



Identifying Green Chemistry Industrialization Barriers through Case Studies

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Flow

- Acknowledging - We have barriers
- Some Barriers to implementation of Green Chemistry
- Background of Recycle@Source™ – all case studies around it
- Case Study 1, 2 & 3
- Challenges Faced, Specific Barriers Experienced & What Worked
- Conclusions



Acknowledging that we have Barriers

Green Chemistry Tool Box is quite “**Empty**”

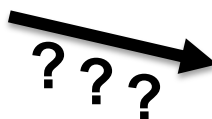
As a country, we have all it requires to address our environmental challenges:

- ✓ Fundamental knowledge of our scientists & academicians
- ✓ Skill, talent and energy of our young chemists & chemical engineers
- ✓ Practical experience of our industry
- ✓ Funding & other resources of our government bodies
- ✓ Spirit of adventure of our entrepreneurs & their ability to take risk

**Growing Magnitude
of Environmental
Challenges**



Barriers



Scale

Urgency



Some Barriers to implementation of Green Chemistry

- Availability of Green Chemistry technologies – GC Tool Box not full yet
 - Viable alternatives (e.g. Nitration, Sulphonation, Friedel Craft, etc.)
- Myths about Green Chemistry in market place
 - good theory, practically not possible
 - difficult & complex (especially SMEs)
 - requires huge resources & very long time to develop
- Awareness & understanding of Green Chemistry & Engg. Principles
 - our teams working on designing products/processes – limited knowledge on GC
 - don't need PhDs – just basic awareness & workable knowledge
 - need to introduce in our orientation/training, curriculum

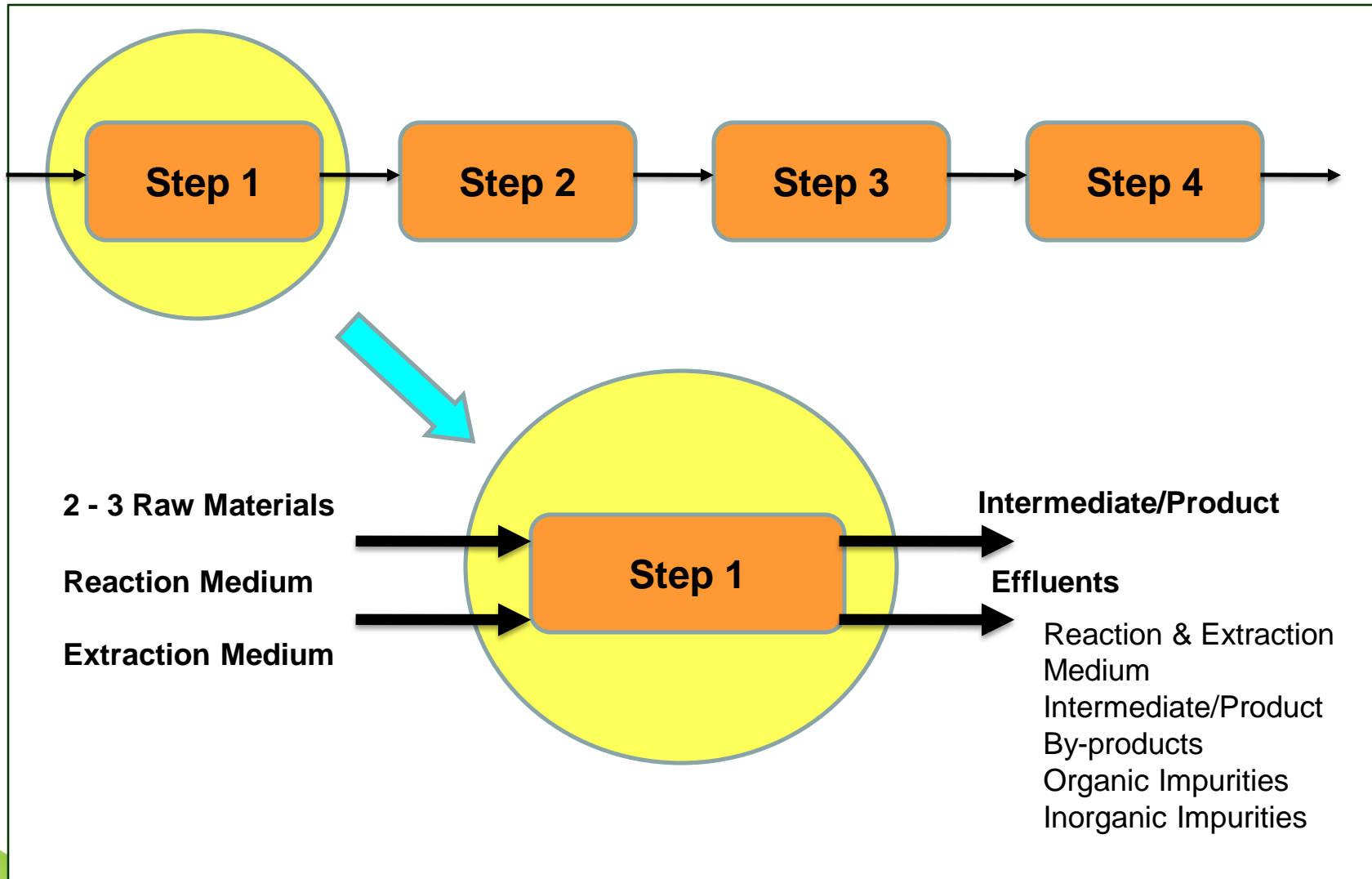


Some Barriers to implementation of Green Chemistry

- **Scale-up & Commercialization of Green Chemistry technologies**
 - Many technologies with Academic & Research Institutes – stuck at lab scale
 - Need for Academia & Industry to stretch slightly
- **Connecting GC Solution Providers to Industry**
 - Proven solutions with Solution Providers (start-ups, academia, technocrats)
 - Most “*low hanging fruits*”
 - Communication Gap (different geographies, insufficient marketing by solution providers, insufficient efforts by industry)

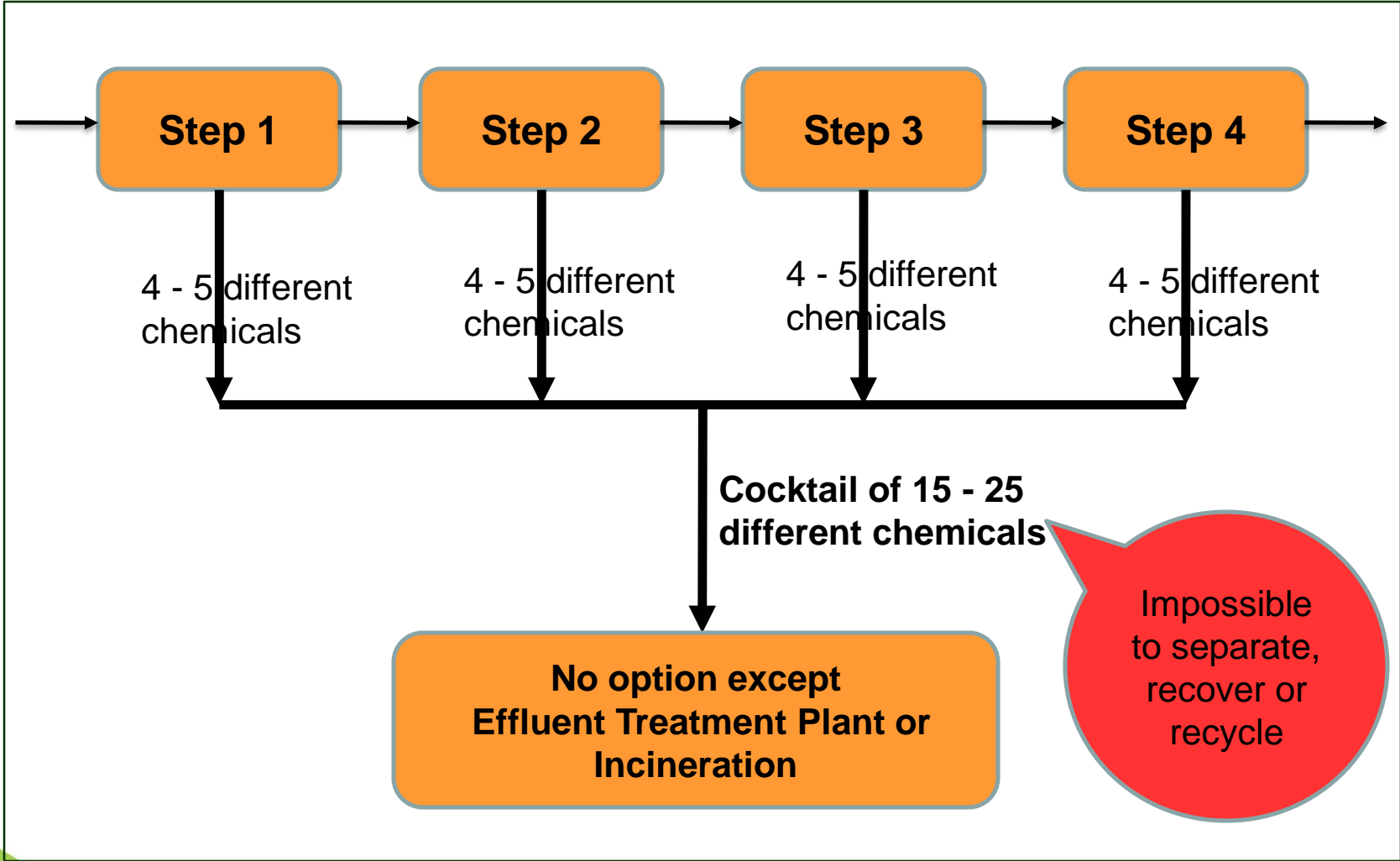


Reality of our processes



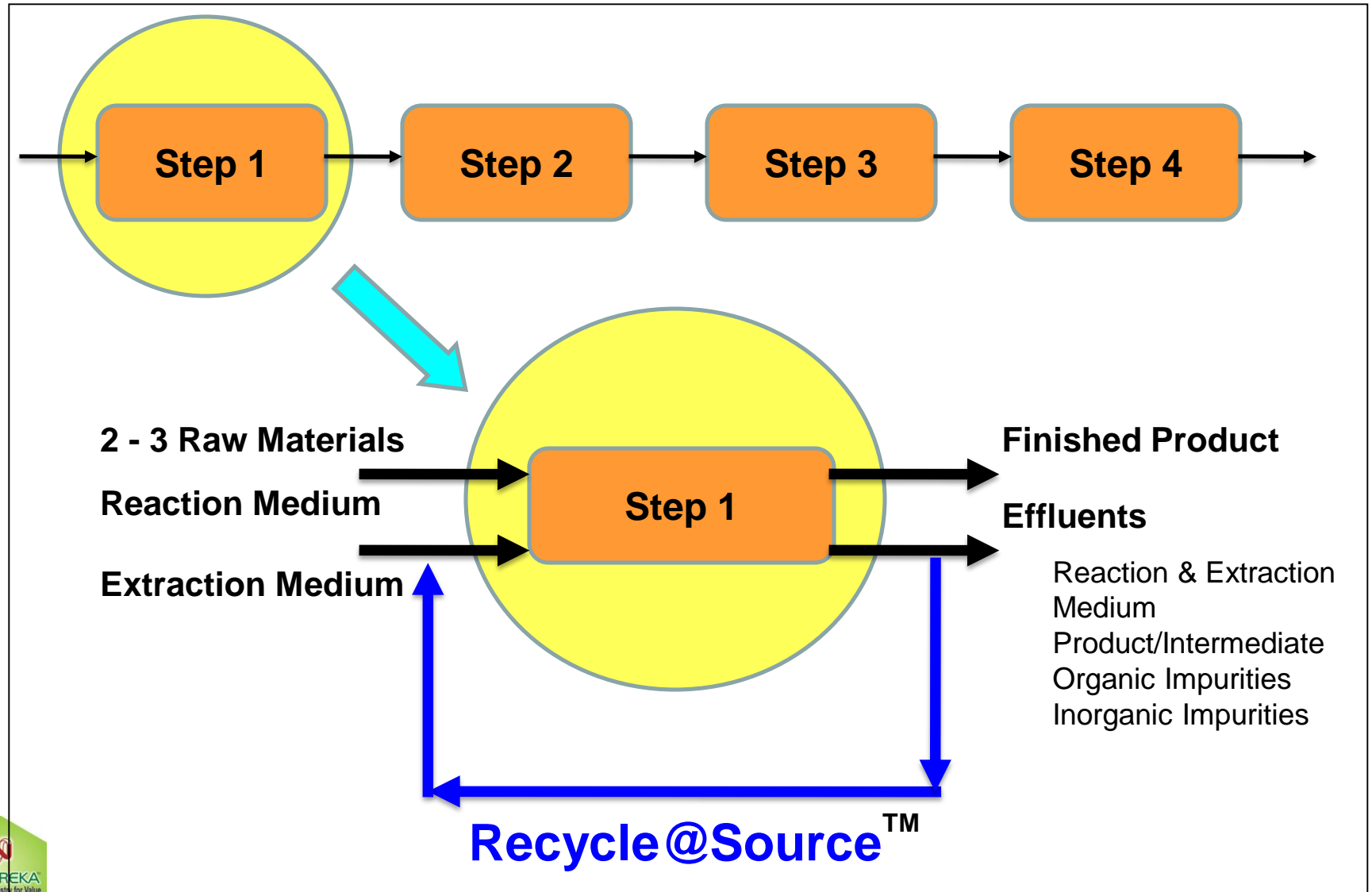


Reality of our processes





Recycle@Source™ Solution: Concept





Impact on our Water Resources

Just 3% of all water on planet is Fresh Water

Only 1% of all this Fresh Water is ready available for human use

In 20th Century, population tripled. Water consumption up 6 times

1 in 5 people don't have access to safe drinking water

1 in 3 people lack access to adequate sanitation

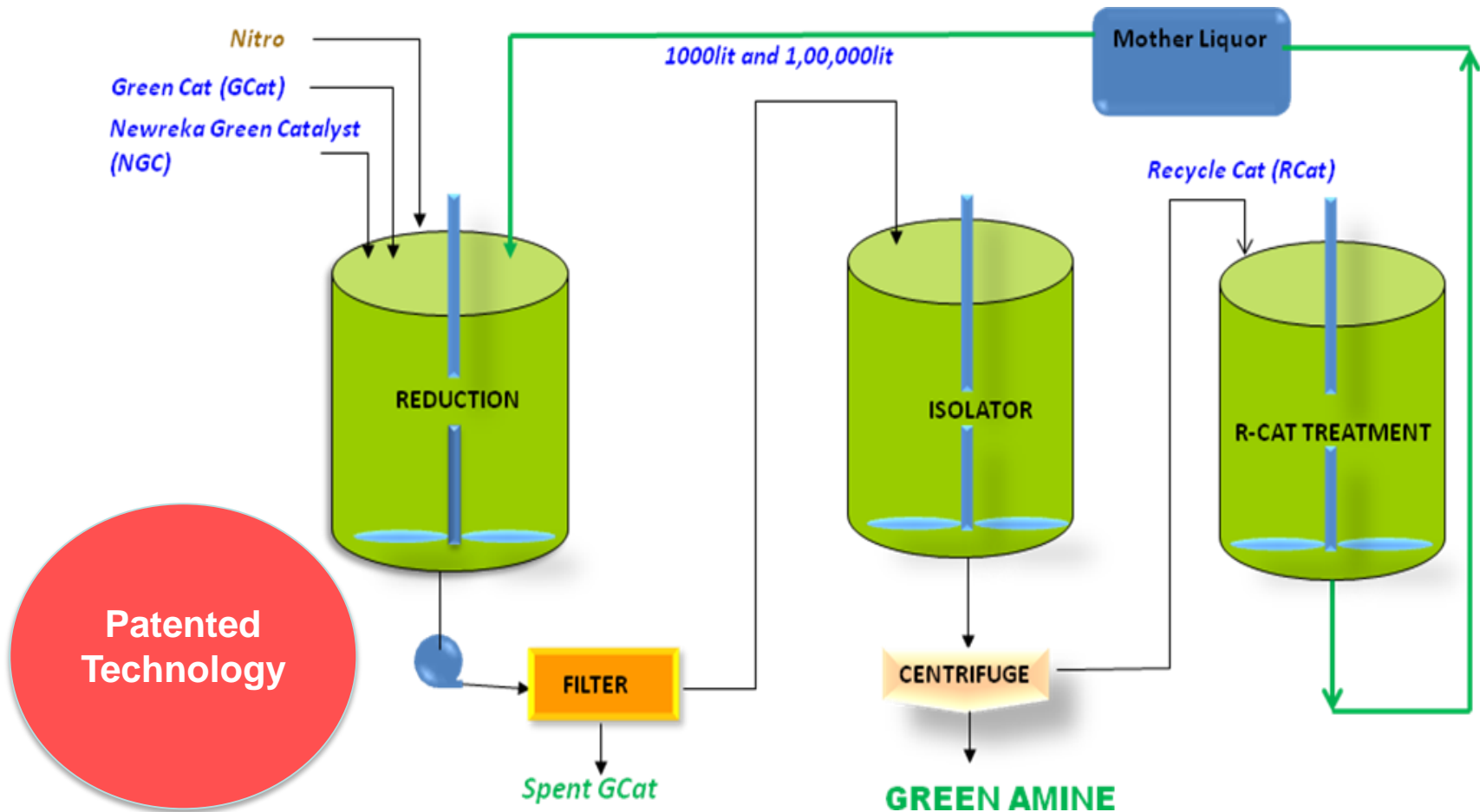
As per UN, a child dies of water related disease every 15 seconds

By 2050, another 3 billion people on planet. **Water for them?**

India: *1 bn people need fresh water daily, limited water resources, increasing outsourcing business & expanding chemical industry*



Recycle@Source™ Solution: Case Study 1



Feedback from customer: Recycling mother liquor for **over 2 years** now.
Over 800 batches (at times on campaign basis)
Just make-up for Water loss (**saved millions of lit of fresh water**)
Amine Quality – 99%+ on HPLC, 10% Yield improvement





Barriers Experienced & What Worked

▪ Barriers Experienced:

Mindset

- Recycle in Pharma Industry – not possible (we don't recycle distilled solvent)

Regulatory Changes

- 5 Recycles at Lab Scale
- Amine Quality of 5 Recycles - Approved
- Downstream Steps up to API for 5 Recycles – Impurity profile OK
- 15 Recycles at Plant Scale - Approved
- Stability Tests, Trace Metal Impurities, Customer Approval, DMF Changes
- Commercial Production Started – After 1.5 years from Lab Scale Demo

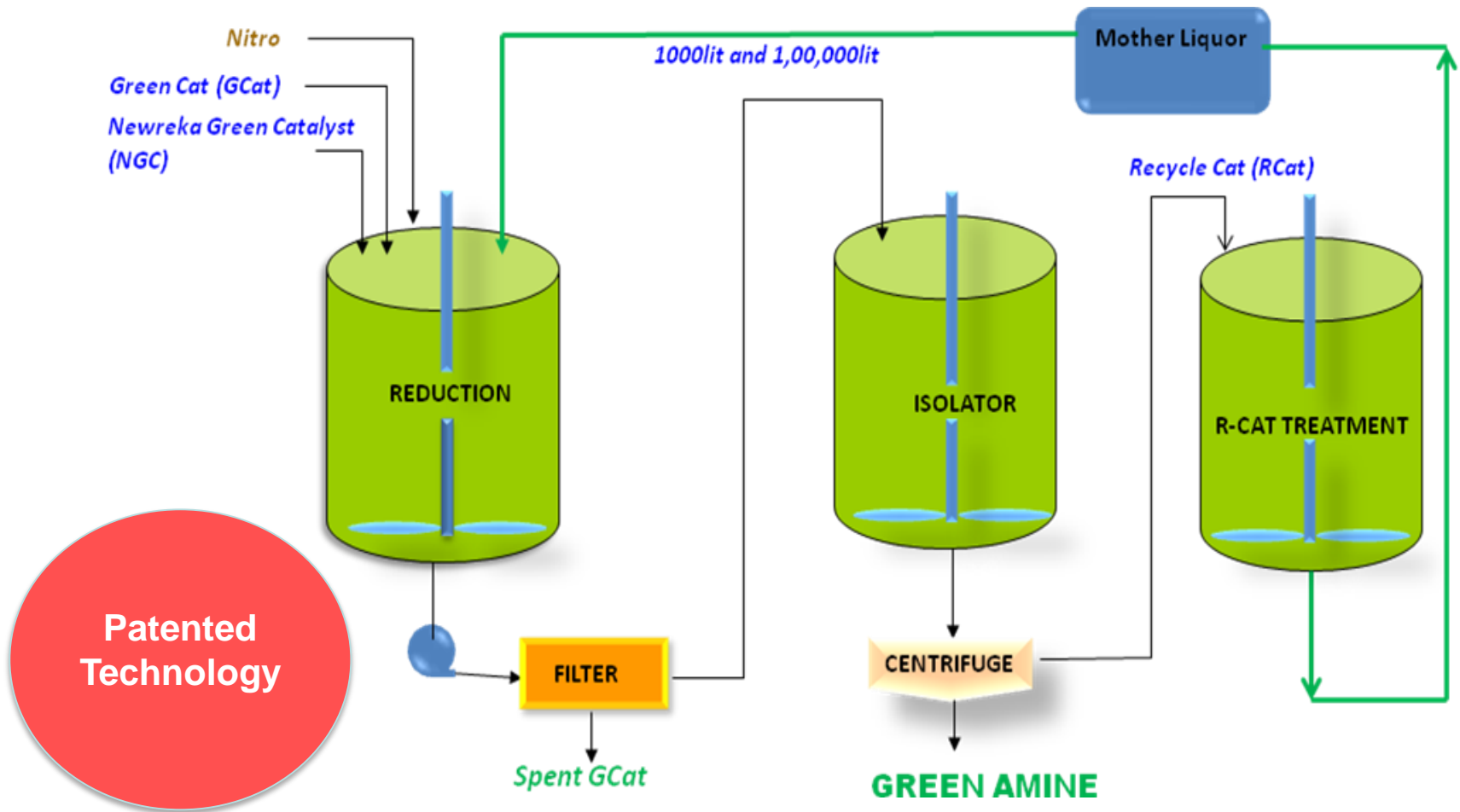
▪ What Worked:

Commitment & Perseverance

Champion of Green Chemistry in Customer's Team



Recycle@Source™ Solution: Case Study 2



Patented Technology

Customer's Feedback : Recycling mother liquor for over one month.
Over 116 batches of 400 kgs each (58 Recycles)
Just make-up for Water loss (saved millions of lit of water)
Amine Quality – 98.5%+ on HPLC, Yield = 96% of Theo.)





Barriers Experienced & What Worked

- **Challenges Faced:**

- Quality of Amine (Colour brown & black instead of Yellow)

- **Barriers Experienced:**

- **Mindset**

- Recycle in Pharma Industry – not possible (we don't recycle distilled solvent)

- **Scale-up**

- Technologies developed by Academia/Research Institutes – key casualties
 - Who would bear the risk?
 - It's not linear all the time
 - Certain Phenomena work better in Plant & some aspects get worse at plant (Mixing, Settling, Filtration, Product Washing, etc improve in plant while Oxidation of Amine deteriorates in plant)
 - Fundamentals of Chemistry & Chemical Engineering have to be clear
 - No Chemical Engineer in the Plant – Basic mass balance not done, no idea where yield is going



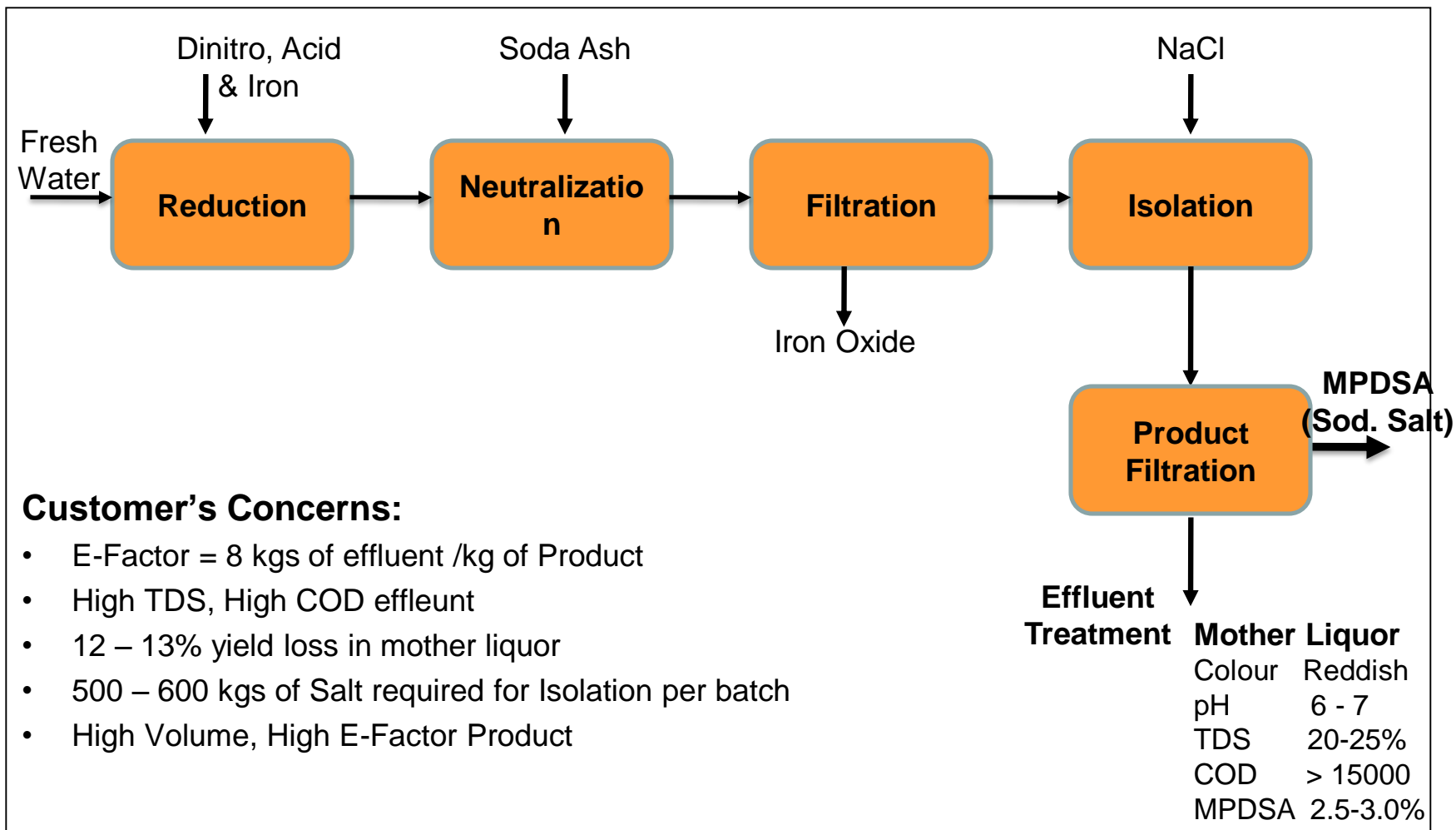
Barriers Experienced & What Worked

- **Actions taken to resolve:**
 - Demonstrated recycle at lab & pilot scale – 5 recycles
 - Used basics of Chemistry & Chemical Engineering
 - Decreased pH (solubility of oxygen decreases with pH)
 - Avoided splashing (increases oxidation)
 - Observed Crystallization temp of Amine & optimized use of Anti-Oxidant
 - Decreased RPM of Agitator & suggested some changes in Agitator design

- **What Worked:**
 - **Trust** between Customer & Us (Industry & Solution Provider)
 - Not much Inertia to Change
 - Willingness to take risk & continue production till technology optimized
 - Surrendering (you know your technology better, guide us)

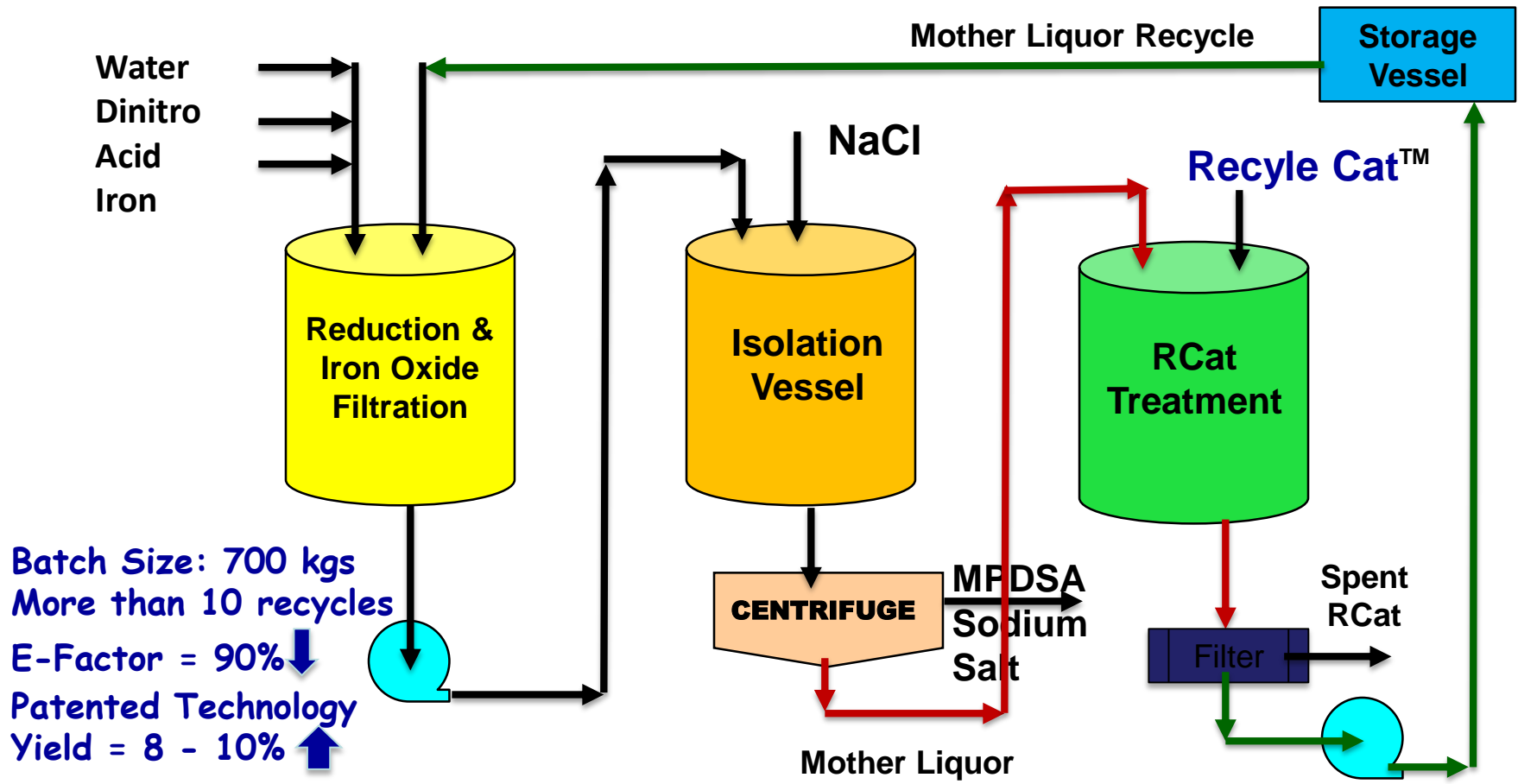


Conventional Manufacturing Process





Recycle@Source™ Solution: Case Study 3



Representative diagram to explain the concept of Recycle@Source™ solution as applied to MPDSA Sodium Salt



Barriers Experienced

- **Challenges Faced:**

- Water Balance, Amine Balance & Salt Balance
- Small/Medium Scale Enterprise – limitations of making Capital Investment

- **Barriers Experienced:**

- **Enrolling all Stakeholders**

- Management enrolled, Shop-floor enrolled, Plant In-charge not enrolled

- **Availability of Plant for Commercialization**

- Reasons why Plant is not available – production full swing, export order, plant shut-down, labour not sufficient, customer audits, production manager tied up, festival season,.....and the list goes on

- **IP Challenges**

- Didn't co-operate – Later copied the technology, tried recycle on their own



Conclusions

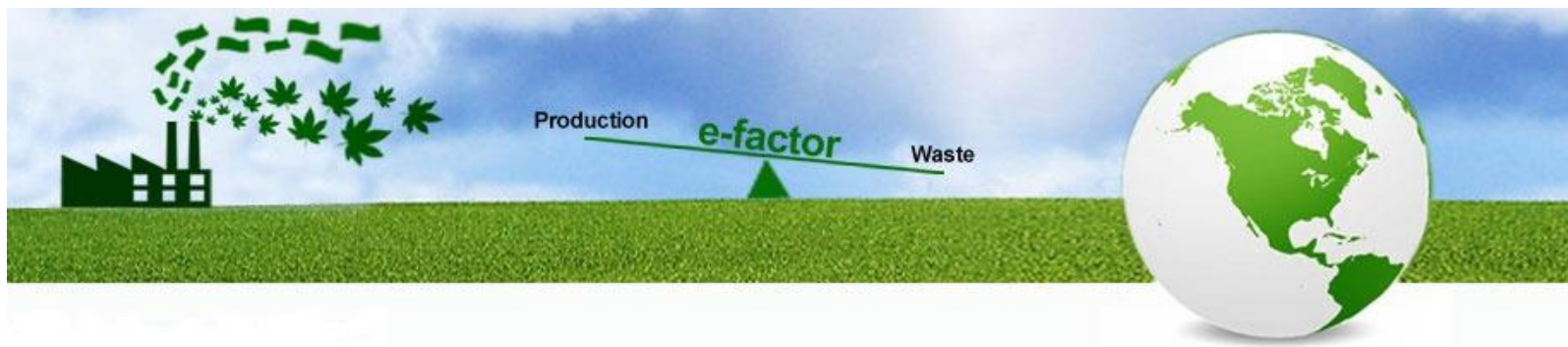
- We have all it takes to develop & commercialize Green Chemistry solutions. What's needed is:
 - **Connect, Collaborate, Create & Commercialize**
- Environmental challenges are opportunities to make **PROFITS**.
- Barriers : 10% Technological. **90% Human Mind Set.**
- Looking at our growing population & needs; given our limitations of water & other resources, we don't have much time. GC an URGENT need.
- Start wherever you want to or can. **But START.**
- Create short term & long term strategy – to implement Green Chemistry & Green Engineering in to operations.
- Need to be open, adventurous, willing to take some risk
- For a solution provider, its all worth it when customers acknowledge & we see tangible difference made to the quality of our Environment.



Thank you & Have a Greener Future

For resources on Green Chemistry
& Green Engineering:

Please visit
www.industrialgreenchem.com





Barriers – Solution Provider's perspective

- Inertia to New Paradigm against the gravity of existing paradigm
- Technical Barriers: no ecosystem for knowledge-based entrepreneurship
- Seed capital & funding barriers
- IP Barriers: protecting IP
- Market Barriers: awareness, business model
- Human Barriers: Inertia to change, culture, language
- Scale-up Barriers: same result in lab as in plant, availability of plant, risk
- Barriers created by “Old Nexus”
- Regulatory Barriers: changes in DMF, FDA & Customer approvals
- Financial Barriers: working capital for growth



Impact on our Businesses

- Additional cost (recurring) of treatment and disposal of effluents
- Financial Losses due to closure notices
 - direct production loss
 - increased utility costs (during restarting of plant)
 - increased overheads
 - sometimes loss of a potential order
 - other additional costs to get approval from authorities to restart
- Loss of credibility with customers – unreliable supplies
- Loss of time, efforts and energy of senior management
- Investment on treatment facilities (triple effect evaporator, incinerator, etc)
- Damage credibility within team, with suppliers, with other bodies, etc.



Impact on our Businesses

▪ Probable Future

- Environmental Norms – **more stringent, more closure notices**
- Common man's awareness about their rights – **expand**
- Customer's / End User's demand for "Green" products – **increase**
- Water – **crisis**
- Energy – **short supply**
- Managing Eco. & Environmental Competitiveness – **big challenge**
 - raw material prices going up
 - labor, power & overheads going up
 - effluent treatment costs going up
 - selling prices going down

Indian Chemical Industry – tough times ahead (with regards to environment), unless we intervene & do something different.