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and



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Commercialization Opportunities in the Chemical Industry
an Individual Inventor's Perspective

Association of Consulting Chemists and Chemical Engineers

American Institute of Chemical Engineers, New Jersey Section



Joint Meeting



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What is Commercialization?

Novel Idea → *Intellectual Property Protection*

Bench Test → *Pilot Plant* →

Semi-Works/Commercial Prototype →

First Commercial Demonstration Plant →

Industrial Readiness →

Profit/Benefit Realization



“Sounds Straightforward – It Is Anything But”

The Landscape

**Internal
Infrastructure**

**General
Guidance**

**Business
Plans**

Finance

**Inventor
Developer**

**Flexible
Day Job**

**Intellectual
Property**

Partnering

Competition

Commercialization Involves

- **Thinking Strategically**
- **Planning with business acumen**
- **Developing and Protecting intellectual property**
- **Marketing effectively to find finance**
- **Maintaining the investor interface**
- **Collaborating with idea partners, colleagues, industry, universities and governments**
- **Team Building for project execution**
- **Coping with personal challenges**

Commercialization Achieves

Advancing the

" Embryonic Clever Bit "

Into

Realistic and Robust Step-Change Innovation

having

Economic and Environmental Foundation

Commercialization Simply

Coupling Knowledge and Action


to benefit

Society

Participants

Self

Chemical Commercialization Opportunity

- Lower-cost goods  all across the economy
- Reduced environmental impact
- Job creation up and down the value chain
- Increased tax revenues to governments
- Personal wealth creation

General Guidance to Inventors and Developers

- **Do something you like**
- **Do something you are good at**
- **Do something somebody is willing to pay for**
- **Understand your Innovation**
 - **Evolution v. Revolution**
 - **One Value Chain vs. Multiple Value Chains**
 - **Technical feasibility**
 - **Large-scale economics**
 - **Realistic stage of development**

Innovation Types (1)

Evolutionary

- Capex vs Fuel
- Efficiency
- Equipment Design
- Metallurgy
- Software

Revolutionary

- Process Simplification
- Novel Equipment
- Re-purposed Equipment
- Bio-processing
- New Materials
 - Buckyballs
 - Graphene

Innovation Types (2)

Simple Value Chains

- Usually evolutionary
- Many chemical processes, each dominated by a few players
- Slow change after perceived maturity

Complex Value Chains

- Step-change paradigm
- Co-production allows market flexibility with cyclic demands
- Biggest potential impact

Innovation Types (3)

Technical Drivers for Increasing IRR

- **Reduced Capex**
- **Reduced Opex**
- **Reduced COP**
- **Reduced Waste**
- **Reduced Pollution**
- **Reduced Water Usage**

Innovation Types (4)

Management Drivers for Increasing IRR

- **Consolidated organization structures**
- **Integrated processes and recycle streams**
- **Integrated equipment and utility systems**
- **Integrated off-site infrastructure and logistics**

Business Considerations (1)

What business are you developing?

- Licensing Company
or
- Operating Company
or
- Big LC and Little OC
(build & run the 1st small commercial plant only)

How do you plan to participate?

- CEO of funded entity?
- Build the initial team?
- Run Small Plant #1?
- Sell Large Plant #2?
- Hand-off control with company succeeding?
- Cash Cow **BEST CASE**


Business Considerations (2)

Self-Assessment

Can you access and convince

- Development partners?
- Industrial collaborators?
- Large-scale finance?
- Others, that you can you really be a CEO ?

Personal Considerations

- Are you ready for very long-term effort?
 - Do you have the enthusiasm, capability and commitment?
 - Do you have the personal financial resources?
- 
- Do the possible – keeping the ultimate in mind
 - Get ready for lots of rejection.

Can you handle all this?

Developing Intellectual Property

First Priority

YOU MUST HAVE A PROTECTED OFFERING

- Yourself, as much as possible
- Formal internal agreements with other parties
- Patent applications and patents
- Proprietary information and trade secrets
- Contractual protection
- Trademarks

Choosing Admin Support

Contracts / Transactions Attorney

Business structure, confidentiality and teaming agreements, dispute mediator

Patent Attorney

Confidentiality and royalty agreements, IP strategy, international relationships

CPA and Financial Advisers

- **Global expertise for tax, royalties, equipment, services, insurance and compliance**
- **Money management**

Choosing Internal Collaborators

- **Be careful - it's a long relationship**
- **One partner or entity; or more?**
- **Why this party over others?**
- **Align vision, strategy, and goals/objectives**
- **Define roles, responsibilities, including overlaps**
- **Formal agreement necessary for work scope and split, equity dilution, % ownership changes, exit policies, and dispute resolution**
- **Be flexible in resolving differences**

“Win – Win”

Choosing External Collaborators

- **Potential investor/strategic partner/exclusive supplier**
- **3rd-Party, industrial – strength, modeling and verification of protected technology**
- **Cost development and economic evaluations**
- **Shop fabrication, material and mechanical testing, and construction capabilities**
- **Market understanding and presence**
- **Access to other collaborators and finance**

Types of Collaborators

- **Universities – business partner or subcontractor relationship?**
- **Government - expertise, labs and funding programs**
- **Industrial – Implement proprietary designs with exclusive fabrication /supply capabilities**



Industrial is best – but hard to find

"Conflicts of Interests"

Strategy and Business Planning

- **Process Development vs. Classical Business**
- **Chemical/bio-tech processes vs. software and discrete item manufacturing**
- **Multi-year stages, millions of dollars for scale-up**
- **Complicated by multi-chemical products**
- **Approach varies with progress, stage of development, amount of funding, market cycles, new competition, perceived risk, etc.**
- **Your own understanding grows over time**

Business Plan vs. Plan for Business

- Write a “BP” every year – Investors want one – then file it for a template to update as needed
- Annual objectives and specific work plans for tangible accomplishments are best
- SWOT Analysis is useful
 - Strengths Weaknesses Opportunities Threats
- SWOT insights keep you current as you work
- SWOT enables real-time tailoring of available information appropriate for planned initiatives and for spontaneous situations → “BP & PB”

Finding Finance

The Biggest Hurdle to Success

- **Straightforward if you have friends in high places**
- **Big companies like to work with big companies**
- **Big companies self-fund chemical process developments with their own balance sheets**
- **Up to USD billions from Wall Street are available for chemical plant replication based on existing market position and proven technology**
- **USD 40-60 million for emerging technology development program** → **very difficult to find**

Sources of Funding (1)

- **Angels – too big for them, usually**
- **Angel Funds – lots of accounting for small USD and high equity demands**
- **“Reg D” & “MLP” Solicitations – possible, but**
 - **Time frames are longer than “one-off” projects**
 - **Complex government regulations and reporting**
- **Venture Capital & Private Equity Houses**
 - **Few have industry knowledge or interest**
 - **Very risk averse even if could assemble the Capex**

Sources of Funding (2)

- **SBIR's** – Government program starts with small funding and requires some public disclosure
- **CRADA's** – Government program is larger but requires 50% match beyond ability of small entity. It's a program for established companies.
- **U.S. D.O.E. ARPA-E** – Increasingly focused on “blue-sky” concepts and fundamental research
- **Universities** – Have expertise and physical test facilities but view the developer as a client with \$\$\$, \$\$\$

Sources of Funding (3)

- **Industry Partners – BEST WAY FORWARD**
 - Quick to understand what you are offering
 - Appreciate the high costs of commercialization
 - More comfortable with long time frames
 - Add credibility to finance as “anchor investor”



Proceed with caution as IP losses can occur from early discussions and abandoned negotiations

Workable Strategy (1)

- **Proceed in small steps under the radar**
- **Find a second source of personal revenue in parallel effort**
- **Seek 2nd-tier industry for expertise and market understanding**
- **Seek 1st-tier industry with the skill sets but not the market presence**
- **Cultivate contacts in the legal and financial worlds for high-level introductions**

Workable Strategy (2)

- **Focus on a site-specific scenario**
- **Find suppliers who will quote on equipment so cost and schedule are realistic**
- **Do proposals at low cost except your own effort, time and travel**

"Rinse and Repeat!"

To evolve your own expertise and understanding

My “Flexible Day Job”

Legal and Insurance Consulting

- Ethylene Plant LSTK bid review – Rio de Janeiro
- Ethylene Plant performance – Houston litigation
- Chlor-alkali Plant – Rita business interruption
- Chlor-alkali Plant in India – Court-ordered review
- Refinery & Pumping Stations – Katrina damage
- Wax Plant in Canada – Explosion BI loss
- Tar Sands Plant in Alberta – Advise Litigators
- Grid Privatization in Brazil – Advise NYC investors

EGT Funded Projects at Thielsch

- **Rocket Reactor & Electric Reactor developments**
- **Partial Oxidation Reactor mechanical analysis and heat exchanger failure - insurance claim**
- **Enhanced Oil Recovery process design and economics - feasibility study for EOR operator**
- **Process, reforming furnace, mechanical, metallurgical and controls evaluations for Ammonia/urea plant - expert litigation support**

Thielsch Engineering Support

Couldn't be where I am without them

- **Rocket Reactor – Process design, mechanical design and thermal stress modeling**
- **Electric Reactor – Chemical kinetic model**
- **Computer Simulations for process flow sheet developments**
- **Piping, Control Systems and Electrical Designs**
- **Capital Cost Estimates and Economic Analyses**
- **Market Intelligence and General Support**

**EGT Enterprises, Inc./
Thielsch Engineering, Inc.
Collaborations**

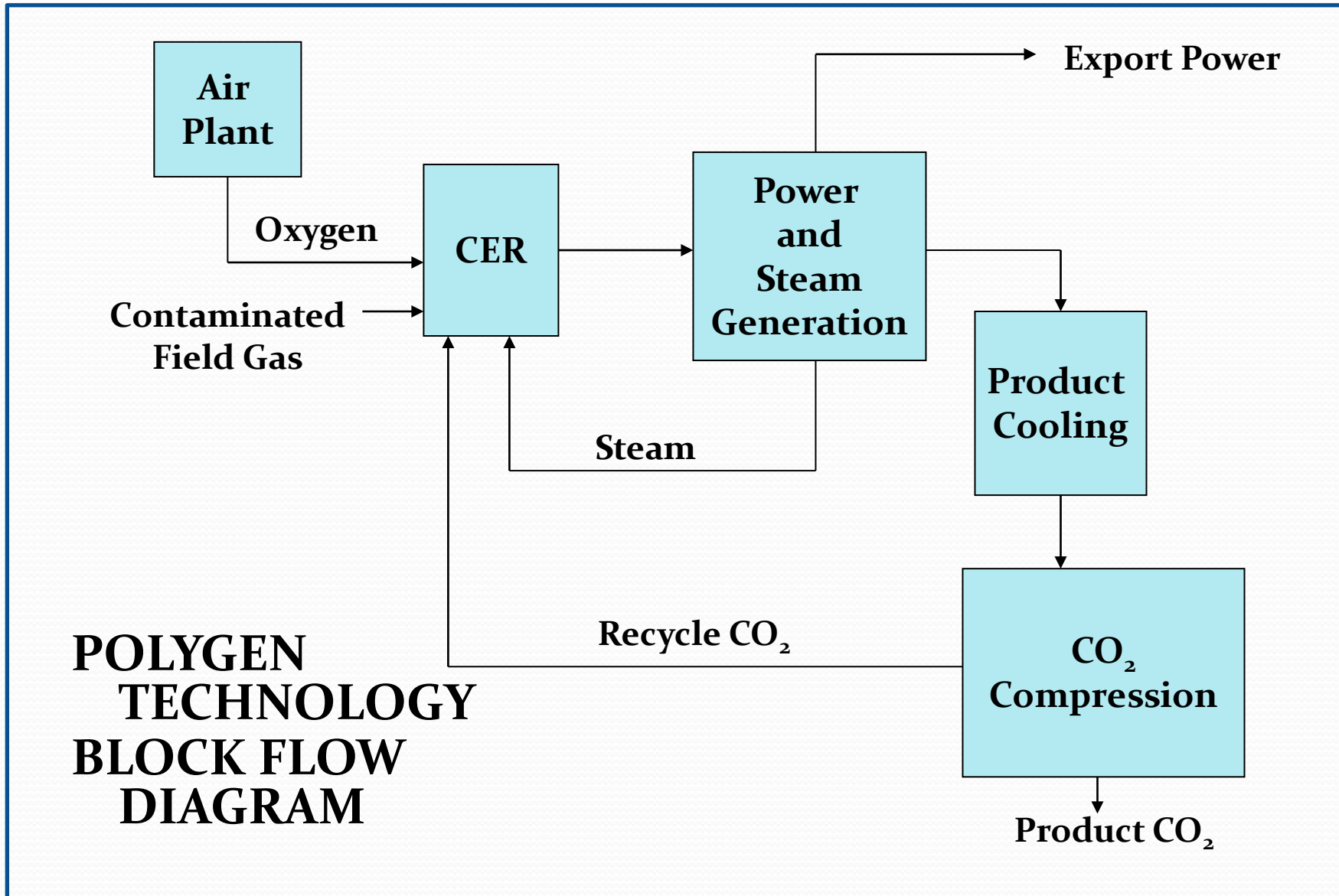


Client – Major U.S. Oil Producer

White Paper Study for Client's Mississippi Enhanced Oil Recovery (EOR) Site

- Conversion of low caloric value natural gas fields into high purity carbon dioxide (CO₂) that may be used for EOR
- Polygen Technology – coproduction of high purity CO₂ and power via EGT's patented CER Technology, a Turbo-Expander, and a Heat Recovery Steam Generation (HRSG) System
- Case studies were performed for various feed stocks and operating conditions
 - Case studies modeled the CER's ability to handle a wide range of varying calorific content
 - Optimization of operating conditions – studies for various inlet conditions to the turbo-expander were considered to maximize power generation

Client – Major U.S. Oil Producer



Client – Major U.S. Oil Producer

Results of White Paper Study

- **Generation of Heat and Material balances and Process Flow Diagrams (PFDs) for five case studies**
- **Equipment sizing and specifications**
 - **Communicated with multiple Vendors to size and quote heat exchangers, boilers, compressors, turbines, etc.**
- **Economic Analyses**
 - **Capital Costs**
 - **Operating Costs**
 - **Internal Rate of Return (IRR)**
 - **Sensitivity Studies**

Client – English University

Engineering study for small-scale Process Research System (PRS) in coordination with an English University

- **Use of EGT's patented Electric Reactor Technology (ERT) to convert hydrocarbons to Carbon Black**
- **Conversion of various feedstocks (LNG, Ethane, Propane, Naphtha) into Carbon Black using engineering software to model the kinetic reaction**
 - **Separation of Carbon Black from Hydrogen before Flare**
 - **Study of Decomposition Reactions and Pyrolysis Reactions**
 - **ERT was optimized for 99 mol % Hydrogen and power requirement of 1 MWe**

Client – English University

Results of Engineering Study

- **Heat & Material Balances, Process Flow Diagrams (PFDs) the Decomposition Reaction for each of the four (4) feedstocks**
- **Preliminary equipment sizing and specifications**
 - **Vendor quotations for ERT reactor, waste heat boiler (HXTR), carbon black separation units, the flare, and reactant supply**
- **Economic Analysis**
 - **Capital Costs**
 - **Operating Costs (including options for various feedstocks)**
 - **Internal Rate of Return (IRR)**
 - **Sensitivity Studies**
 - **Commercialization Options**
 - **Cash Flow Calculations**

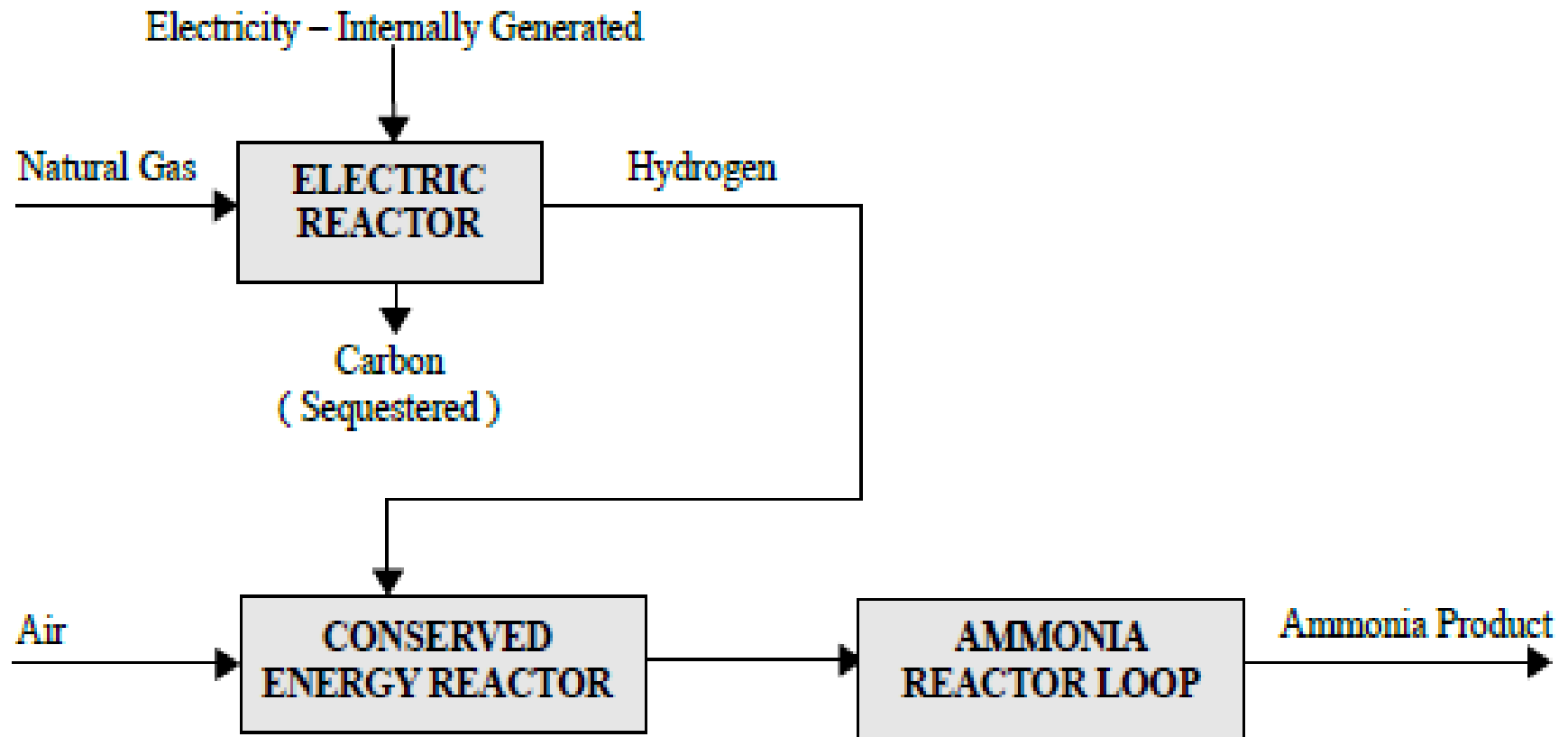
Client – Indian Nations

Engineering study for Process Demonstration and Research Unit (PDRU)

- Use of EGT's patented Electric Reactor Technology (ERT) and Conserved Energy Reactor (CER)
- ERT and CER used to produce H₂ and N₂ stream for Ammonia Production
- PDRU Ammonia Plant design able to achieve 99.8 mol % NH₃ purity
- Carbon produced by ERT is sequestered (Environmentally Friendly process)

Client – Indian Nations

PDRU Ammonia Plant – Basic Process Flow Diagram (PFD)



Client – Indian Nations

- **Results of Engineering Study**
 - **Heat & Material Balances, Detailed Process Flow Diagrams (PFDs) of the PDRU Ammonia Plant including the ERT / CER, Synloop, and Refrigeration Loop**
 - **Preliminary Equipment Sizing and Specifications**
 - **Equipment estimates or vendor quotes for HXTRs, Reactors, Gas Engines, Condensing Turbine**
 - **Economic Analysis**
 - **Capital Costs**
 - **Operating Costs**
 - **Internal Rate of Return (IRR)**
 - **Sensitivity Studies**
 - **Product Sales (Ammonia, Carbon Black)**

Client – Large Oil Refinery in New Jersey

Engineering study for conversion of Olefins in Refinery Off-Gas (ROG) via catalytic reaction

- **Use of a Catalyst Bed Reactor featuring a Palladium hydrogenation catalyst developed by Sud-Chemie (Clariant)**
- **Natural Gas Diluent is added to ROG, pre-heated, and reacted over the catalyst to convert olefins to their alkane counterparts at 350° F**
- **Removing olefins reduces fouling in plant equipment leading to lower maintenance costs**

Client – Large Oil Refinery in New Jersey

Results of Engineering Study

- **Heat & Material Balances, Process Flow Diagram (PFD) of the ROG Hydrogenation Process**
- **Preliminary Equipment Sizing and Specifications**
 - **Equipment estimates or vendor quotes for HXTRs and Reactor**
- **Preliminary Economic Analysis**
 - **Capital Costs**

In Conclusion – What You Need

Enthusiasm – Capability – Commitment

- **Work alone discipline**
- **Work with others**
- **Networking ability**
- **Perseverance**
- **Accept rejection**
- **Work outside your comfort zone**
 - **Ideas – People – Places**

Have fun while attempting the near-impossible!

And, Finally, On “Winning”

Vince Lombardi –

“Winning isn't everything, it's the only thing”

Bum Phillips –

“Winning is only half of it, having fun is the other half”

I am guided by both, remembering to

“Couple Knowledge With Action”

and that

**“No one can achieve success, and maintain it,
without the friendly cooperation of others *anon.*”**

Author Profiles

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Bernard Ennis, P.E. is President at EGT Enterprises, Inc. of Cedar Grove, New Jersey. He has consulted to industry, attorneys and insurance companies regarding ammonia-urea, ethylene, chlor-alkali, and power generation since 1993. Prior he worked in executive management and technical positions at CB&I, Inc. and KBR, Inc. He earned his B.S. and M.S. in Chemical Engineering at Villanova University. He has authored over 25 chemical technology patents. Member American Institute of Chemical Engineers, Association of Consulting Chemists and Chemical Engineers, Sigma-Xi Research Society.

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