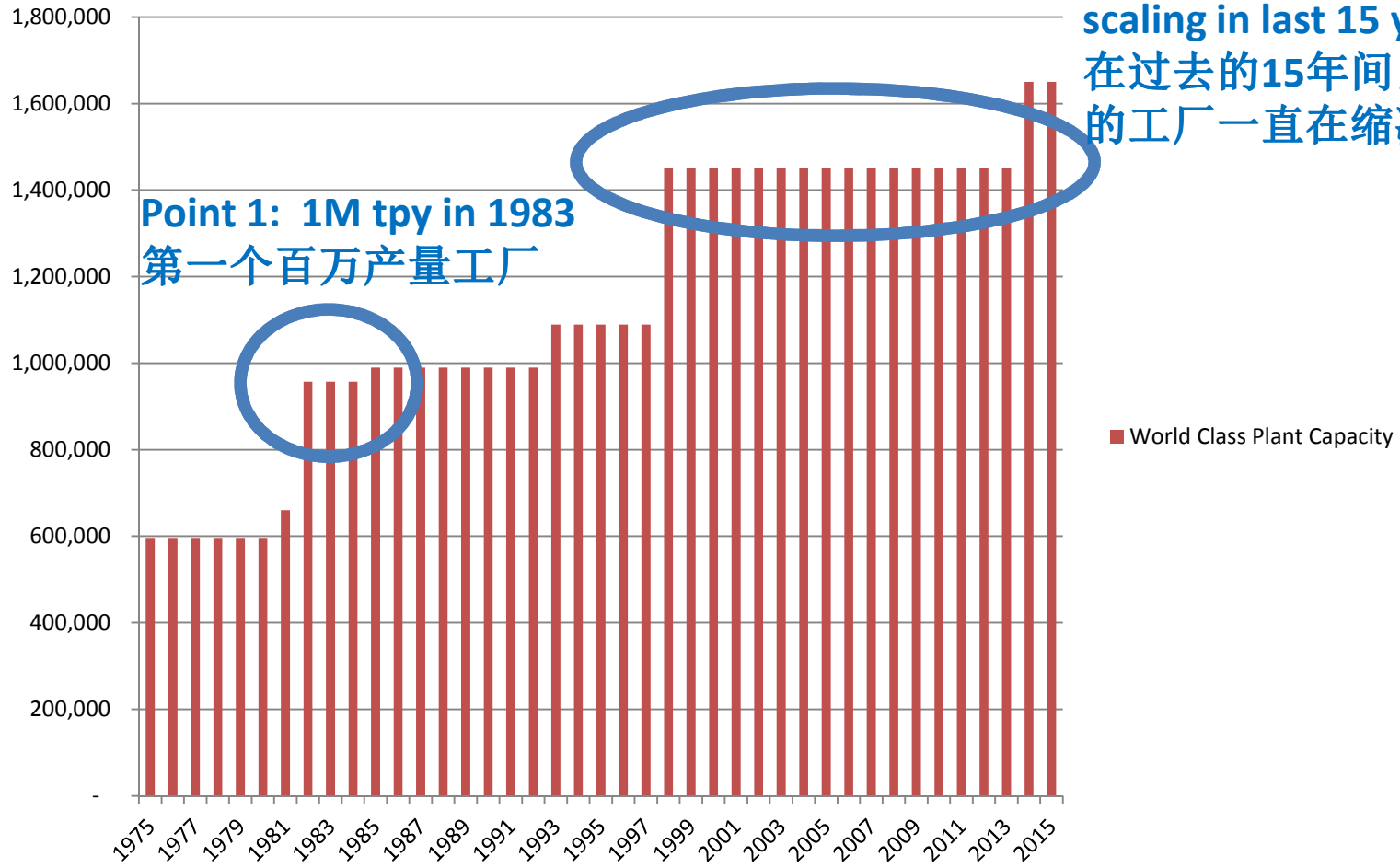
World Class Plant Capacity – 1 Train

世界级硫酸厂产能—单一工厂



Point 1: 1M tpy in 1983
第一个百万产量工厂

Point 2: Little capacity scaling in last 15 years
在过去的15年间，小规模的工厂一直在缩减

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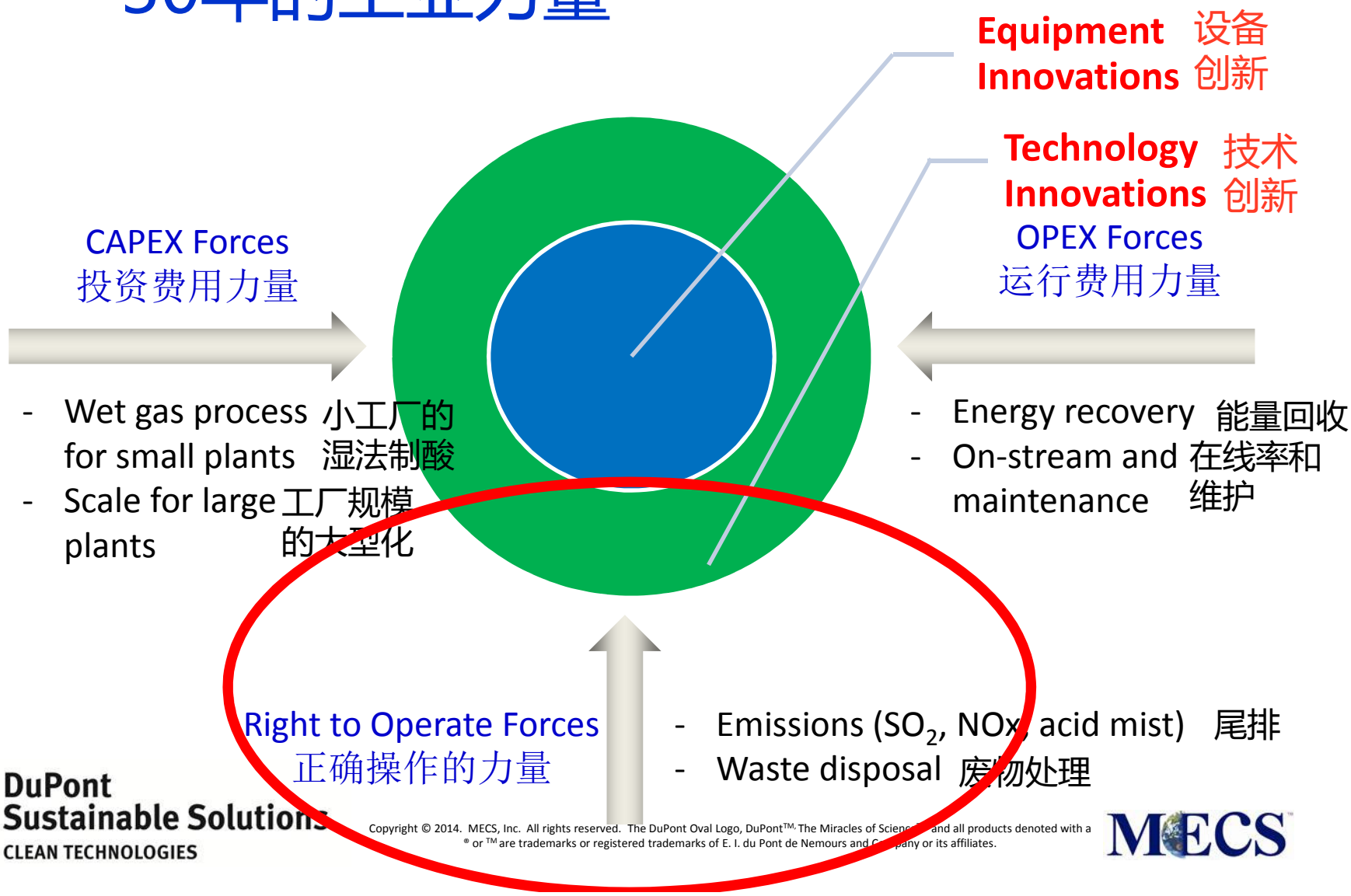
30-Year Industry Forces
30年的工业力量



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Right to Operate – Emissions正确操作-尾排

- Double Absorption – high cost but emissions reduced from 2000 ppm SO_2 to <400 ppm.两转两吸–高成本但是SO2尾排从2000ppm 减小到<400 ppm

- Absorbents – e.g. carbon, limited effectiveness吸附剂–比如活性炭，效果一般

- Catalyst – increased activity, especially with the development of cesium-promotion催化剂–增长的行为，特别是在铯催化剂的推广发展后

- Scrubbing – removal of SO_2 from tailgas using various reagents尾洗–运用不同的溶剂从尾气去除SO2
  - Caustic (high operating cost but very effective)苛性钠（高运行费用但非常有效）
  - Lime/limestone (low operating cost but headache)石灰/石灰石（低运行费用但是令人头疼）
  - Peroxide (high operating cost but effective w/no effluent)双氧水（高运行成本但有效且没有污水排放）

- Regenerative – relatively new, some operating cost and corrosion concerns再生法–相对较新，有一定的运行成本和腐蚀的顾虑

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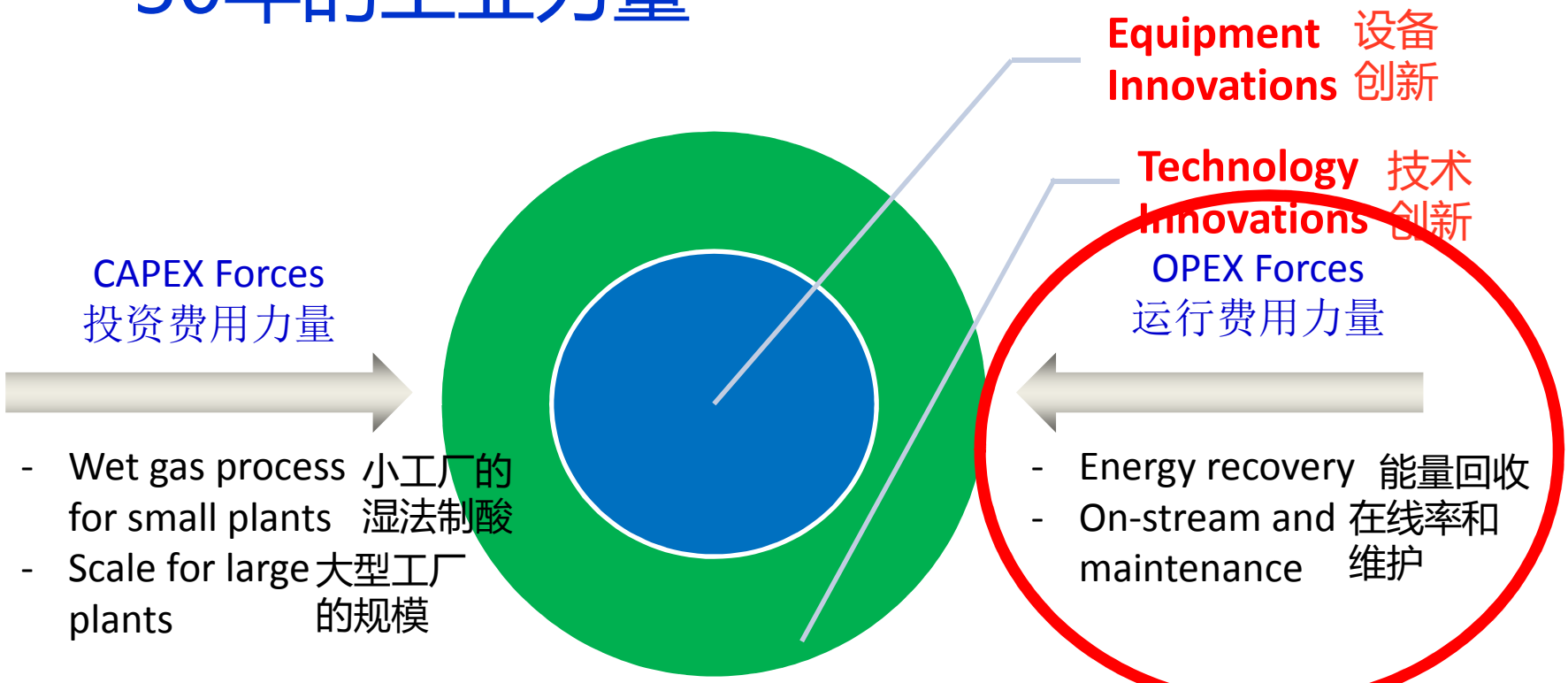
30年的工业力量



Right to Operate Forces
正确操作力量

- Emissions (SO_2, NOx, acid mist) 尾排
- Waste disposal 废物处理

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Energy Recovery能量回收

Era年份	Technology技术	Description描述
1980s	Low temperature economizers 低温省煤器	More high pressure steam更多高压蒸汽
1990s	HRS 低温热回收系统	Intermediate pressure steam中压蒸汽
1990s	Boiler feedwater preheaters 锅炉给水预热器	Boiler feedwater heating in acid circuit用酸的循环加热锅炉给水
2000s	Steam Injection 蒸汽喷射	Steam injection to improve HRS efficiency 蒸汽喷射改进HRS效率
2010s	SteaMax HRS® SteaMax低温热回收系统	Full steam injection instead of dilution in HRS 全蒸汽喷射代替HRS稀释

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Summary of Last 30 Years过去30年总结

Industry Force工业力量	Technology Innovations技术改进	Equipment Innovations设备改进
Reduce cost 减小成本	- Economic wet gas process for small plants小装置的经济的湿法制酸工艺 - Improved computer modeling to predict fluid behavior in large equipment改进计算机模拟来预测流体在大型设备中的表现	- Larger rotating equipment大型的动设备 - Larger steam equipment大型的蒸汽设备 - ZeCor合金材料 - Lower dp ME低压力降的除雾器
Maintain right to operate 维护正确操作	- Double absorption两转两吸 - Improved tailgas treatment options改良的尾气处理选择	- Improved catalyst改良的催化剂
Improve energy efficiency 改进能效	- Improved design to avoid dew point corrosion改进设计来避免露点腐蚀 - HRS低温热回收 - Steam Injection蒸汽喷射	- Larger HRS acid pumps更大的HRS循环酸泵 - Improved diluter design改进稀释器设计 - Improved steam injector design改进蒸汽喷射腔设计

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Mega Trends百万吨趋势

Our collective challenge in the decades ahead is to efficiently protect and feed the world's growing population.我们未来几十年主要的挑战是有效的保护和喂养世界增长的人口。

This a common goal that spans cultures and nations.这是跨越文化和种族的共同目标。

FOOD 食物

ENERGY 能源

PROTECTION 保护

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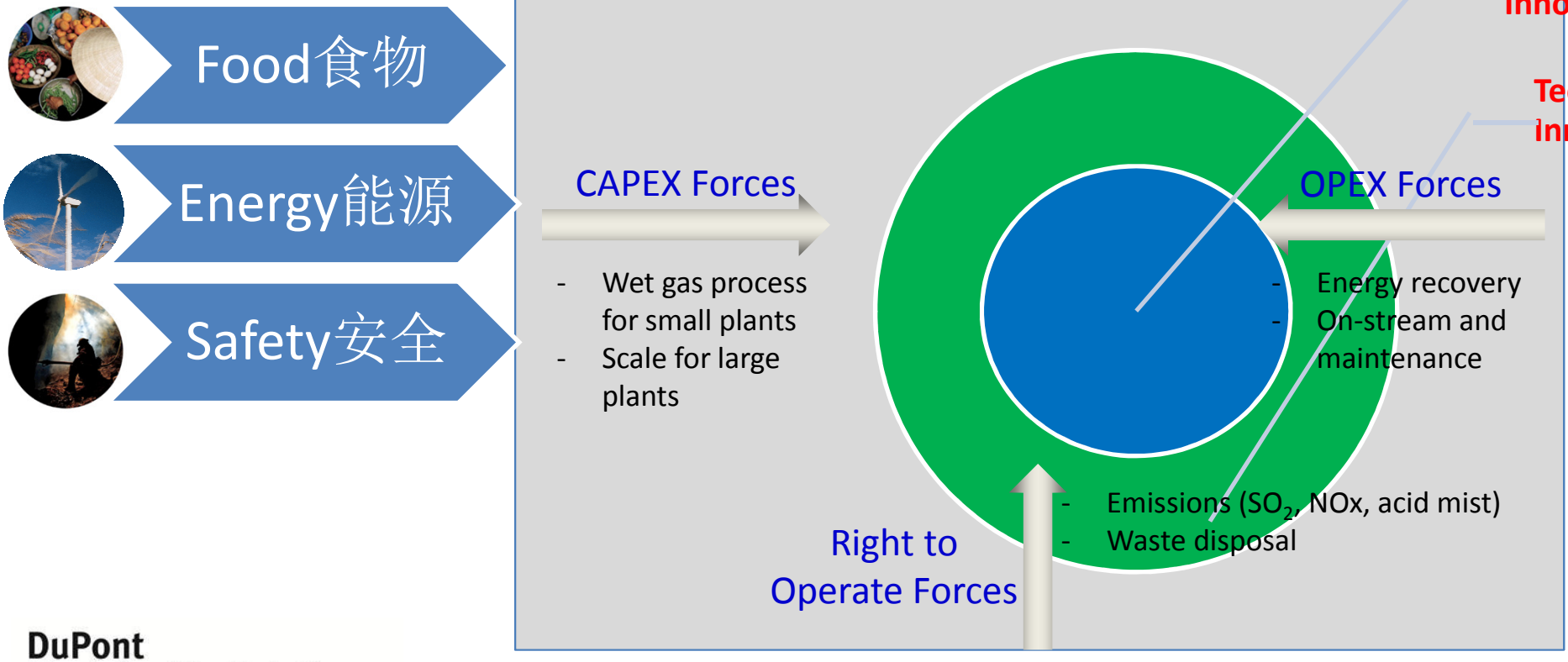
Mega Trends Drive Industry百万吨级趋势驱动工业



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What is link between Mega Trend drivers and sulfuric acid industry?

什么联系百万吨级趋势驱动器和硫酸工业？

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Mega Trends Drive Industry百万吨级趋势驱动工业

Food食物

Energy能源

Safety安全

CAPEX Forces

- Wet gas process for small plants
- Scale for large plants

OPEX Forces

- Energy recovery
- On-stream and maintenance

Right to Operate Forces

- Emissions (SO_2, NOx, acid mist)
- Waste disposal

Equip
Innov

Tech
Inno

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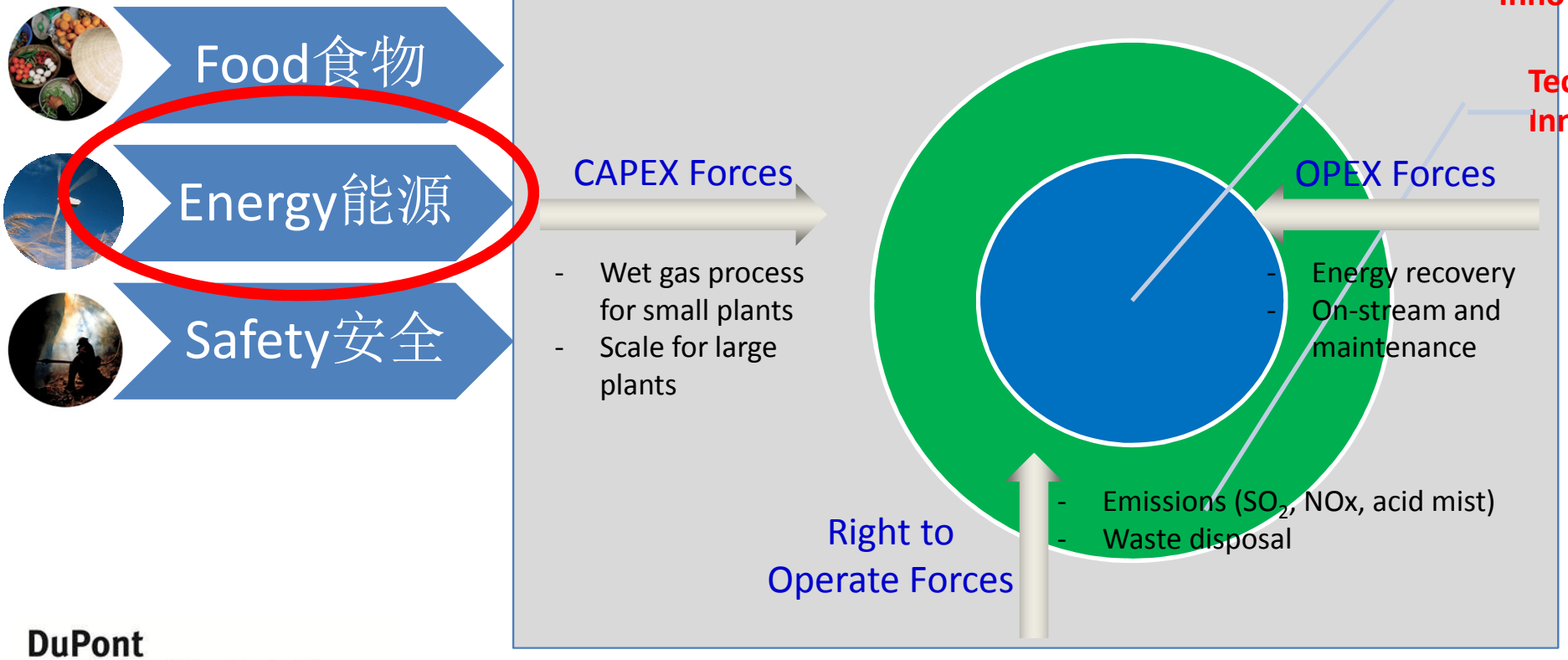
Impact of Food Mega Trend on Sulfuric Acid
硫酸百万吨级趋势对食物的影响

Issue问题	Impact影响
Growth in population 人口增加	Increased supply of fertilizer增加肥料供给
Need to improve utilization of fixed land resources需要改进有限土地资源的利用	Increased supply of fertilizer增加肥料供给
Rising costs in developing countries发展中国家的成本提高	Need for lower cost processes to produce materials in the fertilizer chain在肥料供应链中需要低成本的工艺来生产材料

Mega Trends Drive Industry百万吨级趋势驱动工业



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Impact of Energy Mega Trend on Sulfuric Acid

硫酸百万吨化趋势对能源的影响

Issue问题	Impact影响
Growth in population 人口的增长	Increased energy efficiency增加能效
Increasing scarcity of resources 渐增的资源短缺	Unique, novel solutions to produce clean energy独特新奇的生产清洁能源方案

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Mega Trends Drive Industry百万吨级趋势驱动工业


Food食物


Energy能源


Safety安全

CAPEX Forces

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- Energy recovery
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Right to Operate Forces

- Emissions (SO_2, NOx, acid mist)
- Waste disposal

Equip
Innov

Tech
Inno

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Impact of Safety Mega Trend on Sulfuric Acid

硫酸百万吨化趋势对于安全的影响

Issue问题	Impact影响
Increased greenhouse and acid gas emissions 渐增的绿室和酸性气排放	Reduced emissions缩减尾排
Waste generation from industrial processes工业化工程中的垃圾产生	Reduced effluent缩减污水排放

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Challenges Facing Future Sulfuric Acid Production未来的硫酸生产面临的挑战

Food食物

Energy能源

Safety安全

Issue问题
Lower cost to produce fertilizer肥料厂商的低成本
Increased energy efficiency高能效
Reduced emissions缩减的尾排
Reduced effluent缩减的污水排放

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“Those who do not remember the past are condemned to repeat it”.

“那些不记得过去的人注定要重蹈覆辙”

Multiple Sources多个来源

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Recap of 30-Year Progress
30年的扼要重述

Things Done Well处理好的事情	Things Not Done Well尚未处理好的事情
Development of low cost, wet gas design for small plants低成本的发展，小规模的湿法工艺	Post-2000 capital cost improvements2000年后的投资成本改进
Double absorption for large plants大规模的双吸工艺	Post-2000 step change reduction in emissions2000年后尾气排放的逐步减小
Early (pre-2000) equipment innovations for Mega Plants早期（2000年前）的百万吨级设备变革	Post-2000 scale-up of equipment for even larger Mega Plants2000年后设备对于更大百万吨级工厂的放大
HRS低温热回收	Increased high pressure steam recovery增加高压蒸汽回收

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How Has Industry Performed in Last 15 Years?在过去15年间工业表现如何？

Food食物

Energy能源

Safety安全

Issue问题
Lower cost to produce fertilizer肥料厂商的小成本，差劲
Increased energy efficiency高能效，差劲
Reduced emissions缩减的尾排，差劲
Reduced effluent缩减的污水排放，差劲

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How Has Industry Performed in Last 15 Years?在过去15年间工业表现如何？

New approach required to overcome poor history of addressing issues related to current Mega Trends

新的努力需要克服对于现在百万吨级趋势的有关问题差劲的历史

Food食物

Energy能源

Safety安全

Issue问题
Lower cost to produce fertilizer肥料厂商的小成本，差劲
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Reduced effluent缩减的污水排放，差劲

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What is the new approach?
新的方法是什么？

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Challenges Facing Future Sulfuric Acid Production未来的硫酸生产面临的挑战


Food食物


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Enabling technology that provides integrated solution for all issues

促成技术能提供所有问题的整合解决方案

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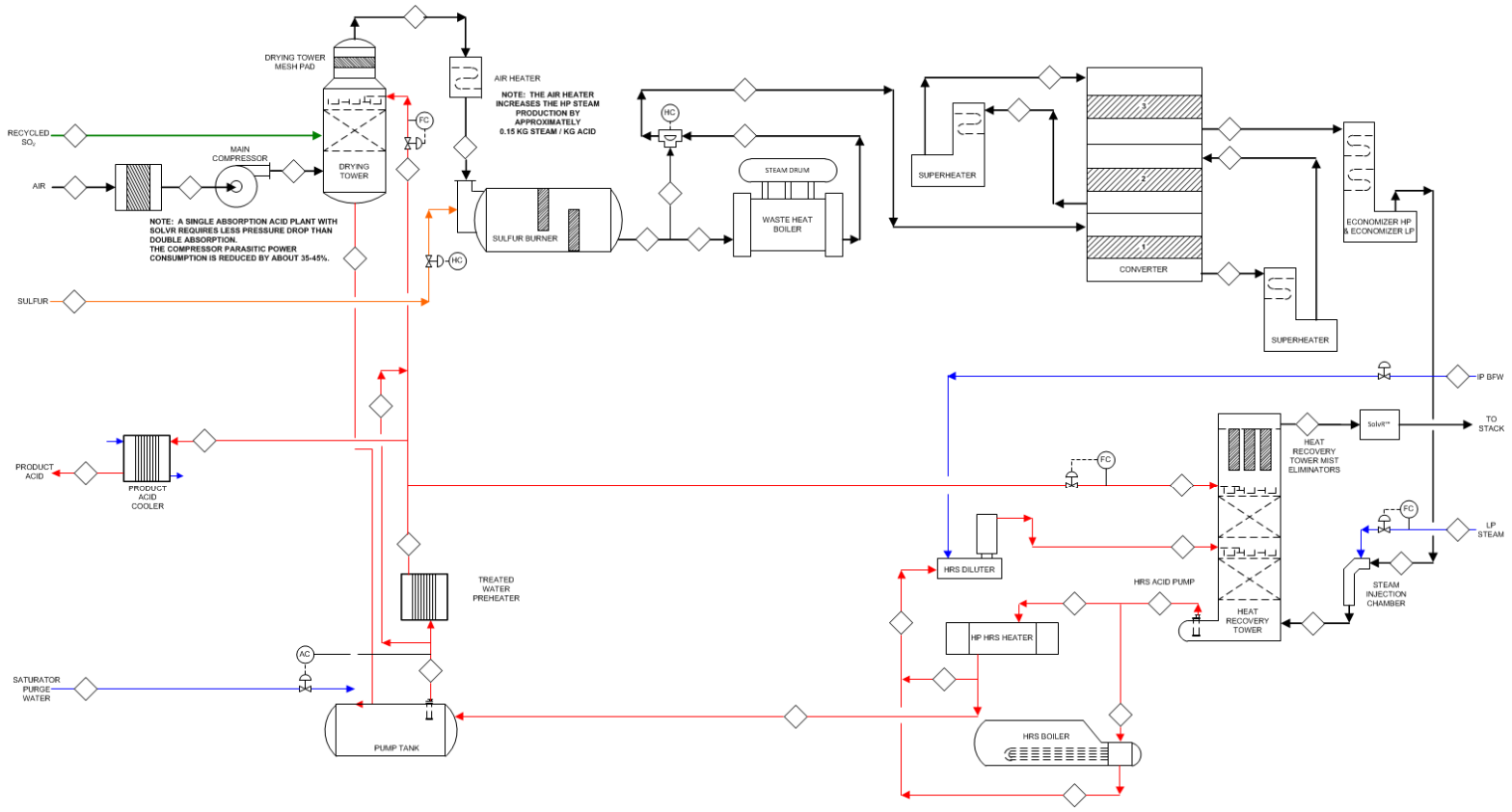
整合的解决方案-Maxene™



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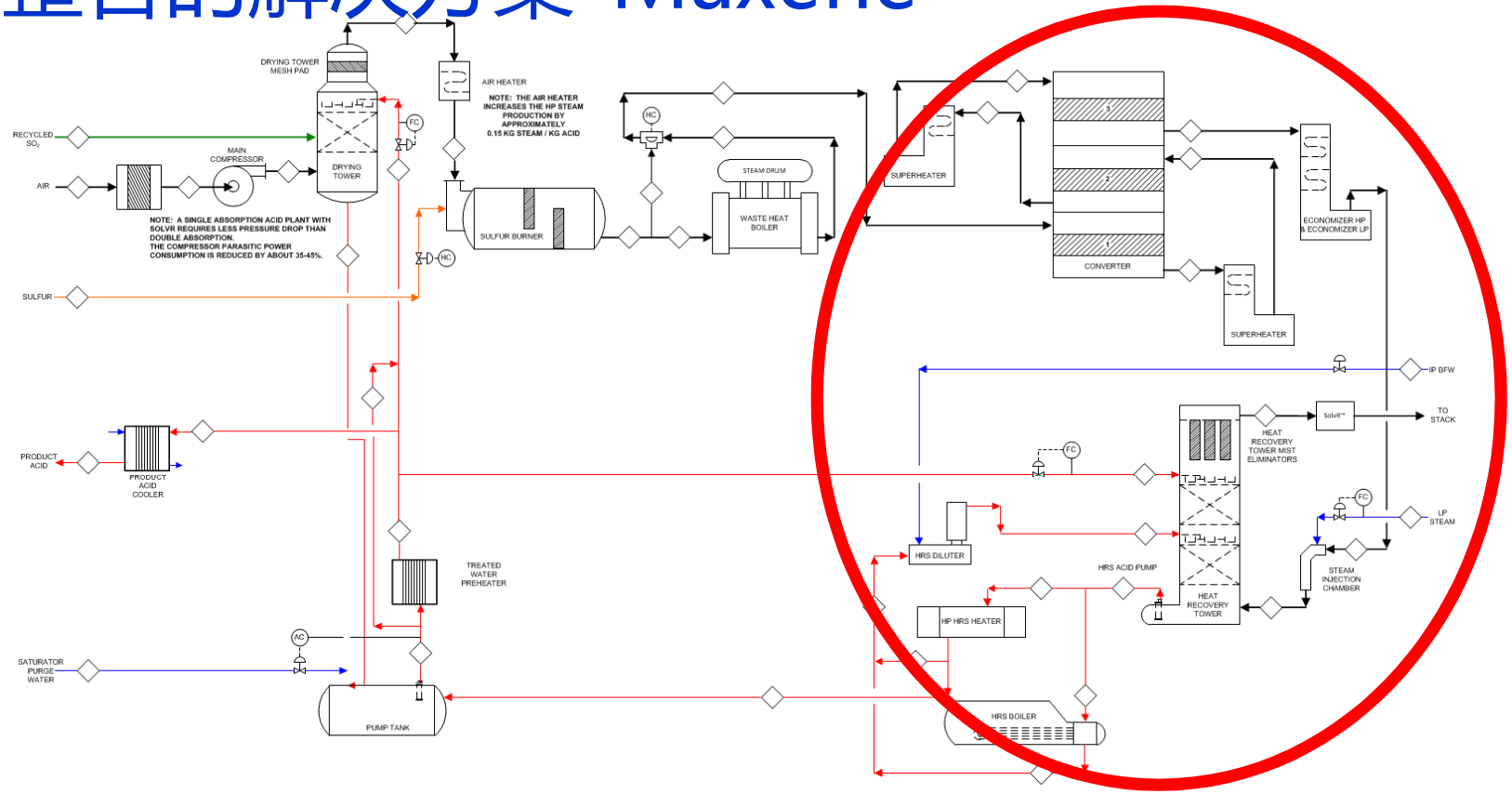

Capital cost reduced by single absorption + SolvR™

减小投资成本：一转一吸+SolvR™

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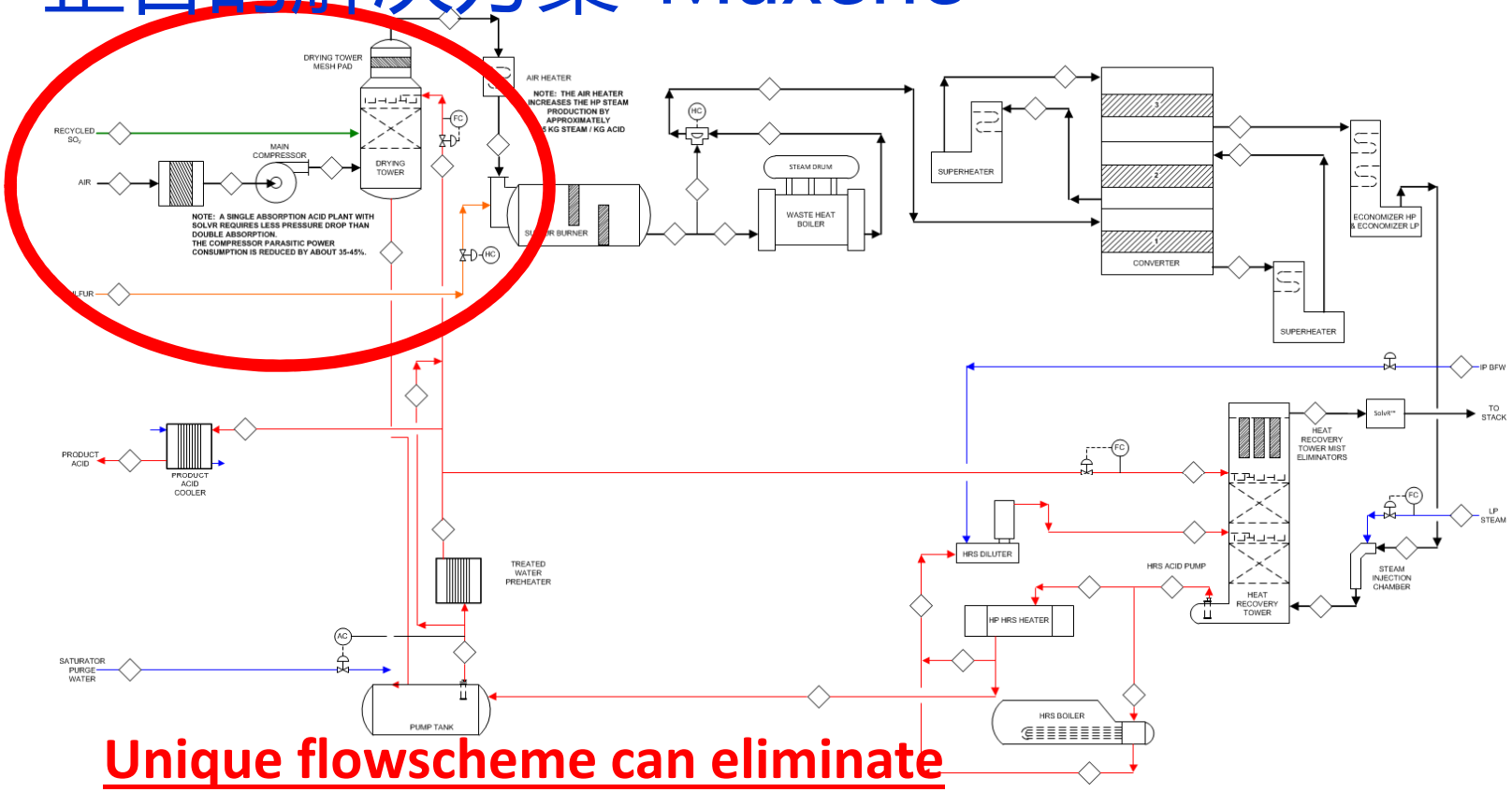

Unique flowscheme can eliminate cooling water consumption

小冷却水消耗：独特工艺

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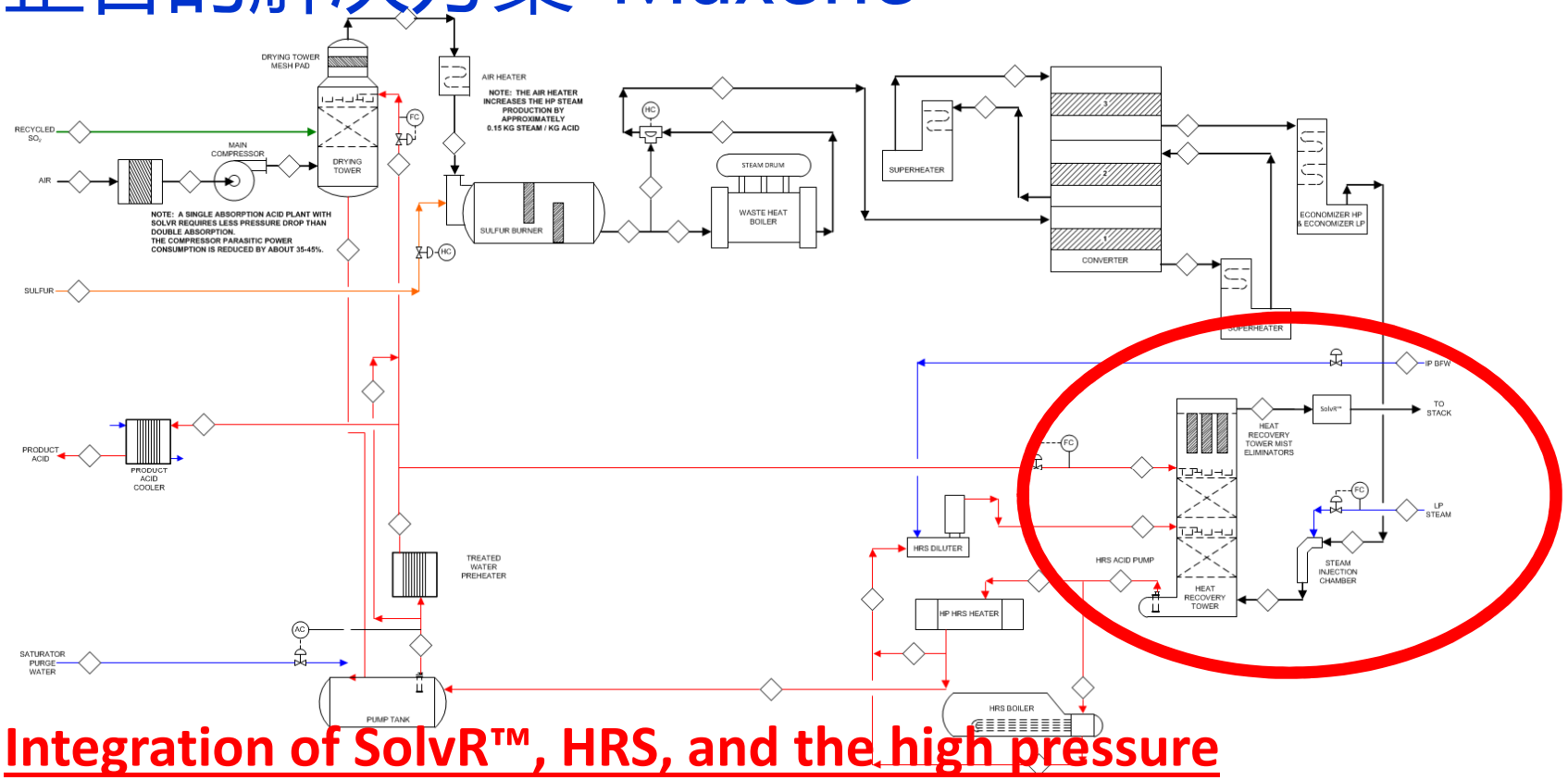

Integration of SolvR™, HRS, and the high pressure steam system improves energy efficiency

高能效：整合的SolvR™,HRS和高压蒸汽系统

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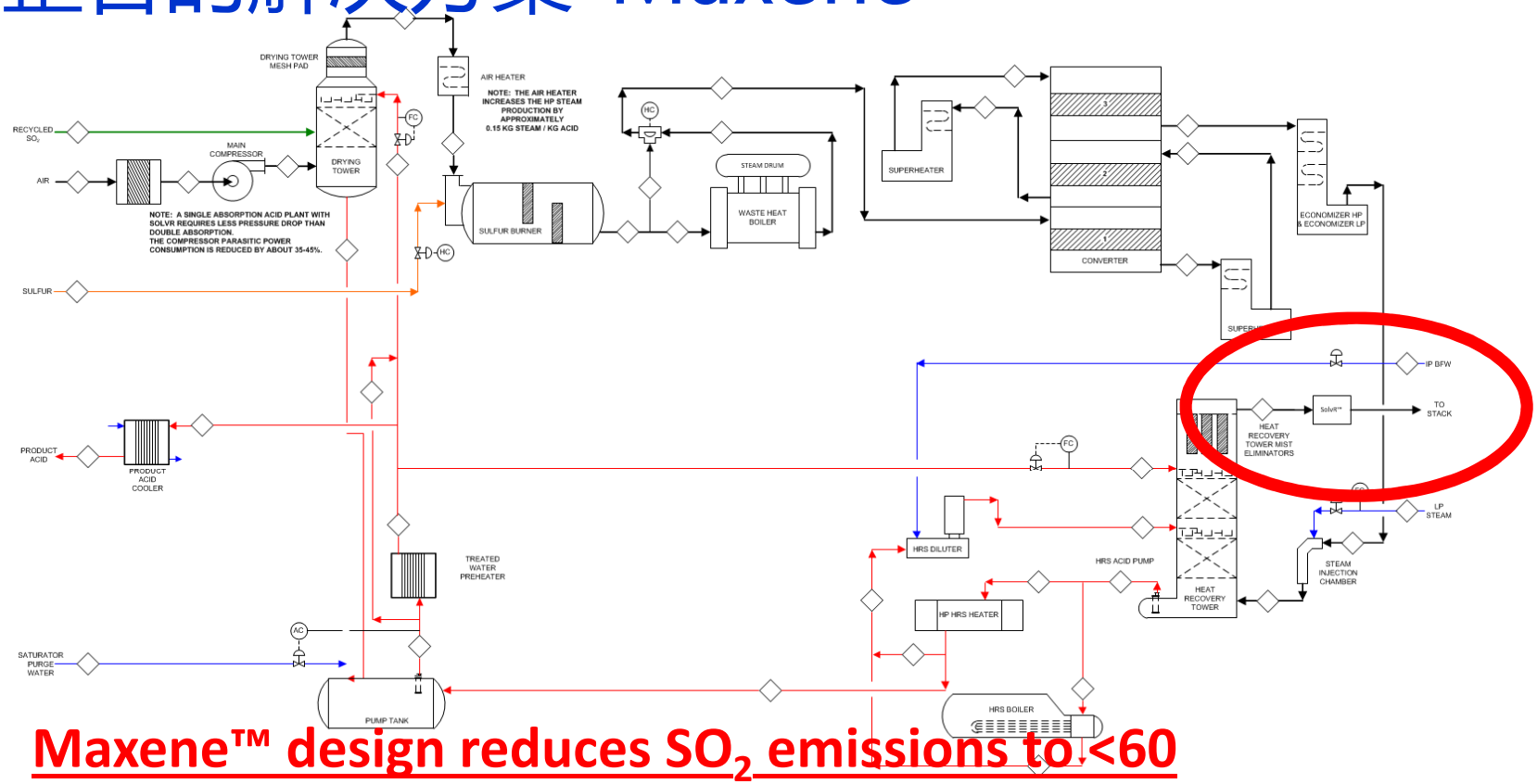

Maxene™ design reduces SO_2 emissions to <60 mg/Nm³

小尾排：Maxene™设计<60 mg/Nm³

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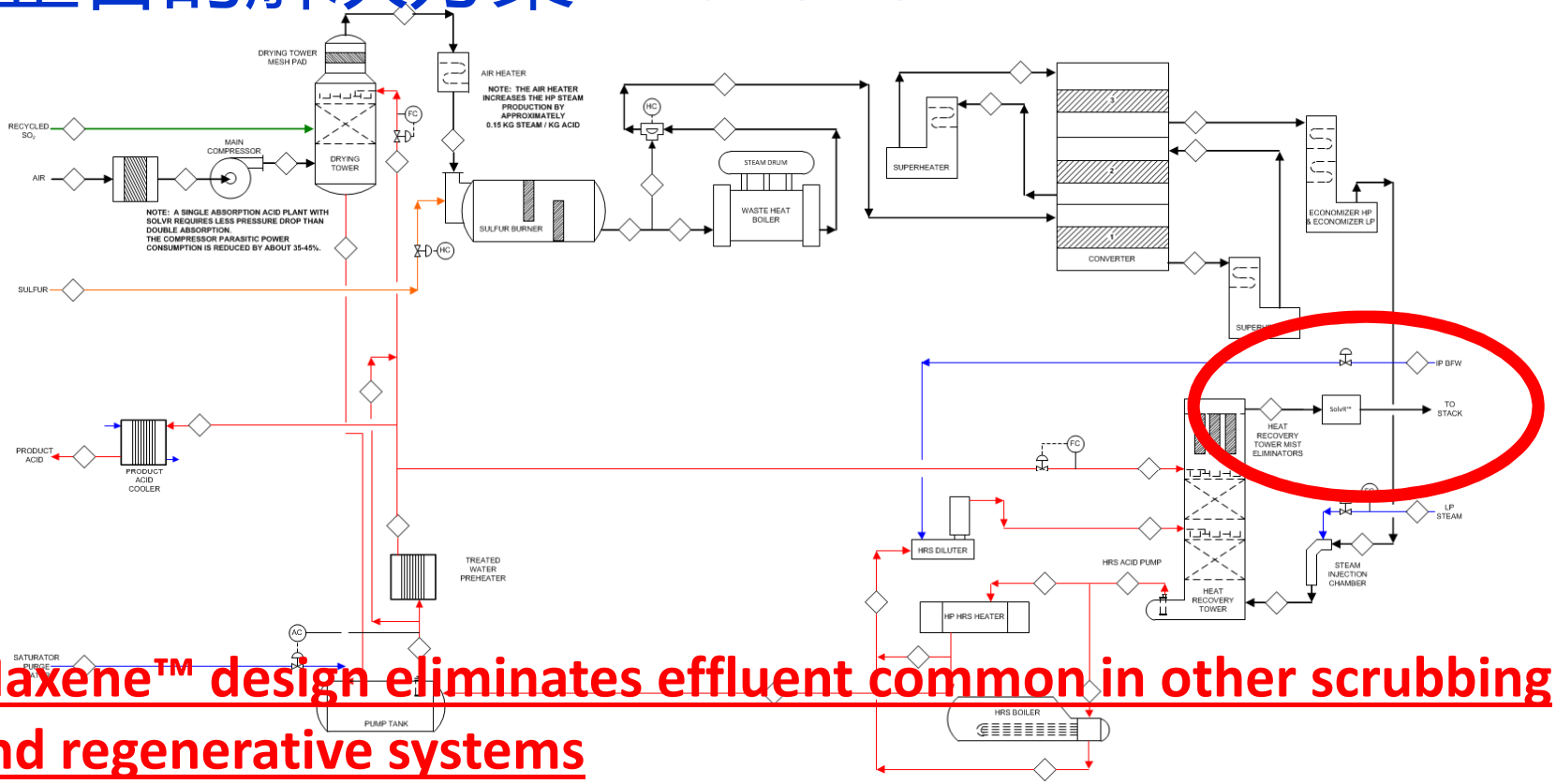
Integrated Solution - Maxene™

整合的解决方案-Maxene™



Maxene™ design eliminates effluent common in other scrubbing and regenerative systems

污水排放：Maxene™设计消除了尾吸和再生通常会有的废物排放

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Maxene™ – Solving Tomorrow's Challenges Today Maxene™ -现在来解决明天挑战

Food食物

Energy能源

Safety安全

Issue问题	Solution解决方案
Reduce capital cost减小投资成本	Maxene™ eliminates equipment, TIC-neutral减少设备，不增加投资
Improve operating cost改进操作成本	Reduced power consumption, low/0 cooling water小能耗，很少接近0的冷却水
Increase energy efficiency高能效	Increased high pressure steam (>1.5 t/t)增加高压蒸汽产量(>1.5 t/t)
Reduced emissions缩减的尾排	<60 mg/Nm3 SO2
Reduced effluent缩减的污水排放	No high-volume byproduct like with scrubbing同尾洗不同，没有大量的副产品产生

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Topics目录

- Yesterday: Past 30 Years – Innovation in Technology and Equipment

  昨天：过去的30年-技术和设备的变迁

- Today: Mega Trends and Industry Transformation

  今天：百万吨级趋势和工业化变革

- Tomorrow: Innovation Today for Tomorrow's Needs

  明天：今天创新为明天的需求

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