



TOCICO 2008 Conference

# TOCICO CONFERENCE 2008

## *First Solar Case Study*

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**Date: November 4, 2008**

# Forward-Looking Statements



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- ❑ **Company Overview**
- ❑ **Introduction of TOC**
- ❑ **Drum – Buffer - Rope**
- ❑ **Critical Chain Project Management**
- ❑ **The Mafia Offer**
- ❑ **The Thinking Processes**
- ❑ **Lessons Learned**
- ❑ **Managerial Attributes for Success**

## Company Overview



# Company Overview



## Strategic Objective

**Reduce the cost of solar electricity to a level competitive with conventional energy, enabling solar to become a sustainable mainstream source of energy**

- ❑ Reduce the cost of solar modules using thin film technology and automated, scalable production
- ❑ Migrate from subsidized markets to non-subsidized markets by leveraging economies of scale – become “subsidy independent”
- ❑ Reduce dependence on scarce natural resources and curtail greenhouse gas emissions to improve our environment



First Solar Manufacturing Plant, Frankfurt (Oder), Germany

# Company Overview



## Key Accomplishments

- ❑ Formed in 1999 and launched production of first commercial products in 2002
- ❑ Raised \$450 million in November 2006 IPO. Publicly traded on NASDAQ (FSLR)
- ❑ Largest thin-film module manufacturer in the world
- ❑ Lowest cost PV manufacturer in the world
- ❑ First pre-funded module collection and recycling program in the PV industry



First Solar Manufacturing Plant, Frankfurt (Oder), Germany

# Company Overview



## > 1GW of Capacity in Operation or Under Construction [1]

### Perrysburg, Ohio, U.S.

- ❑ Scaled first production line to steady state volume in 2005
- ❑ Qualified two additional production lines in August 2006
- 3 manufacturing lines with annual capacity of approximately 75MW based on Q4'06 run rate



### Frankfurt (Oder), Germany

- ❑ Four production lines constructed in Frankfurt (Oder), Germany which reached full capacity in the third quarter of 2007
- 7 manufacturing lines with annual capacity of 308MW (end of 2007) [1]



### Kedah, Malaysia (Four 4-line plants under construction)

- ❑ Plant 1 will reach full production during second half of 2008
- ❑ Plant 2 will reach full production during the first half of 2009
- ❑ Plants 3-4 will reach full production in second half of 2009
- 23 lines with annual capacity of 1012 MW (second half of 2009)



[1] Based on Q4'07 run rate of 44 MW per line

# Company Overview



## Worldwide Associates > 1,462

### United States

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Phoenix, Arizona	Corporate Headquarters
Perrysburg, Ohio	Operations, R&D and Manufacturing Headquarters
Bridgewater, New Jersey	First Solar Electric

### Germany

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Mainz	Sales, Marketing, Customer Support (EU)
Berlin	Government & Public Affairs
Frankfurt (Oder)	Manufacturing Plant

### Europe

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Brussels	Government & Public Affairs (EU)
Madrid	Sales
Amsterdam	Business Development

### Malaysia

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Kedah	Four Manufacturing Plants Under Construction
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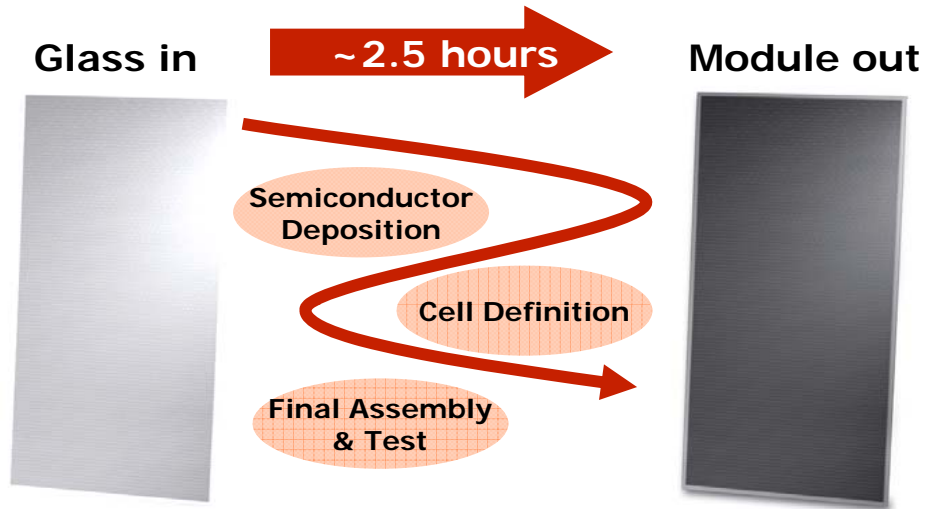
## Technology



# Technology & Manufacturing

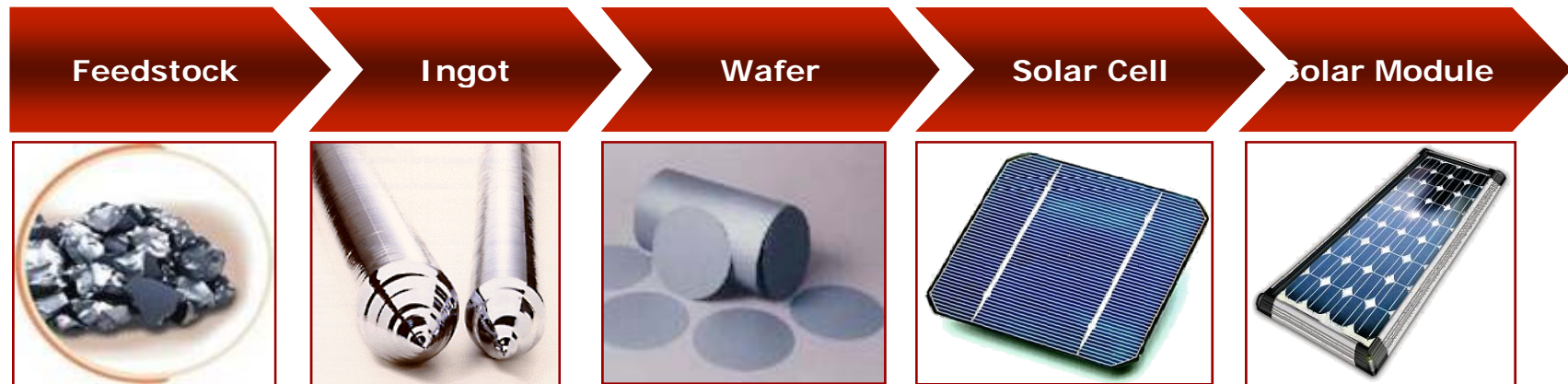


## Fully Integrated, Automated and Continuous Thin Film Process



- ✓ 99% reduction in high-cost semiconductor material
- ✓ Fully integrated, continuous process vs. batch processing
- ✓ Large (2'x4') substrate vs. 6" wafers

## vs. Crystalline Silicon Batch Processing



## Products & Performance



## First Solar Series 2 Module Features

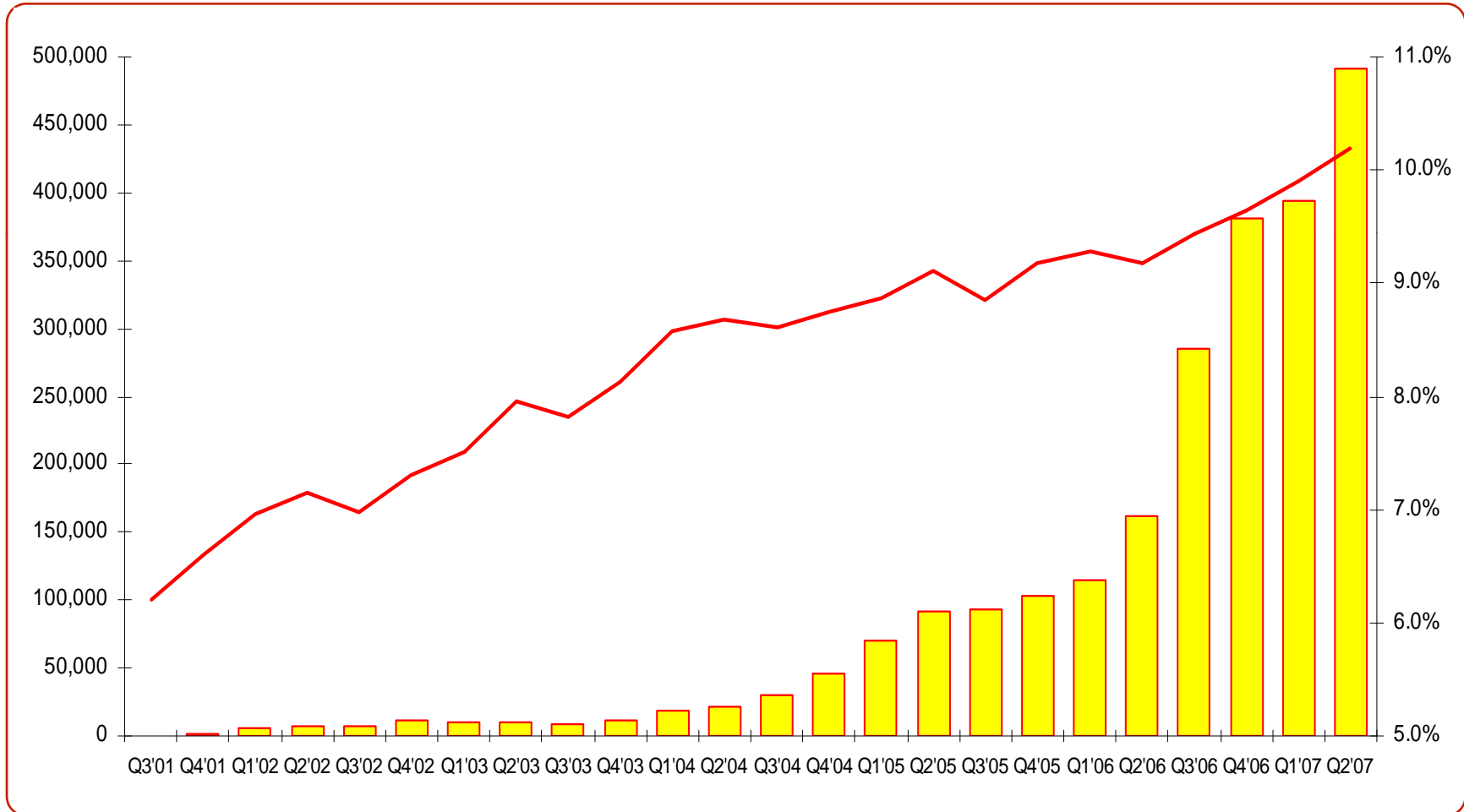


- ❑ Frameless glass-glass laminate (60 x 120 cm, 27 lbs) is durable and recyclable
- ❑ Power increments of 2.5W (5% rating tolerance) with power per module of up to 75W
- ❑ High energy yield in real operating conditions (PR>80%):
  - Low temperature coefficient (-0.25%/°C)
  - Excellent low light response
- ❑ Robust against shading in landscape orientation (perpendicular to cells)
- ❑ Certified for reliability and safety according to IEC 61646 and SK II @ 1000V
- ❑ Manufacturing certified to ISO9001:2000 quality and ISO14001:2004 environmental standards
- ❑ 25 year Power Output Warranty for 80% of nominal power subject to warranty terms & conditions
- ❑ Pre-financed collection & recycling program

# Products & Performance



## Proven Record of Increasing Module Conversion Efficiencies

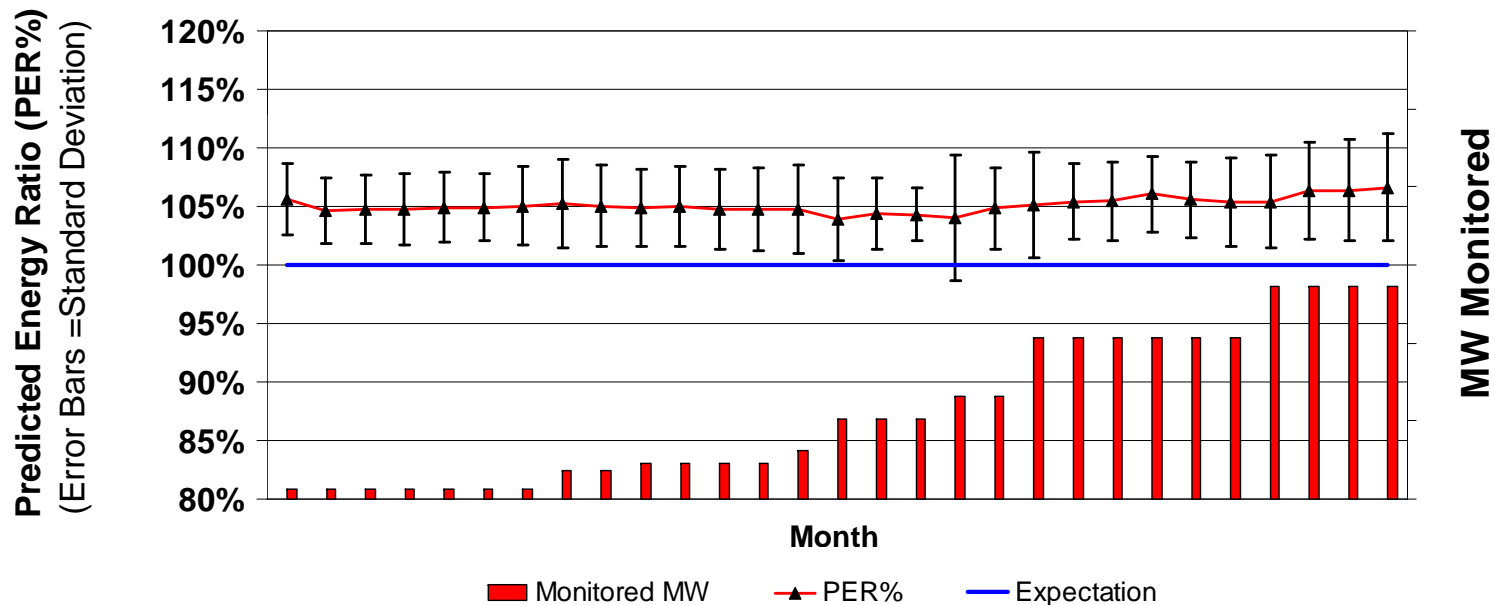


# Products & Performance

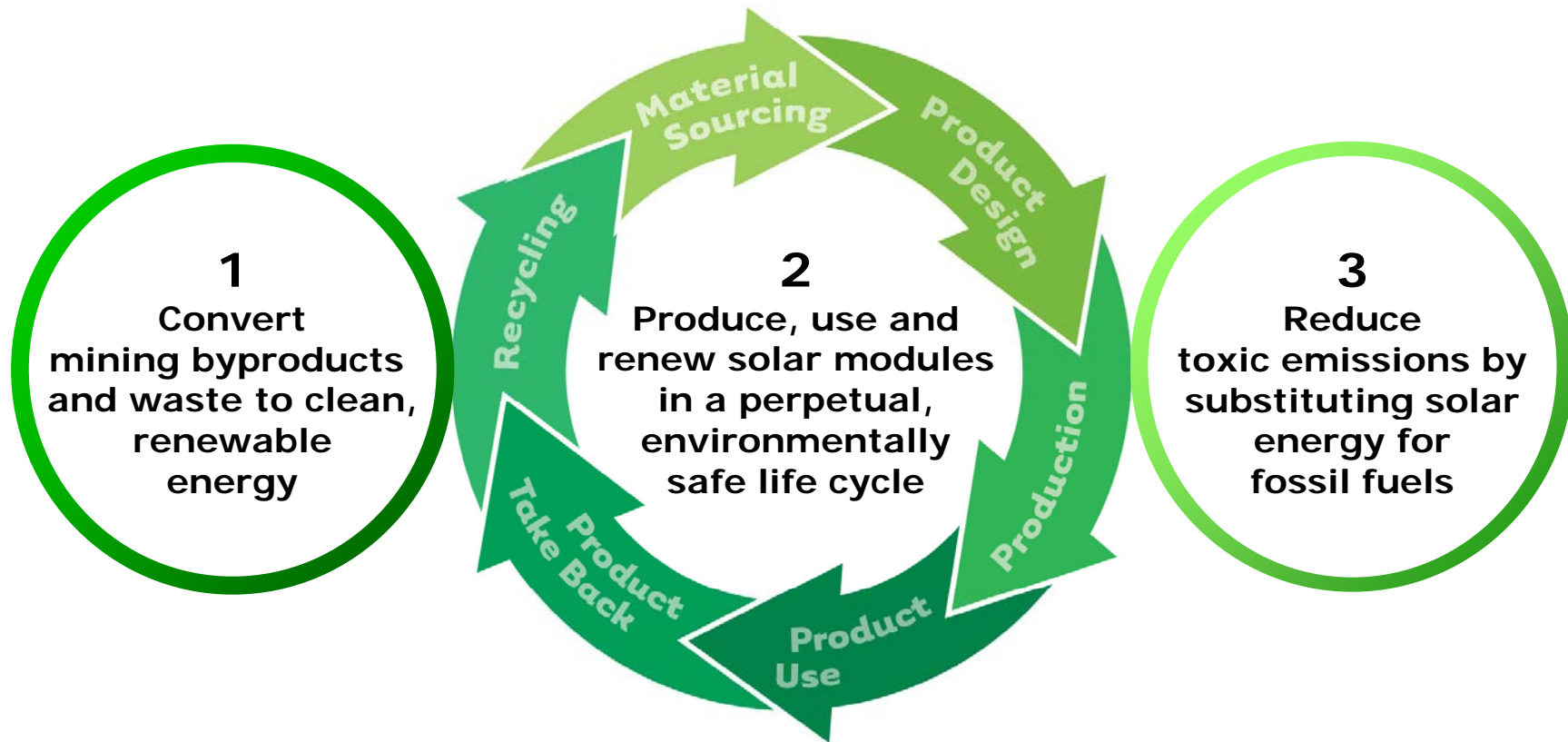


## Proven Field Performance

- ❑ Documented and approved designs define the module mounting, electrical design, and the system energy yield expected in order to ensure that systems are designed to perform optimally
- ❑ First Solar monitors the performance of > 20MW of installed modules in a wide range of systems to ensure modules perform as designed



## Our 3-Point Environmental Plan



## Target Applications

- ❑ Ground Mounted Systems
  - Typically Multi-MW



- ❑ Commercial Roof Mounted Systems
  - Typically 30kW to 1MW+



# Project Profiles



**40 MW**

Brandis, Germany  
Project Developer: juwi

Under Construction  
12,5 MW Commissioned/ 15 MW Installed

## Introduction of TOC



# Where it began..



- ❑ Purchased by True North Partners in 2002
- ❑ 50 associates with 30-50 panels output, low efficiency
- ❑ COO had worked with TOCC before, recommended TOC as continuous improvement approach
- ❑ Dodgy technology, Shaky manufacturing process, Unknown market
- ❑ Tremendous in-fighting – “Theoretical Physics should be separate department”
- ❑ Initial project led by Bob Fox and Ray Immelman
- ❑ Living from hand to mouth – School furniture
- ❑ “Stop turning knobs” – brought discipline to organization
- ❑ Also introduced Six Sigma and Taguchi- Robust Engineering toolset



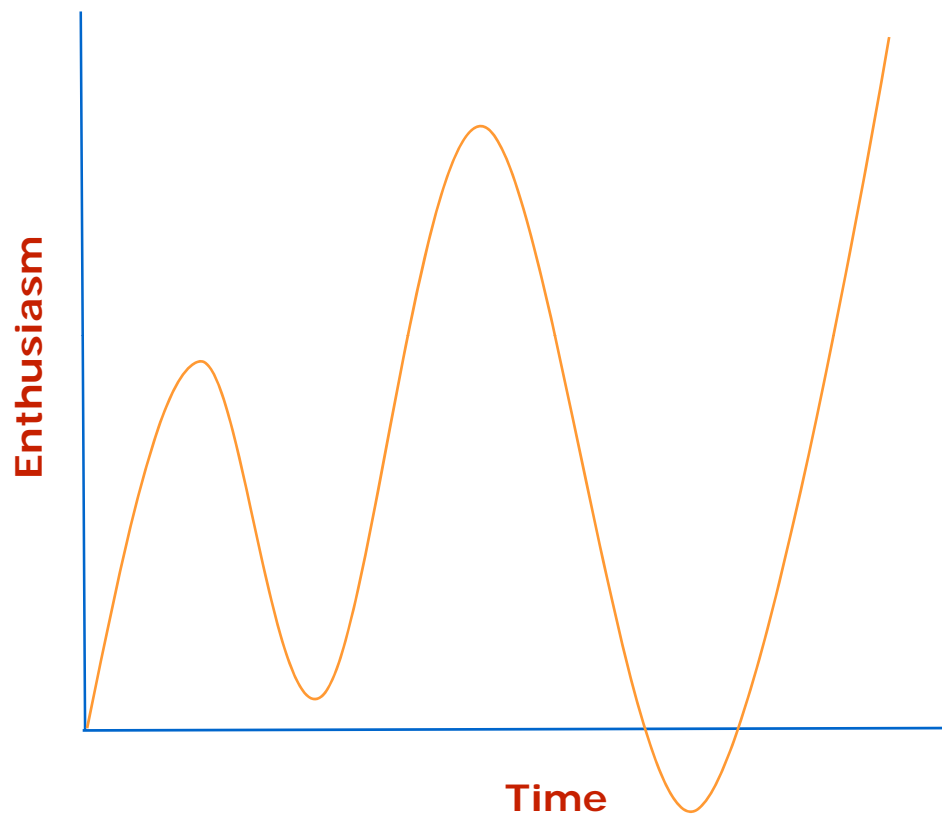
# Where it began..



- ❑ Step One: Read "The Goal"
- ❑ Step Two: Sim 10 for everyone
- ❑ Step Three: PmSim for everyone
- ❑ Weekly TOC support meetings until it was 'real'
- ❑ Focus moved from "turning knobs" to disciplined focus on constraints
- ❑ Strong leadership from Michael Ahearn, who immediately grasped the relevance of TOC.
- ❑ 2003: Decision made to build Gen 2 plant, since Gen 1 technology did not support required cost curve to be competitive
- ❑ Brought confidence to the group that they can tackle immense challenges and succeed



# The Improvement Graph



- Intellectual interest
- Tacit support
- Common acceptance

## Drum - Buffer - Rope



## Under the radar

- ❑ “Last Man Standing” article
- ❑ “Copy smart” manufacturing strategy
- ❑ Proprietary equipment designs created constraints
- ❑ Exclusive relationships with key vendors created constraints
- ❑ Huge challenge to stabilize manufacturing process to ensure high throughput

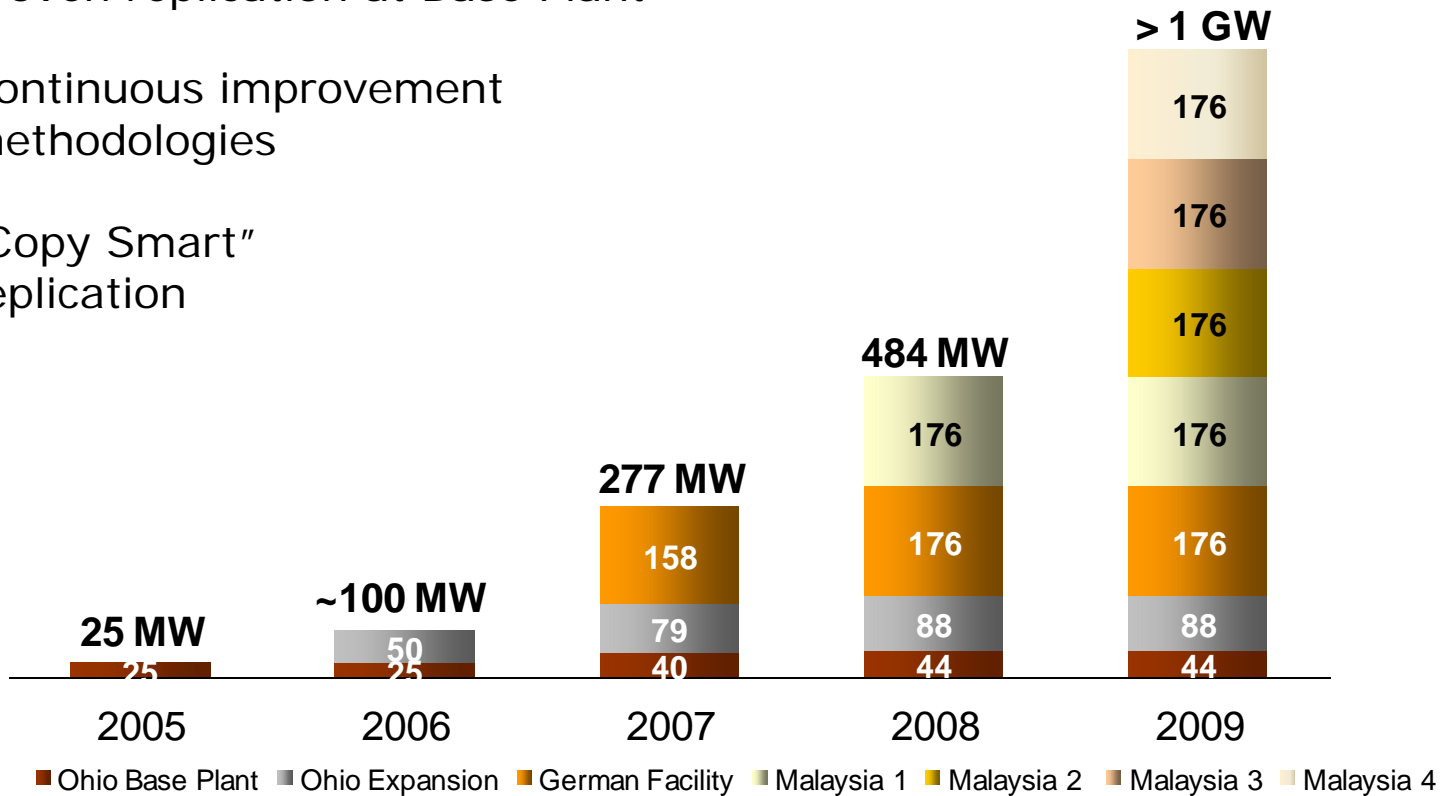


# Manufacturing



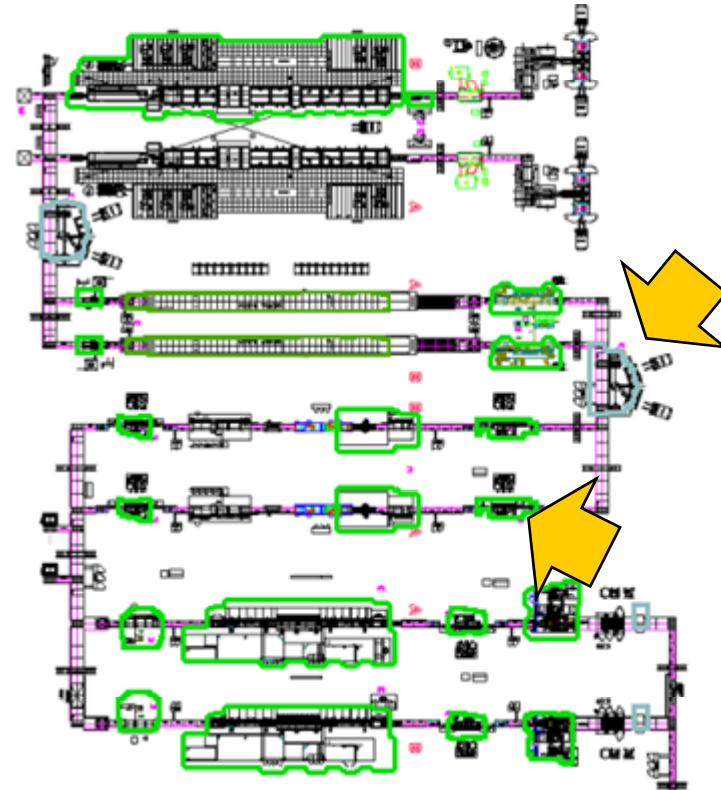
## Disciplined Replication Process

- Proven replication at Base Plant
- Continuous improvement methodologies
- "Copy Smart" replication



# Constraints and buffers

- ❑ Identified and locked down the control point in the line
- ❑ Designed automated constraint buffers
- ❑ Designed automated space buffers
- ❑ Completely automated control of buffering
- ❑ Continued focus to increase non-constraint capacity
- ❑ This is important for step four - elevation
- ❑ Obsessive use of simulation models – Simul8 software, to determine throughput reliability
- ❑ Lines run near nameplate capacity 24/7.



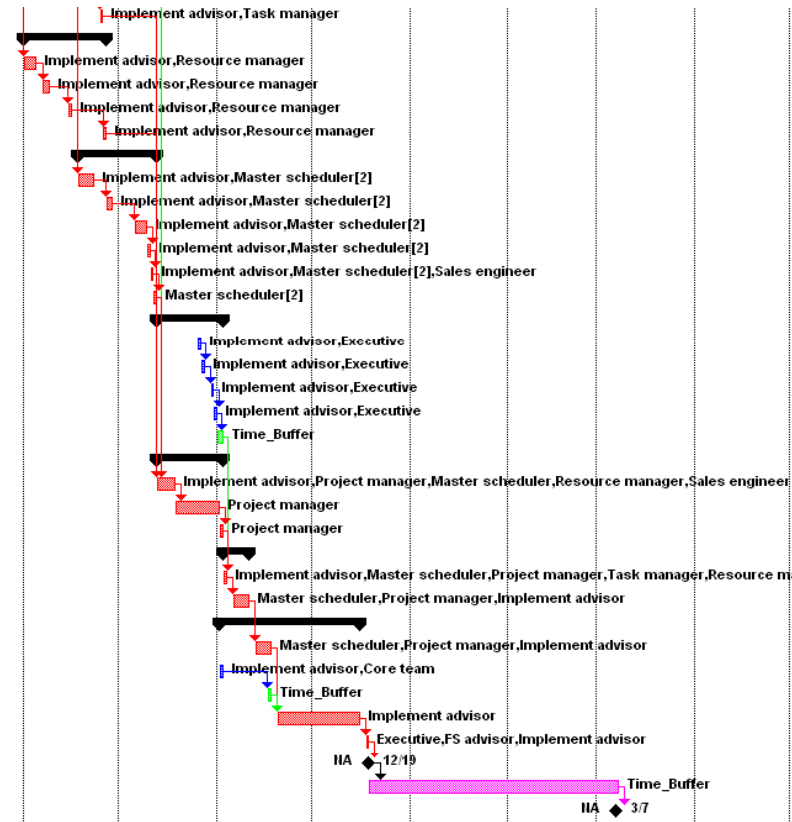
## Critical Chain Project Management



# Where it began..



- ❑ Construction of Gen 2 plant posed a new challenge
- ❑ Needed to develop manufacturing technology, facility construction and process reliability simultaneously
- ❑ Critical Chain supported with Concerto software introduced in 2002
- ❑ Dedicated CCPM Manager appointed
- ❑ Gen 2 plant completed significantly ahead of schedule, even though participants had grave doubts it could be done
- ❑ Now in EPC part of business



# The power of success...

- ❑ Brought immense confidence to the team
- ❑ Took on greater projects with confidence
- ❑ Buffer reports all the way up to board level for reporting status
- ❑ Pressure on vendors to reduce Critical Chain task duration
- ❑ Vendors now applying pressure to their vendors to shorten their critical chain



## The "Mafia Offer"



# The constraint moves to the market



- ❑ With Gen2 coming on line, market needed!
- ❑ Strengthened sales and marketing infrastructure and staffing
- ❑ All participated in Jonah program
- ❑ Reviewed original Sales & Marketing trees to help thinking around the long-term constraints our customers faced
- ❑ Resulted in an order book multiple years into the future.
- ❑ Secured long-term contracts with key players in the industry
- ❑ Do not build a new plant unless capacity is pre-sold

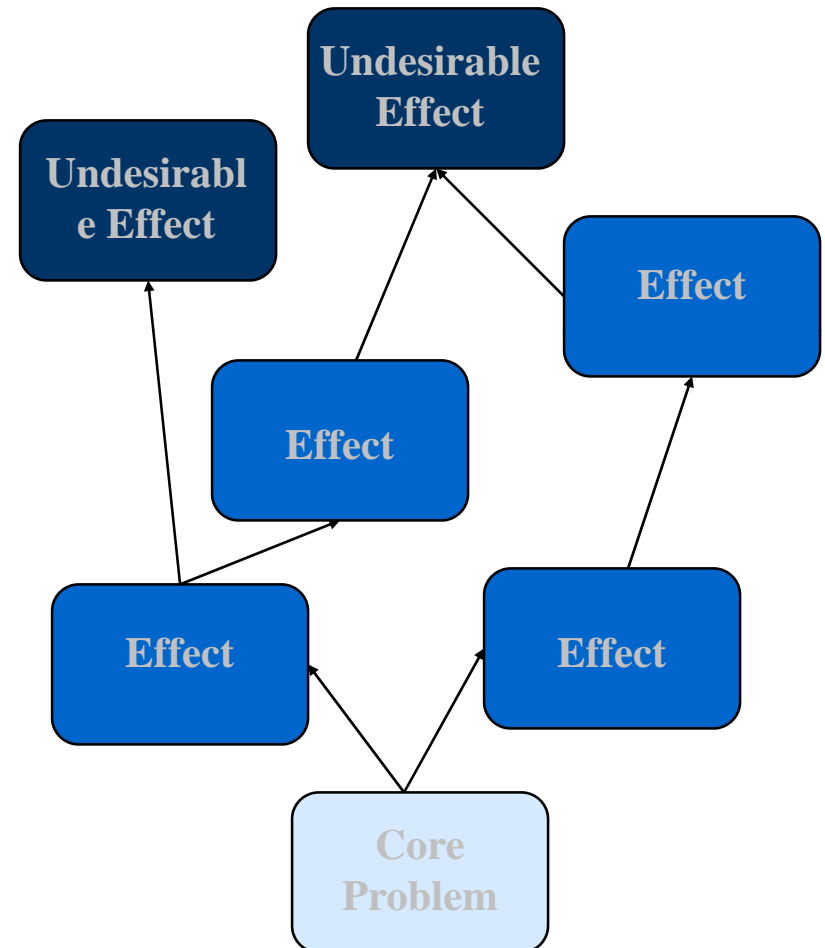


## The Thinking Processes



# Reinforcing the throughput culture..

- ❑ CEO participated in Thinking Process training
- ❑ All VP level staff participate in Thinking Process training
- ❑ Creates a consistent way of thinking, common language and process for new, rapid growing organization
- ❑ CRT, FRT and Injections created by CEO, vetted and agreed on by Executive staff
- ❑ Operational strategy derived from trees
- ❑ Shared with senior management every quarter
- ❑ Took on its own life – “ Where do I learn this stuff?”



- ❑ How to drive motivation on the shop floor ?
- ❑ Fully integrated reporting system form all tools on the floor
- ❑ Huge digital display on factory wall showing cumulative throughput
- ❑ Shows manufacturing lines with constraint status, breakdown locations, buffer status
- ❑ Galvanized the shop floor associates
- ❑ Next step will be to show all lines in all plants
- ❑ Manufacturing VP has access to status of every line in near-real time around the world.

# What made it work for First Solar?



- ❑ TOC is simply a means to an end
- ❑ Provided a central concept around which a strong throughput driven corporate culture could be built
- ❑ Had extremely strong buy-in and long-term support from the CEO
- ❑ Extensive exposure to the concepts of cost world and throughput world – this is a strong tribal issue
- ❑ Use of the tools in all possible areas built process and systems around the concepts – reliability labs, EPC
- ❑ Over time, helped to build confidence in own capability, which drove an increasing virtuous loop
- ❑ President appointed partly on strength of his experience and skill in TOC
- ❑ Small, successful applications builds trust and confidence
- ❑ Critical mass and bench strength perpetuates the throughput culture
- ❑ Hiring in some cases on TOC skills

# What must managers be good at ?



- ❑ Many individuals from many organizations in a very short time.
- ❑ Step up to the challenge of truly rapid change
- ❑ Strongly support the culture of “ How can I help?”
- ❑ Able to work closely with others - frequently unknown
- ❑ Don't hesitate to configure/reconfigure systems and processes
- ❑ Standardize to replicate, change to grow
- ❑ Understand cross-impact of proposed changes on other systems
- ❑ It's OK to talk about conflicts in systems
- ❑ Use the common language of throughput-driven organizations

# Summary of lessons learned..



- ❑ Create an enduring mindset of throughput vs. cost world company
- ❑ Have a strong champion
- ❑ CEO support for creating a new culture
- ❑ Work to spread the message to all levels
- ❑ Work to spread to the supply chain
- ❑ Use internal experts to support TOC tools

