Scientific and Technical Advisory Panel

The Scientific and Technical Advisory Panel, administered by UNEP, advises the Global Environment Facility
(Version 5)

STAP Scientific and Technical screening of the Project Identification Form (PIF)

Date of screening: May 04, 2015 Screener: Christine Wellington-Moore

Panel member validation by: Ricardo Orlando Barra Rios
Consultant(s):

I. PIF Information *(Copied from the PIF)*
FULL SIZE PROJECT GEF TRUST FUND
GEF PROJECT ID: 6921
PROJECT DURATION : 5
COUNTRIES : China
PROJECT TITLE: Demonstration of Mercury Reduction and Minimization in the Production of Vinyl Chloride Monomer
GEF AGENCIES: UNIDO
OTHER EXECUTING PARTNERS: Foreign Economic Cooperation Office, Ministry of Environmental Protection, China

GEF FOCAL AREA: Chemicals and Waste

II. STAP Advisory Response *(see table below for explanation)*

Based on this PIF screening, STAP's advisory response to the GEF Secretariat and GEF Agency(ies):
Major issues to be considered during project design

III. Further guidance from STAP

The objective states that the project seeks to "reduce risks of mercury on human health and the environment from industrial production of Vinyl Chloride Monomers in China". With attendant adjustment and strengthening of institutional, legislative and regulatory frameworks, the project hopes to "reduce risks of mercury on human health and the environmental impact from industrial production of Vinyl Chloride Monomers to achieve 50% reduction of mercury use in per unit production by the year 2020 (reference year 2010) through optimization the existing production and achieving 90% recovery of mercury in production processes, [as well as] promote mercury-free catalyst R&D and trial application as the initial step of commercialization".

The project indicates that it will be the first initiative to demonstrate low mercury catalyst technologies and mercury free alternatives in China (see page 12, para 24), and proposes to introduce the private-public-partnership (PPP) model of venture capital to foster a wide range of domestic and international exchanges and cooperation partners between VCM producers, catalyst producers, academic institutions to promote technology transfer and exchange. (see page 9, para 12).

Page 9, paragraph 12 of the PIF also discusses the potential alternatives being considered, including zeolite-based catalysts, fluidized bed reactor systems (both of which require retrofitting of current systems to function), as well as other un-named mercury-free alternatives that are "still in the laboratory stage.

The summary of barriers to be overcome listed in the PIF are stated as:

1) Lack of relevant policy;
2) Insufficient capacity of implementing, regulation, and monitoring the existed policy or rules;
3) Low-mercury catalyst (containing of about 4.0-6.0% mercuric chloride) shows less cost-effectiveness than high-mercury catalyst, and the mercury-free catalyst technology is still in the stage of experiment;
4) Few technology of conducting mercury containing waste and mercury contaminated sites;
5) The plants 'weak awareness of implementing Mercury Convention and low resistance to the risks;
6) R&D has been organized and programmed unsystematically, lacking the risk allocation

instrument and international cooperation;
7) Lack of fiscal, financial, tax and other incentives to encourage the BAT/BEP to remove market barriers.

STAP Comments:

The STAP recognizes a need for elimination of mercury from the PVC manufacture process, and the overall design of the project is quite logical. However, based on its research in reviewing the issue, the STAP sees a lack of acknowledgement of work that has proceeded this effort in China, as well as recognition of commercially demonstrated, zero mercury alternatives.

Since the 1980s it has been discovered that finely supported divided nanoparticles of gold could act as catalysts for reactions at low temperatures, which was a ground breaking observation since most consider gold to be an unreactive metal (Nanostructure Science and Technology 2007, pp 39-54. Nanotechnology in Catalysis: "Catalysis by Gold: Recent advances in Oxidation Reactions", Hutchings, G.J.). The first significant practical demonstration of the commercial relevance of catalysis by gold was carried out in the mid-1990s by Hutchings in South Africa ("Catalysis: A Golden Future". G.J. Hutchings. Gold Bull., 1996. 29, 123.). Further, as research on fluidized-bed operation developed, it was noted that a new catalyst would be required to move from fixed to fluid bed operations, and the one selected was a supported gold-palladium system in the form of very fine spheres, prepared in collaboration with the Johnson Matthey company. Indeed gold-based catalysts are well-established in fixed-bed processes for the large-scale manufacture of VAM (Gold: Science and Applications. 2010. Ed. Christopher Costi; Richard Holliday. CRC Press. Taylor and Francis Group LLC.), and are also seen as critical for mercury free fluidized-bed systems.

The early work by Hutchings in South Africa indicated that gold catalysts supported by activated carbon were about three times more active than commercial mercuric chloride catalysts for vinyl chloride production, and to deactivate much less rapidly than other supported metal catalysts. Deactivation can be minimized if high loadings of gold are used, and gold catalysts could be reactivated by treatment off-line with hydrogen chloride or chlorine, and by co-feeding nitric oxide with the reactants from the start of the reaction, deactivation could be virtually eliminated ("Catalysis: A Golden Future". G.J. Hutchings. Gold Bull., 1996. 29, 123.). It has been concluded in the literature that gold is the catalyst of choice for the production of the monomer which acts as the building block for PVC, with the economics of the use of gold assisted by the cost-effective recycling of the gold where market demand for PVC is great (Gold: Science and Applications. 2010. Ed. Christopher Costi; Richard Holliday. CRC Press. Taylor and Francis Group LLC) .

Looking specifically at the case of China, the STAP found significant work done in the country that does not seem to have been recognized in the PIF, which would be useful for future project development. The Royal Society of Chemistry has discussed the case of China in its 2013 Catalysis Series (Royal Society of Chemistry. 2013. Volume 13. "Environmental Catalysis over Gold-based materials". Eds George Avgouropoulos; Tatiana Tabakova) , noting the preference for the coal-based, ethyne hydrochlorination process and use of mercury chloride catalysis, but also that ironically enough, the ethyne hydrochlorinaation process was one of the first reactions to show gold's huge potential as a catalyst, and that gold on carbon is now under investigation at industrial scale in China as a sound replacement to mercuric chloride. They further indicate that from a commercial perspective, Johnson Matthey is active in China, having already filed patents in China, along with other China-based organisations.

Further investigation by the STAP found that since 2011, Johnson Matthey, partnered with Jacobs Engineering Group out of the Netherlands and UNEP to carry out a joint multi-year private-public initiative that specifically focuses on commercializing an economically feasible, mercury free catalyst for the manufacture of vinyl chloride monomer (VCM) using China as the focal country for efforts. This so-called Jacobs / JM partnership area has also been informing the Minamata Convention, and baseline feasibility reports and the like are readily available online (see http://www.unep.org/chemicalsandwaste/Mercury/PrioritiesforAction/VinylChlorideMonomerProduction/tabid/4523/Default.aspx). Therefore, one has to question the thoroughness of baseline research undertaken for this PIF, since it claims to be the first effort towards finding non-mercury alternatives, and yet it would appear that there is so much evidence of serious investment and demonstration into mercury-free catalysis for VCM/PVC production, including the Foreign Economic Cooperation Office, Ministry of Environmental Protection of the People's Republic of China. In STAP's view, the project relies on very weak scientific support for researching alternatives to mercury in VCM production, while the scientific literature clearly indicates that there is significant previous work in this domain in China that the PIF does not acknowledge nor incorporate into the conceptualization of this initiative.

STAP proposes therefore that UNIDO should reach out to Agencies such as UNEP (UNEP Mercury Partnership and the Science officer of the Convention Secretariat in particular) to first go over the feasibility of earlier work in this domain, and to establish which alternatives have been identified as the most viable for China. STAP's review of the literature would appear to indicate that alternatives such as gold catalysis are tested and viable, but a more rigourous discussion with partners, the scientific community, the private sector, as well as the relevant Chinese Ministries could help significantly in fine tuning the design of the project, and ensure the most effective use of GEF resources based on recent advances in technology and lessons learned.

Some additional points:-

1) The Tianjin University School of Chemical Engineering and the School of Chemistry and Chemical Engineering of Shihezi University in Xianjing, have also published significantly on cleaner production processes/non-mercury catalysts for the Chinese VCM/PVC industry.

2) The Xinjiang Tianye (Group) Co., Ltd, largest calcium carbide PVC manufacturer in China also appeared to be one of the local private sector partners involved in the UNEP PPP initiative.

3) Whilst some of the current risks laid out on pages 14-15 of the PIF will certainly be correct, the full scope of risks cannot be known without first ascertaining what risks may have been delimited, or what additional risks were identified, by previous work apparently not yet acknowledged.

STAP advisory response	*Brief explanation of advisory response and action proposed*
1. Concur	In cases where STAP is satisfied with the scientific and technical quality of the proposal, a simple "Concur" response will be provided; the STAP may flag specific issues that should be pursued rigorously as the proposal is developed into a full project document. At any time during the development of the project, the proponent is invited to approach STAP to consult on the design prior to submission for CEO endorsement.
2. Minor issues to be considered during project design	STAP has identified specific scientific /technical suggestions or opportunities that should be discussed with the project proponent as early as possible during development of the project brief. The proponent may wish to: (i) Open a dialogue with STAP regarding the technical and/or scientific issues raised. (ii) Set a review point at an early stage during project development, and possibly agreeing to terms of reference for an independent expert to be appointed to conduct this review. The proponent should provide a report of the action agreed and taken, at the time of submission of the full project brief for CEO endorsement.
3. Major issues to be considered during project design	STAP proposes significant improvements or has concerns on the grounds of specified major scientific/technical methodological issues, barriers, or omissions in the project concept. If STAP provides this advisory response, a full explanation would also be provided. The proponent is strongly encouraged to: (i) Open a dialogue with STAP regarding the technical and/or scientific issues raised; (ii) Set a review point at an early stage during project development including an independent expert as required. The GEF Secretariat may, based on this screening outcome, delay the proposal and refer the proposal back to the proponents with STAP's concerns. The proponent should provide a report of the action agreed and taken, at the time of submission of the full project brief for CEO endorsement.