

# Independent In-Depth Mid-Term Review

# UNIDO-ICHET



UNITED NATIONS  
INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO EVALUATION GROUP

**Independent In-Depth Mid-Term Review**

# **UNIDO-ICHET**



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This document has not been formally edited.

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## Abbreviations and Acronyms

CNG	Compressed Natural Gas
DELHY-3W	Delhi Hydrogen three wheeler (project)
EC	European Commission
GEF	Global Environmental Facility
HQ	Headquarters
ICGEB	International Centre for Genetic Engineering and Biotechnology
ICHET	International Centre for Hydrogen Energy Technologies
ICT	Information and Communications Technologies
IRENA	International Renewable Energy Agency
MENR	Ministry of Energy and Natural Resources (Turkey)
MOU	Memorandum of Understanding
NOx	Nitrogen Oxides
OSL/EVA	Bureau for Organizational Strategy and Learning/Evaluation Group
QAG	Quality Advisory Group (UNIDO)
PAC	Project Approval Committee (UNIDO)
RD&D	Research, Development and Deployment
REEEP	Renewable Energy and Energy Efficiency Partnership
SMART	Specific, Measurable, Achievable, Realistic, and Time bound
SME	Small and Medium Enterprise
TIKA	Turkish International Cooperation and Development Agency
TME	Turkish Ministry of Energy
TC	Technical Cooperation
TOR	Terms of Reference
TUBITAK	The Scientific and Technological Research Council of Turkey
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
UPS	Uninterruptible Power Supply
UR	UNIDO Representative

## **Acknowledgements**

This independent review was prepared with the invaluable assistance from relevant UNIDO-ICHET staff in Istanbul as well as relevant UNIDO headquarters staff. However the review analysis, conclusions and recommendations are solely the responsibility of the evaluation team.

# Glossary of terms<sup>1</sup>

Term	Definition
Baseline	The situation, prior to an intervention, against which progress can be assured
Effect	Intended or unintended change due directly or indirectly to an intervention
Effectiveness	The extent to which the development intervention's objectives were achieved, or are expected to be achieved.
Efficiency	A measure of how economically resources/inputs (funds, expertise, time, etc.) are converted to results
Impacts	Positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended
Indicator	Quantitative or qualitative factor or variable that provides a simple and reliable means to measure achievement, to reflect the changes connected to an intervention, or to help assess the performance of a development actor
Intervention	An external action to assist a national effort to achieve specific development goals
Lessons learned	Generalizations based on evaluation experiences with projects, programmes, or policies that abstract from the specific circumstances to broader situations. Frequently, lessons highlight strengths or weaknesses in preparation, design, and implementation that affect performance, outcome, and impact
Logframe (logical framework)	Management tool used to improve the design of interventions, most often at the project level. It involves identifying strategic elements (inputs, outputs, outcomes, impact) and their causal relationships, indicators, and the assumptions or risks that may influence success and failure. It thus facilitates planning, execution and evaluation of a development intervention. Related term: results based management
Outcome	The likely or achieved short-term and medium-term effects of an intervention's outputs. Related terms: result, outputs, impacts, effect
Output	The products, capital goods and services which result from a development intervention; may also include changes resulting from the intervention which are relevant to the achievement of outcomes
Sustainability	The continuation of benefits from a development intervention after major development assistance has been completed. The probability of continued long-term benefits. The resilience to risk of the net benefit flows over time.

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<sup>1</sup> Based on a glossary prepared by OECD's DAC working party aid evaluation, May 2002

# Executive Summary

## Background

The establishment of the International Centre for Hydrogen Energy Technologies (ICHET) was the result of a sixteen year process that included many international meetings, consultations and studies, with the overall objective of developing an institution that would promote the tangible applications of hydrogen energy technologies in developing countries.

ICHET was formally established in October 2003 with the signing of a Trust Fund agreement between the Government of Turkey and UNIDO. The Government of Turkey agreed to fund the five year initial phase of ICHET with USD 40 million, with UNIDO managing the process of forming and running ICHET. The ICHET Trust Fund agreement contained a provision for an independent mid-term evaluation, and accordingly this review was initiated in July 2009.

This review's overall purpose was to independently assess ICHET design, its achievements and performance to date, identify the main scenarios for its future, and to make recommendations for ICHET's performance and long-term sustainability. Given the early stage of development of many of the ICHET substantive activities, the emphasis of the evaluation was more on ICHET relevance than on its effectiveness to date. Alongside a comprehensive document review, a two week evaluation mission was undertaken in Vienna, Istanbul and New Delhi between September and October 2009 to obtain first-hand information and opinions from stakeholders and ICHET staff. Initial findings were presented to ICHET in Istanbul and to UNIDO offices in New Delhi and Vienna, and the review report was then finalized, incorporating the feedback received from UNIDO and ICHET. The evaluation team was composed of Mr. Frank Pool (Independent evaluation consultant and clean energy specialist, Team leader) and Mr. Johannes Dobinger (UNIDO Evaluation Group, Team member). The Turkish Government participated through an observer, Mr. Osman Demirci.

## ICHET design and implementation

Analysis of the ICHET background documentation shows that a series of highly optimistic assumptions were made in its design regarding the then alleged "commercial" status of hydrogen technologies and the potential for a series of simultaneous multiple breakthroughs to be achieved in: hydrogen supply from renewable energy; fuel cell cost reductions and performance improvements; hydride storage density, tolerance to impurities, and recharge time; and so forth. However, to be fair, such highly optimistic assumptions were common at this "over hyped" visionary stage of the supposedly imminent "hydrogen economy". ICHET was also in

good company in buying into the “hydrogen economy” vision as at that time many billions of USD were invested by governments and the private sector – in particular to achieve the highly ambitious multiple and simultaneous promised hydrogen technology breakthroughs, that have not eventuated to date. When the promised breakthroughs did not appear, some people have concluded that the support of hydrogen technology development and deployment should now be completely abandoned.

However, the true potential for hydrogen technology applications lies somewhere between the original over-optimism and the common current excessive pessimism. Real progress is now being achieved in some key mass market hydrogen energy applications. For example, the limited series production of the Honda FCX Clarity fuel cell car for lease by selected people in their daily driving is now doubling the number of working hydrogen cars in the world. The Daimler-Benz hydrogen B Series limited series production car for lease to selected users is apparently also imminent. These vehicles have real world performance, weight, 400 km range and 3-minute refuelling times and provide an insight into a long-term future of vehicles using hydrogen and fuel cells for longer range transport alongside shorter range battery powered vehicles. While hydrogen fuel cell applications for cars remain the domain of large players and will stay beyond ICHET reach, these advances clearly show that hydrogen energy technologies are becoming an important element of the global clean energy future.

Tangible ICHET operations started on 01 May 2004. The first three years of ICHET operations were focused on general hydrogen awareness raising activities, attempts to obtain suitable land to build a permanent Istanbul campus for ICHET, and attempts to raise funds to fully cover the costs of proposed hydrogen demonstrations and activities in a range of countries.

In early 2007 there was a “fresh start” made to ICHET. The new emphasis was on undertaking tangible hydrogen application projects with co-funding from ICHET and local partners to realize these projects. ICHET now has a number of specific hydrogen applications underway, nearly all of which offer the potential for useful replication in developing countries.

Of particular relevance in terms of replicable demonstrations is the DELHY-3W project being undertaken in Delhi, India. The DELHY-3W project involves an intermediate and appropriate technology ICHET project application with fifteen standard Mahindra 3-wheeler vehicles. The hydrogen 3-wheelers will use Compressed Natural Gas (CNG) -style pressurised fuel storage tanks and their hydrogen will be supplied by one of the largest merchant hydrogen suppliers in the world, Air Products. This project is an excellent fit with the 2007 Indian National Hydrogen Energy Road Map’s early target areas for hydrogen transport applications in India. The DELHY-3W project has a promising potential for replication using

hydrogen (without the need for cleaning up the hydrogen to the extremely high levels of purity required for fuel cell applications) that is produced as a by-product from the Indian chlor-alkali industry and that is apparently currently being flared. Hydrogen fuelling is expected to be a solution for the high Nitrogen Oxide (NOx) emissions (instead of the use of expensive 3-way catalytic converters) from the inexpensive CNG fuelled 3-wheelers in Indian cities that have now largely replaced the original smoky diesel powered 3-wheelers.

There is a current real direct replication potential of the DELHY-3W project to other countries that currently use Indian 3-wheelers, have severe urban pollution problems, and have a good potential for expanded renewable electricity supply to produce hydrogen from electrolysis from renewable electricity supplies, e.g. Kathmandu in Nepal.

In terms of institutional structure and capacity, ICHET has made considerable progress during the past two years. In particular, ICHET has established the originally envisaged Steering Committee and Scientific Advisory Committee, recruited international staff, established a professional planning and monitoring system for its projects, and developed systems that are now in compliance with UNIDO administrative procedures, rules and regulations. Within this structure and capacity, two areas remain to be strengthened: appropriate expertise and procedures for development cooperation (while the ICHET focus should remain technical, it will function within the existing international framework conditions of development cooperation); and expertise and processes to ensure that the focus of ICHET technology applications moves beyond the current primary area of technical proof-of-concept demonstrations and technical learning focused pilot projects.

ICHET is now aiming to place greater emphasis on being a system integrator - where existing hydrogen technologies are integrated into functioning and sustainable real world hydrogen systems. This is a promising area for ICHET future focus, although this requires a new and explicit emphasis by ICHET on how to integrate existing hydrogen technologies into real world and relevant developing country applications. This will require a conscious shift by ICHET to further replication or to mass market applications in developing countries from its current "proof-of-concept" and/or "technological learning" focused pilots and demonstrations that have minimal apparent explicit links.

### **Assessment**

In terms of relevance, ICHET activities are in principle relevant to developing countries' industrial applications, and ICHET has made good progress in improving its relevance from a design that had limited specific relevance in its grand "hydrogen vision" starting point. Through this DELHY-3W project, ICHET has demonstrated its in-principle relevance as a partner for developing countries and its capacity in

managing complex projects in environments that are very different from its home base in Turkey. However, more needs to be done to make ICHET activities fully relevant to subsequent hydrogen replications in developing countries.

In terms of efficiency, ICHET has made good progress from its 2007 “fresh start” to where it now seems to have an acceptable overall level of efficiency in its operations. One outstanding efficiency issue is that the steady drift towards ICHET undertaking projects only in Turkey (the existing DELHY-3W project and an upcoming Cook Islands projects being the only exceptions) means that the ICHET structure is not very efficient with its use of complex UNIDO rules and administrative procedures, nor with its staff being paid international rates (as ICHET is an international institution) to work on predominantly Turkish projects.

The effectiveness of ICHET has made steady progress, but the unresolved issue of the new ICHET campus, which is still officially under development, is an issue that now needs to be resolved, probably with a formal decision to defer or cancel the new campus until ICHET ultimate form, funding and governance is properly clarified and agreed.

ICHET has made good progress in improving its sustainability of operations and projects since an uncertain beginning, but serious discussions are now required in a tripartite meeting between UNIDO, ICHET and the Turkish government on how ICHET can be made more sustainable in the future. In particular, the tripartite meeting should consider the four main scenarios of ICHET ultimate funding and governance basis (for their full details see section VII), make a clear choice, and then all parties should start mutually working together towards this agreed goal. The four options, all of which will require Turkish base funding of USD 5 to USD 8 million per year for the foreseeable future, are: -

1. ICHET as an independent legal entity international organization (the recommended long-term focused option);
2. ICHET as an integral part of UNIDO (a medium term option while the independent legal entity options is being developed);
3. Continue relying on Turkish Trust Fund support as a UNIDO project (the short to medium term option while base funding and UNIDO-ICHET ownership” is being diversified);
4. ICHET as a Turkish focused organization (the default TCHET option if current trends are not reversed).

## **Recommendations**

This review also makes a series of detailed recommendations (see details in section VII) on future steps to be taken by ICHET. These recommendations cover the following issues:

- Taking a decision on the long-term institutional future of ICHET
- Improving UNIDO-ICHET formal governance structures
- Improving ICHET real applications, deployment and replication focus
- More realistic ICHET funding plans and mobilization
- Defer ICHET permanent campus and extend project end date
- Reinforce ICHET international and real project focus
- Articulating a new strategic rationale for ICHET

## **Lessons learned**

From the ICHET experience to date, some lessons can be learned for planning and implementing similar UNIDO projects in future:

1. New organizations need a clear institutional perspective;
2. Demonstrations must solve real development problems;
3. New technologies start in “killer” niche applications;
4. New technologies do not develop in a vacuum – they compete with other developing technologies.



# I

## Introduction

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### 1.1 Purpose and objective of the mid-term review

The project TF/INT/03/002 “Establishment and Operation of the International Centre for Hydrogen Energy Technology (ICHET)” is based on a Trust Fund agreement signed in October 2003 between the Government of Turkey and the United Nations Industrial Development Organisation (UNIDO). The rationale and scope for the promotion of hydrogen technologies by ICHET are detailed in the May 1998 ICHET Project Document and are an integral part of the 2003 Trust Fund agreement. After starting operations in 2004 and some delays in implementation, the project had spent approximately 40 per cent of the original budget by September 2009. The Trust Fund agreement contains the requirement of a Mid-Term Review (MTR) and a terminal evaluation. Accordingly, in consultation with the Turkish authorities, UNIDO launched this independent Mid-Term Review (MTR) in July 2009.

The overall purpose of this MTR is to provide an independent assessment of the relevance of UNIDO-ICHET original design; its achievements and performance since its tangible operations started on 01 May 2004; its prospects for post-project relevance; its funding and governance sustainability; and to make recommendations for its improved operations up to project end date (its current agreed end date being 31 December 2010 although project partners are considering an extension). On the basis of the evidence reviewed and its analysis, the review will also assess the likelihood of subsequent Trust Fund replenishments and co-financing in its continued operations. The MTR will also be used as input into a thematic assessment that is being undertaken of the UNIDO network of International Technology Centres.

The evaluators selected for this review were completely independent from the design, implementation or supervision of UNIDO-ICHET and its activities and projects. The review team was chosen to possess a complementary mix of national and international experience in both UNIDO activities and in wider development interventions, as well as project design, operation and review/evaluation. The MTR Team comprised of:

- Mr. Frank Pool, Independent Clean Energy Specialist, Team leader

- Mr. Johannes Dobinger, Evaluation Officer, UNIDO Evaluation Group

The Government of Turkey participated through an observer in the evaluation:

- Mr. Osman Demirci, Advisor to the Minister of Energy and Natural Resources, Government of Turkey

## **1.2 Scope and criteria of the evaluation**

This MTR was conducted in compliance with UNIDO evaluation policies and its Guidelines on Technical Cooperation programmes and project operations. The scope of the review covers three levels: i) a review of UNIDO-ICHET as a whole; ii) a review of the individual UNIDO-ICHET projects; and iii) a review of how UNIDO-ICHET can position itself to maximise its chances to obtain continued funding.

The review was designed to meet UNIDO requirements for independent evaluations to provide transparent reviews of UNIDO operations and to maximize the learning and refinement opportunities from UNIDO ongoing activities.

The MTR recognizes the early stage of many ongoing activities of ICHET and hence focuses on the assessment of the relevance of ICHET and the UNIDO support to it. To the extent possible, other aspects such as effectiveness, efficiency, sustainability and impact are also assessed.

## **1.3 Methodology**

The review was carried out in accordance with the Terms of Reference, which established the review methodology (see Annex A). Although the term “mid-term review” was applied in accordance with the requirements of the trust fund agreement, an in-depth evaluation approach was adopted, including: (a) examination of the overall aspects of UNIDO-ICHET and its design and implementation through a desk-review of the available documentation; (b) validation of data and verification of facts through semi-structured interviews with key project stakeholders and by undertaking selected site visits; (c) in-depth analysis of information from different sources to underpin independent and evidence-based findings; (d) documentation and discussion with project stakeholders of preliminary evaluation findings and recommendations; (e) circulation of the draft evaluation reports to key UNIDO-ICHET stakeholders; and (f) adjustment of the report reflecting feedback and suggestions received.

The evaluation team reviewed all of the available documents relevant to UNIDO-ICHET and to its constituent activities and projects (design, progress and terminal reports). A list of the main documents consulted is in Annex B. Discussions with relevant project managers at UNIDO HQ, Vienna were conducted prior to the field

discussions and visits in Turkey and New Delhi.

The two-week fieldwork was undertaken in Turkey and New Delhi in September – October 2009. A list of people consulted is provided in Annex C. The team held discussions with key stakeholders and UNIDO-ICHET staff in Turkey and the UNIDO Representative (UR) in New Delhi. At the end of the field mission in Turkey a brief presentation of initial findings was provided to: UNIDO-ICHET staff and at the end of the New Delhi mission an updated presentation was provided to the UR in New Delhi and UNIDO staff, and UNIDO-ICHET. Subsequently their feedback was incorporated in the final presentation made at UNIDO HQ. The feedback of UNIDO-ICHET and UNIDO staff has been incorporated in this review report.

The mid-term review was carried out in September-October. It encompassed an initial familiarisation mission to Vienna to discuss UNIDO-ICHET key issues with UNIDO HQ staff and the Turkish permanent mission to UNIDO; a one week field mission in Turkey to visit the UNIDO-ICHET site in Istanbul and meet key project stakeholders, visits to pilot project sites in Istanbul, a visit to the Bozcaada Island demo site (a replication of this project is currently under consideration in the Cook Islands with GEF support), and visits in Ankara to meet key Turkish Government representatives from MoEF (Ministry of Environment and Forestry), MENR (Ministry of Energy and Natural Resources), Middle East Technical University, and an SME specialising in hydrogen electrolyser R&D; and a one week mission in Delhi, India to review the DELHY-3W project (the sole UNIDO-ICHET international project undertaken to date, although a GEF funded Cook Islands replication project of the Bozcaada Island project is currently under development).



## **ICHET and its context**

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### **2.1 History and overview of ICHET**

UNIDO-ICHET formation was the culmination of preparatory work and various studies and numerous meetings since 1988 in many countries and international fora by UNIDO and particularly by Professor T. Nejat Veziroglu. Professor Veziroglu was the main proponent and visionary behind UNIDO-ICHET formation and was its founding Director.

The UNIDO-ICHET Trust Fund agreement, that established UNIDO-ICHET for an initial 5 year period with USD 40 million funding, was formally signed by the Turkish government and UNIDO on 21 October 2003. Tangible UNIDO-ICHET operations started on the 1st of May 2004, with an initial project end date of 30 June 2009. The first three years of UNIDO-ICHET operations did not involve the anticipated annual expenditure levels. In 2007 important changes to the management of- and support to UNIDO-ICHET were implemented (establishment of the Steering Committee and International Scientific Advisory Committee, and a new Managing Director). Since then expenditure and tangible output levels have increased significantly. UNIDO-ICHET still has a budget of approximately USD 25 million uncommitted from its original USD 40 million Trust Fund amount, and accordingly there are plans underway to extend its current end date from 31 December 2010 to 31 December 2011. However, considering the ICHET original focus and ongoing commitment to undertake international projects (e.g. the GEF Cook Islands funded project design and proposed EU funded projects), its considerable remaining unspent budget, and the need for ICHET to review its governance and proposed future institutional form, an extension of the initial phase of ICHET to the end of 2012 would be more appropriate.

At its inception, there was a clear vision to establish UNIDO-ICHET as a multi-stakeholder supported institution with contributions in addition to those provided by Turkey. Significant amounts of co-funding have been obtained in some projects, however, no general donor funding has yet been provided to cover UNIDO-ICHET general operations, and although significant project based funding has been obtained, this is specific project focused co-funding and is not ICHET revenue that

could be routed through UNIDO or UNIDO-ICHET accounts. The proposed GEF Cook Islands project would be the first example (if successful) where donor or external project funds would be received by UNIDO or UNIDO-ICHET that would cover most of the costs of a hydrogen energy project.

According to the original project document the objectives of UNIDO-ICHET were to:

- a) to develop and strengthen the scientific and technological capabilities in closing the gap between research and development organizations, innovative enterprises and the market place, so as to stimulate appropriate applications of hydrogen energy technologies in industrial development throughout the world in general and in developing countries in particular;
- b) to further, for the benefit of developing and developed countries, the application of hydrogen for peaceful aims, as well as the development and transfer of hydrogen energy related technologies, including the associated technology management processes;
- c) to further the advancement of applied research and development on hydrogen energy, with direct involvement of developing countries' scientists and technologists; and
- d) to support the strengthening of developing countries' research, development and technology transfer centres and programmes, including mechanisms for supporting existing enterprises and the creation of new industrial enterprises, all involved with the application of hydrogen energy technologies.

Furthermore, the immediate objectives of the UNIDO support provided to the establishment and operation of ICHET were defined as follows:

- a) to demonstrate international support for the Centre and to promote involvement of the international community in ICHET programmes; and
- b) to lay the foundation for the long-term functioning of ICHET.

At its inception, UNIDO-ICHET had a budget broken down by year and budget line for inputs of its operations (e.g. staff and consultants), but not by output, e.g. demonstrations, feasibility studies etc. to be produced. There were also no specific targets for funds to be mobilized by other donors or any timescales, let alone what such funds would be used for. So in terms of providing a project summary "fact sheet" it is not possible to detail UNIDO-ICHET original planned budget, comprising the Turkish government provided USD 40 million Trust Fund budget and any other planned donor or co-funding budgets to be mobilized, and provide a breakdown of proposed vs. actual spending by component or programme theme.

However, it should be noted that a key output specified in the original documents was the construction of a new campus for UNIDO-ICHET for which a sum of approximately USD 12.5 million was earmarked.

The UNIDO-ICHET project had a long gestation period from its inception in 1988 as a concept to the signing of a USD 40 million Trust Fund agreement between the Ministry of Energy and Natural Resources of Turkey (the donor) and UNIDO (the operating agency for the Trust Fund) that established the International Centre for Hydrogen Technologies (ICHET) on 21 October 2003 as a UNIDO project. The UNIDO-ICHET project was established for an initial five-year period and started tangible operations on 1 May 2004. The specification of what UNIDO-ICHET was expected to do was stated in its Project Document (Pro Doc) which was signed by UNIDO and the Government of Turkey on 17 June 1998 and repeated verbatim in Section B4.3 of the Trust Fund agreement signed on 21 October 2003.

In its summary form, the scope of ICHET at its inception was seen as being “ICHET will become an applied technology bridge between the demonstration and commercialization of hydrogen technologies” (ICHET brochure 01 November 2003) with particular emphasis on the needs of the developing world.

The choice of Turkey as the donor and location for UNIDO-ICHET was because Turkey was seen as an intermediate development status country that would span the gap between the dominant work on “the Hydrogen Economy” being undertaken in industrialized countries and the postulated need for these envisaged commercial, near commercial and allegedly already demonstrated hydrogen technologies to be deployed in developing countries. Another factor in the choice of Turkey as the donor country and location for UNIDO-ICHET would seem to have been that the driving force behind UNIDO-ICHET was Professor Veziroglu of the University of Miami, Florida, United States of America. Professor Veziroglu had been a leading international hydrogen energy economy visionary and advocate since 1974. Professor Veziroglu originally came from Turkey, and had apparently maintained strong ties to his homeland even although most of his career had been spent working as an academic in the U.S.A. However, an open issue is how realistic it is to expect Turkey to continue to provide baseline funding for UNIDO-ICHET into the foreseeable future? This is because as long as UNIDO-ICHET is to be based in Turkey, Turkey will need to support it by providing an estimated USD 5 to 8 million per annum of ongoing baseline funding. If another country starts to provide the bulk of the funding, then that country might expect to host UNIDO-ICHET.

## **2.2 The context of hydrogen energy technologies**

The rationale and scope of UNIDO-ICHET rested on a number of core assumptions which would seem to have not been subjected to very close or explicit scrutiny in the 16 years of effort to get UNIDO-ICHET established. These core assumptions were

also only at best only partly explicitly stated in UNIDO-ICHET 1998 Project Document. The UNIDO-ICHET 2003 Trust Fund agreement largely used the 1998 Project Document UNIDO-ICHET rationale and scope without making any changes.

The planning documents and interviews revealed a number of important but mostly implicit assumptions behind the establishment of UNIDO-ICHET, with regard to the context of hydrogen energy technologies:

1. That developed countries had undertaken (or were in the process of undertaking) the majority of the necessary R&D efforts required for the realization of commercial and/or large-scale/mass-market hydrogen applications.
2. That the key RD&D elements needed for mass-scale hydrogen applications in developing countries had already been successfully demonstrated in developed countries (in fact generally just proof-of-concept of hydrogen applications had been demonstrated)
3. That there was little risk of the remaining assumed technical breakthroughs not succeeding, or not delivering the assumed aggressive cost reduction, fundamental performance improvements, and greatly extended operational lifetimes, and so forth. This in particular applied to lower cost and durable hydrogen fuel cells and the use of high storage and fast charge hydride storage systems for acceptable weight penalty hydrogen storage for mobile applications. This ignored the fact the hydrogen fuel cells had been in use for decades in space programmes and that the breakthroughs and rapid reduction in costs often found in the early stages of development of new energy technologies were therefore unlikely.
4. That “proven” hydrogen applications were now commercially ready for widespread mass deployment in developing countries without the need for ongoing (unsustainable) subsidies to be competitive with conventional fossil fuels and technologies.
5. That the successful dissemination of proven and commercially available hydrogen technologies in developing countries was primarily a matter of human and technical capacity building and one-off proof-of-concept demonstration / pilot projects in these developing countries.
6. That new, low GHG emissions (especially renewable energy based) and significantly lower cost sources of hydrogen supply were imminent that would enable hydrogen to directly compete with conventional fossil fuel energy sources, whereas in fact hydrogen already was a mass-scale produced industrial gas where breakthroughs in low cost hydrogen production was unlikely.
7. That the main competitor technologies to successful mass hydrogen

applications would not also steadily improve their performance, reduce their costs and improve their operational lifetimes at the same time as hydrogen applications were being developed, disseminated and applied to mass commercial markets. For example, modern and affordable petrol and diesel internal combustion engines using the now standard low sulphur and low lead fuels and fitted with conventional catalytic converters/particulate traps can reduce all pollutants except CO<sub>2</sub> to almost negligible levels, thereby removing one of the original local air pollution control rationales of the “hydrogen economy”.

8. That any demonstrated application of a hydrogen technology would be a useful step towards increased hydrogen technology uptake, even if the application does not address a real energy and development issue. An example of a demonstration not addressing a real energy problem would be the UNIDO-ICHET Bozcaada Island demonstration where the cost, complexity and energy losses from the addition of a hydrogen electrolyser, storage system and fuel cell will not lead to any increased use of the grid connected PV and wind energy parts of the system, and where the contribution of renewable energy at the demonstration site will increase if the hydrogen system does not keep working post-project end. As a result, the effects of the project are limited to the accumulation of technical experience in handling this type of projects in a (more or less) remote location, which – in the present stage of development of ICHET is important. But the demonstration effect of how hydrogen can solve real problems in real applications does not seem likely to materialize from such contrived hydrogen technology applications.

However, very similar implicit rationales and assumptions for hydrogen technology R&D and commercial deployment were also widely held and generously funded for many years in many developed countries. A recent example is the United States Federal Government’s 2003 USD 1.2 billion five-year Hydrogen Fuel Initiative. The “hydrogen economy’s” technical, affordability and hydrogen supply constraints were widely seen as being issues that would definitely be solved in very short timescales with little delay or risk of failure if a large enough R&D effort was adequately funded and believed in passionately enough.

The view then underlying UNIDO-ICHET rationale and initial priorities (and still commonly held for other allegedly mature energy development technologies such as distributed electricity generation negating the need for expansions of electricity grids) was that developing countries could leapfrog over the current polluting and/or imported energy dependent fossil fuel development phases of past industrial and current economic development paradigms straight to a pollution-free indigenous and low cost renewable energy supplied futuristic “hydrogen economy”. This simplistic “hydrogen economy” consensus is now rightly being questioned and a more realistic

view of hydrogen technologies future is now emerging. However the result of the over-hyped “hydrogen economy” not emerging as promised is that many commentators are now excessively pessimistic (and also some key policy makers such as Stephen Chu, the current United States Secretary of Energy) and are now claiming that because mass market key hydrogen applications are not expected to eventuate in the next 20-30 years (a view incidentally not currently shared by some major commercial firms spending their own precious R&D funds such as Honda, Toyota, Daimler amongst others), therefore clean energy R&D efforts should be completely directed away from hydrogen to alternative technologies with what are seen to have more immediate commercial application prospects. An example would be the plug-in electric-petrol engined hybrids - and particularly now for battery/electric light duty vehicles - where similarly highly optimistic projections of cost reductions and performance and lifetime increases of what are actually already existing mass scale technologies (e.g. for Lithium-Ion batteries) are now being made as were formerly made for key parts of the “hydrogen economy”. The realistic view of hydrogen energy technologies as being the one promising energy technology amongst many options is now emerging. But UNIDO-ICHET over-promotion of the future benefits of hydrogen energy technology developments and applications in developing countries needs to be avoided as it may invite a future backlash when such general optimistic predictions do not eventuate.

The gloomy current re-assessment of hydrogen technology uptake prospects in high profile applications such as light duty vehicles is not surprising, as for automotive applications the earlier hydrogen vehicle boosters ignored the prospect of developments in hybrid petrol-electric drive-trains, modern turbocharged common-rail diesel engines, and vehicles using existing and new battery technologies. In practice hydrogen technologies are one future technology path amongst many, and it is likely that multiple technology pathways will co-exist in similar and different regions simultaneously in different applications, in particular battery vehicles for urban use and fuel cell/hydrogen vehicles for highway and intercity use.

Unfortunately the assumption that hydrogen fuel could compete without subsidies with conventional fossil fuels completely ignored the fact that hydrogen supply is already a large-scale and mature industrial gas (a total of around 50 million tons of hydrogen is produced every year—enough hydrogen to fuel 250 million fuel cell cars if all the hydrogen was used to fuel cars) where overnight and easy to achieve significant hydrogen supply cost reduction breakthroughs are highly unlikely. To give a specific example, Air Products (the hydrogen supply partner to the UNIDO-ICHET DELHY-3W project in Delhi and apparently the largest supplier of merchant hydrogen in the world) is a USD 10-12 billion a year business and hydrogen comprises around 30-40 per cent of Air Products’ business worldwide. So with bulk commercial supplies of hydrogen being a more than USD 4 billion per year international business, and hydrogen still being around three times more costly than comparable

fossil fuels, with most hydrogen being produced from fossil fuels via steam reformation anyway, and with very few developing countries having a surplus of renewable electricity that cannot be utilised directly and that would be available at low cost for hydrogen electrolysis, it is a very ambitious assumption that these factor of three hydrogen fuel supply cost reductions could be achieved in the near term.

The realistic uptake of hydrogen technologies (including in developed countries) will probably lie between the almost religious conviction of some of its earlier proponents that it could completely replace fossil fuels almost overnight as if it faced no significant technical barriers or economic constraints if implemented on a large enough scale (with unrealistic “learning-by-doing” economies of scale assumed) and the “lets completely stop hydrogen R&D funding as it is not showing signs of meeting its (over-hyped) potential as fast as was claimed” reaction. This is a very common evolution from unrealistic expectations to excessive gloom common to the development and mass market deployment of new energy technologies. For example, the imminent mass market take up of “too cheap to meter” nuclear power in developing countries was expected in the 1950 and 1960’s and the deployment of “Atoms for Peace” research nuclear reactors in many developing countries was expected to lead to nuclear power being a significant power generation technology. There are numerous other examples in the literature on new energy systems that were seen as having highly promising futures that in the event did not work or have not yet eventuated at any scale, including fusion power, the Wankel rotary engine, Vertical Axis Wind Turbines (VAWT), Ocean Thermal Energy Technology (OTEC), Stirling engines, tidal power, and currently for wave, ocean current and hot dry rock power systems. There are also many new energy technologies that took decades to reach mass market take-off, such as the diesel engine in light duty vehicle applications, solar water heaters, and some where the technology has been in full utility scale demonstration use for decades but the timescale to commercial take up for mainstream grid applications without significant ongoing subsidies is still not clear such as solar thermal power generation, utility scale PV, and Integrated Combined Cycle Gasification Combined Cycle (IGCC) power plants.

In practice, hydrogen energy technology applications being developed by ICHET in developing countries are almost certain to start in niche applications where they offer some compelling special advantages and where intermediate hydrogen technologies are likely to be used as a bridging technology and applications step rather than trying to move in one single step to the mass application of the most advanced hydrogen technologies possible. A good example of such a niche application using intermediate hydrogen supply, energy conversion, and storage technologies is the UNIDO-ICHET DELHY-3W project (see assessment in chapter 6).



## **Project planning and design**

### **3.1 The underlying assumptions of UNIDO-ICHET**

Previous sections have already highlighted that UNIDO-ICHET planning and design had a 16 years gestation period, with extensive consultation and design efforts prior to its tangible operational start in May 2004. UNIDO-ICHET development started in 1988 and involved discussions with the relevant authorities of many countries (mainly in 1993), such as India, China, U.S.A., Japan, Kuwait, Egypt, France, Belgium, Germany, Italy, and Turkey. Experts meetings were also held in Bahrain, Nepal, and Cuba attended by (hydrogen) experts from many countries, including many developing countries. These discussions and meetings endorsed the proposed UNIDO initiative to establish ICHET.

From 1992 the Government of Turkey was involved as the proposed host country of ICHET. In 1996 at an expert meeting in Istanbul, the government of Turkey announced its decision to support ICHET with a grant of land, to provide funds, to build the centre (on the land provided) and to support the operation of the centre as a contribution of Turkey. In October 2003, the Turkish government signed the Trust Fund agreement with UNIDO and UNIDO-ICHET was formally established.

The question then arises as to how was it possible that (what in retrospect was) a whole series of compounding and ongoing unrealistic assumptions were made regarding hydrogen energy technology uptake prospects in the many steps over 16 years of UNIDO-ICHET project identification, stakeholder consultation, feasibility study analysis, donor negotiations, project document formulation, and funds negotiation? The simple answer is that most of these unrealistic assumptions were common assumptions internationally (that were later proven to be over-optimistic) about the marketing, extrapolation, development and deployment of the “hydrogen economy” from 1988 to 2004 (see Box 1).

So UNIDO-ICHET cannot reasonably be blamed for also relying on similar unrealistic assumptions as made by the science, technology and industrial development

programmes of many major developed countries - and well as major manufacturers such as GM, Ford, Daimler and United Technologies - that had also each individually invested over a billion United States dollars on similar hydrogen technology breakthrough development efforts. These governments and large corporations have invested billions of United States dollars in hydrogen R&D programmes predicated on a cascading series of science and engineering breakthroughs being achieved and then being successfully and profitably brought to the most demanding mass market applications in unprecedented short timescales.

Box 1

**Common early international assumptions about the potential of hydrogen energy technologies**

1. that hydrogen technologies were already available at a sufficient level of technical and commercial maturity for deployment in mass market applications, including in particular for UNIDO-ICHET design, in developing countries;
2. that leapfrogging straight to mass deployment of hydrogen technologies was possible for developing countries without first going through a fossil fuel use phase, although this had not been achieved for similar other energy technology application deployments in developing countries;
3. that extremely rapid reductions in costs and improvements in performance of hydrogen technologies would come from dramatic economies of scale and technical learning effects;
4. that hydrogen fuel supply costs would quickly drop by a factor of 3 to 4 (ignoring that hydrogen was already a mature and very large-scale commercial industrial gas);
5. that fuel cell costs would quickly reduce by around a factor of 100 (ignoring that fuel cells had already by then been under continuous development for 30 - 45 years in space applications and hence were already a reasonably mature technology);
6. that major breakthroughs would be achieved in cost reductions, tolerance for hydrogen impurities, cycle life, speed of recharging and hydrogen energy storage density of hydride storage systems (that were only then at a very early laboratory stage of development);
7. that one of the most demanding low initial capital cost, high specific power output, low maintenance, rapid refuelling and high lifetime reliability mass market applications (automotive) would be a key entry point for hydrogen technologies and that mass deployment in only a few years was realistic (although mass deployment had never been achieved before at such a short timescale with a major new energy technology, let alone a new fuel and fundamentally new energy conversion technology in mass market automotive applications);
8. that most new technologies are first deployed in niche applications and then gradually move into mainstream mass market applications;
9. that there would not be parallel development of alternatives to hydrogen technologies, in particular batteries for storage and automotive applications and of petrol-electric hybrids and improved diesel engines for light automotive applications (in other words hydrogen technologies had to compete with a moving target of other technologies that could provide solutions in other ways to the assumed hydrogen mass market application niches).

The predominant assumption of UNIDO-ICHET design was that there were existing commercial hydrogen technologies, or hydrogen energy technologies that UNIDO-ICHET could readily commercialize, and that UNIDO-ICHET could then assist in meeting developing country energy needs by a variety of means. In the UNIDO-ICHET design there was no mention of hydrogen technology costs, or of renewable energy derived hydrogen costs, the need to obtain donor or government funding support for tangible hydrogen applications, or the need for ongoing subsidies for such hydrogen technology applications to continue their post project operation in developing countries. It was critically (implicitly) assumed that UNIDO-ICHET could obtain technologies without paying for their Intellectual Property (IP). In contrast, the commercialization objectives for UNIDO-ICHET assumed that UNIDO-ICHET could control and profit by the licensing of the IP of the specific technologies disseminated by UNIDO-ICHET. However, on one hand gaining free input technology IP and on the other obtaining revenue from licensing any new IP developed is still a logical contradiction that UNIDO-ICHET needs to resolve.

The proposed activities of UNIDO-ICHET were very broad, and more in the nature of an inclusive list of activities that UNIDO-ICHET could undertake. There was no prioritization of hydrogen technologies, developing country energy needs, or most promising regions to focus on. Such prioritization was to be an initial focus of the work programme to be undertaken by the management and staff of the centre, with input/oversight to be provided by the Steering Committee and International Scientific Advisory Committee.

### **3.2 The intervention logic of the UNIDO support to the establishment and capacity building of UNIDO-ICHET**

The project document clearly distinguishes between the institution building of ICHET on one side and the actual technical activities of ICHET – once established - on the other. The emphasis of the project document is on the former, with a detailed description of outputs and activities, while the latter is described only in general terms.

The development objectives of the project describe the expected benefits of ICHET promotion of hydrogen energy technologies: develop scientific and technological capacities to stimulate hydrogen application in industry, advancement of applied research involving developing countries and strengthen developing countries' research, development and technology transfer centres and programmes.

The two immediate objectives are explained in more detail, including outputs and activities, and describe the institution building work to be done by UNIDO (see table 1 below):

**Table 1 – From activities to outcomes**

Immediate objectives (outcomes)	Outputs	Activities
<b>Immediate objective 1:</b> to demonstrate international support for the Centre and to promote involvement of the international community in ICHET programmes	Initial project office established	Find office host, purchase equipment
	Potential for international participation assessed and pilot activities for ICHET identified	Recruit international experts, identify needs of potential participants, plan pilot activities that mobilise long-term support to ICHET from participants
	Pilot activities implemented and international participation secured	Joint planning of ICHET collaborative activities
<b>Immediate objective 2:</b> to lay the foundation for the long-term functioning of ICHET	The institutional framework for the operation of ICHET set up	Establish Steering Committee (SC) and Scientific Advisory Committee (SAC), recruit core staff
	Temporary premises established	Adapt temporary offices to ICHET needs (equipment, etc.)
	Initial design and construction of permanent premises	Planning, subcontracting, construction (move into new premises planned for month 38)
	Needs of the potential clients of ICHET and the areas of their cooperation with the centre assessed	Visits to 12 developing- and 3 industrialised countries Secure continued participation in ICHET
	Long-term interest of clients confirmed	Generate documents on collaborative activities with identified institutions; establish a world database on hydrogen energy
	Core network of focal points established	Identify focal points, prepare rules and procedures of the network of focal points, ICHET newsletter
	Strategy for securing the long-term additional funding for ICHET finalized	Select countries and international institutions with interest in participation in ICHET programmes; Secure long-term commitments; Adaptation of ICHET structure to the needs and interests of countries/institutions participating in ICHET

Source: ICHET Trust Fund agreement document, 2003 (Note - same as 1998 Project Document text)

From the planned outputs and activities it is evident that from the beginning there was a clear vision to establish ICHET as an autonomous institution (under UNIDO auspices) with long-term contributions (i.e. not only project-based cooperation) other than the one from Turkey supporting the Centre. However, the concrete form of the institutional set-up was not described in detail, leaving it to be defined along the way in consultations with potential partners.

The project design of UNIDO-ICHET placed considerable emphasis on the construction of a permanent campus (“this [permanent premises] element will form an essential part of the project design”, Section B4.3 b (ii) of Project Document) and allocated 30 per cent of its budget (and probably 50 per cent of the budget if the in-kind value of the land envisaged is added to the initial USD 40 million Trust Fund contribution by Turkey). Such a new campus was seen as being a critical element for UNIDO-ICHET effectiveness in its first five years of operations, for additional funds mobilization, and for post-project sustainability.

It appears that an underlying assumption of funds mobilization to support an expansion of UNIDO-ICHET activities and to fund subsequent UNIDO-ICHET phases was that if an iconic permanent UNIDO-ICHET campus was built, then other countries would provide such funding. However, it is not clear if the need for such a permanent campus and its prerequisite status to obtain funding beyond Turkey’s contribution was a finding of the UNIDO-ICHET consultation process, or a subjective view that was never analyzed or tested in depth. It was also not clear who in UNIDO (it seems to have been assumed by the Turkish government that UNIDO-ICHET or UNIDO was to lead the fundraising) was to do what in this fundraising effort, how much was expected to be raised, nor if any account was taken of the fact that UNIDO did not have a track record in successful multi-donor fundraising for international centres.

Although UNIDO-ICHET clearly needed to be housed in a building of some sort, many world famous institutes have started life in modest existing or even temporary buildings. Furthermore, where purpose built buildings are provided to an institute at its initial stages, it is not uncommon for the institute to outgrow its buildings or subsequently move out of them due to wider parent institute changes or mergers with other institutes.

So in an ideal world, UNIDO-ICHET would indeed have been located in a purpose built campus with award winning architecture, stunning natural settings, on-campus accommodation for visiting fellows, purpose built laboratories, and be powered by on site renewable energy generated hydrogen systems. But it does not follow that UNIDO-ICHET could not have successfully started and successfully operated in its first five-year inception phase (and perhaps even beyond) in a modest refurbished office-style building in a convenient location.

In terms of its proposed operations, the design of UNIDO-ICHET had a strong emphasis on inputs and activities (staff, campus, missions to developing countries) but was mostly silent on the outputs that UNIDO-ICHET was to achieve in terms of institution building. In the first three years of ICHET, a strong emphasis was put on staff, campus, and missions to developing countries, but little emphasis into producing tangible outputs in terms of technology demonstration and promotion. Then in the “fresh start” from 2007 a high priority of the UNIDO-ICHET management actions was placed on the actual establishment of the internal structure, including the formation of the Steering Committee and International Scientific Advisory Committee, and on developing, with their assistance, a series of outputs that UNIDO-ICHET would achieve in its initial five-year establishment phase. In neither phase was there a clear explanation as to how the envisaged long-term partnerships of ICHET with other countries and international organizations would be institutionalized.

A key thread in the UNIDO-ICHET design was that it would be a coordination body, would cooperate with national bodies, and would “focus on transfer and development of application oriented hydrogen energy technologies” (Pro Doc, A.2, 2nd last paragraph). The scope and focus of UNIDO-ICHET proposed activities on collaborative applied research and deployment in developing countries was realistic and appropriate, and the establishment of a Steering Committee and an International Scientific Advisory Committee was in principle a suitable means to provide the necessary oversight and prioritization to the UNIDO-ICHET work programme as this was developed in detail and implemented.

# IV

## **Project implementation**

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As previously stated, the UNIDO-ICHET USD 40 million Trust Fund agreement between Turkey and UNIDO was signed on 21 October 2003. By 09 December 2003 the Turkish Ministry of Energy (TME) and UNIDO had agreed that Dr Veziroglu would be nominated as Director of the Centre, and an initial list of activities had been agreed to be undertaken for the start of tangible operations of the Centre on 1 May 2004. Priority early activities planned to be in place by 01 May 2004 included the establishment of the Steering Committee and the International Scientific Advisory Committee, identification of temporary office options, and recruitment of the necessary UNIDO-ICHET staff.

The initial budget for the first full year of UNIDO-ICHET operation of April 2004 to March 2005 was set at USD 1.5 million, excluding any expenditure on the establishment of permanent premises. The matching first scheduled payment of Trust Funds amounting to USD 1.5 million was received from Turkey by UNIDO on 04 March 2004 ahead of schedule. UNIDO-ICHET then successfully started its operations on 01 May 2004 from rented premises.

By January 2005 a Work Plan had been developed by a consultant to guide UNIDO-ICHET plans and activities for its planned four years of operation under its original USD 40 million Trust Fund provided by Turkey. As previously discussed, the 1998 UNIDO-ICHET Project Document and the 2003 Trust Fund agreement both considerably overstated the case for hydrogen and dramatically understated the work and resources required to encourage the uptake of hydrogen technologies into tangible applications in developing countries. In contrast, the 2005 Work Plan contained a much simplified and far more realistic background section, and hence had a much more realistic context for UNIDO-ICHET proposed activities to encourage tangible hydrogen applications in developing countries. This new 2005 Work Plan background section was a major improvement, compared with the original design, by explicitly stating that:

- Hydrogen technologies would co-exist with electricity based applications as longer term future energy carriers (the original design documents ignored the use of electricity as an energy carrier and even still contained some elements of the early extravagant “hydrogen economy” arguments that hydrogen was an energy resource in its own right);
- hydrogen technologies would be developed, demonstrated and disseminated

over a long transition period as they continued to be refined (the original design claimed that hydrogen technologies were already available for mass deployment, including in developing countries); and

- the UNIDO-ICHET focus would be on developing country applications (the original design stated in some places that the beneficiaries would include both developed and developing countries)

The 2005 Work Plan specified a range of activities that UNIDO-ICHET was to achieve, including the construction of a permanent campus, which was envisaged as accounting for some USD 15 million of the USD 40 million five year UNIDO-ICHET budget. It is also important to note that although the 2005 Work Plan stressed the importance of pilot and demonstration projects and identified a range of possible demonstration regions, and the timing of the realization of such pilot/demonstration projects was shown, there was no budget provision for UNIDO-ICHET to support such projects with any hardware, consultancy or hydrogen fuel funding support. It would seem that it was envisaged that the office of the Associate Director of Projects and Development would be responsible for the fundraising necessary to fully cover such costs, although it is also possible that budgets for such costs were just not considered. Subsequently in the 2005 Work Plan, UNIDO-ICHET responsibility for implementation would appear to have been seen as being primarily a matter of hosting visiting scholars, hosting meetings and conferences, and general enthusing and support of tangible demonstration projects whose implementation would be fully funded by donors and other non UNIDO-ICHET sources. It would also seem that the demonstration of hydrogen applications was expected to be primarily done with on-site renewable solar and wind power energy generation being used to produce hydrogen for the UNIDO-ICHET campus hydrogen power plant and hydrogen fuelled campus vehicles. The 2005 Work Plan talked about making the UNIDO-ICHET Centre self-sustaining at the end of its initial five years, and talked about various sources of funds such as grants and donations, but did not include any specific plans or timelines or responsibilities to realize this general desired financial self-sustainability outcome.

The second scheduled payment of Trust Funds of USD 10.34 million was then received by UNIDO on its due date of 20 April 2005 from Turkey. Presumably the production of the 2005 Work Plan with its greatly improved focus and more specific outputs to be undertaken assisted in the release of this payment.

By 31 December 2006 the cumulative project expenditure was USD 4.84 million (including the 5 per cent UNIDO support costs) with a balance of funds in hand for the project being USD 7 million. This was a low rate of expenditure (12 per cent) nearly three years after (60 per cent of the planned project duration) the UNIDO-ICHET Trust Fund agreement had been signed. It would appear that the main focus of project activities to that point had been general hydrogen advocacy and co-ordination work through missions and participation in international hydrogen meetings, a considerable focus on getting the permanent ICHET campus built (although no tangible progress with this seems to have been achieved then or even

now) and the funding of around twelve pre-feasibility studies. It would also appear that UNIDO-ICHET budgeting and payment systems were rather ad-hoc and not fully in compliance with UNIDO operational rules to this point. No meetings of the project Steering Committee had been yet held, no detailed project budgets by output were available (the budgets were focused on staff etc inputs not by output), and it would appear that general project funds mobilization efforts had been undertaken but had been unsuccessful as UNIDO-ICHET tried to act as a broker but did not offer to provide any seed funding that other project supporters could match with co-funding. However, it would seem that the ground work for some of the subsequently realized UNIDO-ICHET project based activities was usefully laid during this period until the end of 2006.

In early 2007 there were a number of major changes to the project. These changes were seen as a “fresh start” for the project. The project at that point was clearly running behind schedule, not fully utilizing its available funds, highly focused on the construction of an iconic UNIDO-ICHET campus as a pre-requisite for obtaining external funding for projects and post project operations. The project was also not producing the expected results in terms of tangible hydrogen technology support in developing countries, which at that point should have started to materialize.

In January 2007 a new UNIDO permanent Allotment Holder (Project Manager) became responsible for the management of the project replacing an interim Allotment Holder who had been in this role from April to December 2006. In April 2007 the first Director of UNIDO-ICHET (Dr Veziroglu) returned to his position at the University of Miami at the end of his three years leave of absence from his academic position at the University. Dr Engin Ture was officer-in-charge from May 2007 to February 2008 when the current Managing Director, Dr Mustafa Hatipoglu became responsible for UNIDO-ICHET overall management. An administrative manual for UNIDO-ICHET operations was commissioned so that UNIDO-ICHET could start to operate in compliance with UNIDO administrative rules and hence improve accountability and reduce administrative delays. Recruitment of further senior ICHET staff was also successfully initiated.

In April 2007, a new Work Plan was jointly produced by the five senior UNIDO-ICHET managers (the three Associate Directors as well as Dr Ture and Dr Babir). The new 2007-2008 Work Plan was designed to cover the then two final years of UNIDO-ICHET operations, and was based on the experiences of the first three years of UNIDO-ICHET operations, and hence it articulated the “fresh start” that was being made in the project. A list of 23 project based budget lines was specified. Vastly more specific detail was provided on what was being sought, beneficiaries of the activities, budgets and timescales for realization for each project line than had hitherto been the case for UNIDO-ICHET planning and documentation.

In the 2007 – 2008 Work Plan, the new focus was on funds being allocated to

specific projects rather than to general hydrogen support activities. It is apparent that the projects were considered as “proof of concept” demonstrations as there was no language about explicitly linking the projects to real developing country industrial development needs, nor to how the projects would obtain the necessary budget and management support to continue to operate after their brief operational period (apparently in some cases as little as two weeks operation before project end was being contemplated, see Section 4.2.1.6 in the 2007 – 2008 Work Plan). A useful innovation was a shift from a sole “bleeding edge” technology focus on fuel cells and hydride storage to also consider hydrogen internal combustion engines using compressed hydrogen gas applications as intermediate stage technologies that would be more appropriate for developing countries in the medium term. Six specific pilot and demonstration projects were flagged, although these were all Turkish based projects. However, Turkey is not a developing country and that there were no apparent plans to translate Turkish pilot project results to industrial development applications in developing countries.

The activity of the first three years of UNIDO-ICHET operations in supporting feasibility studies was to be continued in the 2007 – 2008 Work Plan, although a useful innovation was that there was to be a new structured and open process of calling for proposals for the feasibility studies to be supported by ICHET.

The 2007-2008 Work Plan was strongly influenced by the fact that the attempts to obtain outside funding for UNIDO-ICHET projects to date had proven to be unsuccessful, so in future it was now planned for UNIDO-ICHET to take a more proactive role in developing specific hydrogen application projects. UNIDO-ICHET would now devote a variable but overall significant amount of its own funds to “co-fund” such tangible pilot and demonstration hydrogen application projects through the provision of hardware and through supporting local experts. In the 2007-2008 Work Plan there were very ambitious (given that not any co-funding had been achieved in the first three years of UNIDO-ICHET operations) co-funding budgets being sought for the six specific proposed potential demonstration / pilot projects. In two of the proposed projects, large amounts of project co-funding were proposed to be sought without any specific project funding being provided by UNIDO-ICHET. This should have been recognized as being an unrealistic co-funding assumption, and indeed the hydrogen island and hydrogen bus projects did in fact subsequently require significant UNIDO-ICHET funding to proceed.

The construction of a permanent campus still accounted for a then (April 2007) estimated total cost of USD 11 million and it was planned for UNIDO-ICHET to move into this new campus by April 2009. However, as per UNIDO rules, construction of the new campus could only begin when UNIDO received all the necessary funds, so even if a building permit had been obtained, a start of construction would have first required the payment of the fourth budget installment by the Government of Turkey.

However, by then (April 2007) the building of a permanent campus was seen as “being tangential to the main thrust of ICHET activities” (Section 4, 2007 - 2008 Work Plan), and only one person was proposed to work on a full-time basis realizing the new campus, although the administrative overhead was expected to be high (and the management focus and distraction would have been large as well, although this was not apparently considered). A considerable amount of detail was provided on the new campus site options, what was being sought in a new campus, and the timescales and programming for the construction of the new campus. It is clear that by this point that a more conventional campus was being envisaged, for instance with gas and fuel oil fired boilers, and with the wind and solar powered hydrogen fuel cells only providing back-up power and not being a fully hydrogen powered centre as seem to have been previously envisaged. It seems that by April 2007 the campus was being progressed by UNIDO-ICHET due to it being an integral part of, and output for, the Trust Fund agreement, rather than from a deep conviction that it was an absolutely integral part of UNIDO-ICHET operations and future. This then represented a clear departure from the focus, indeed obsession, with the construction of an iconic permanent campus that had been clear for the first three years of UNIDO-ICHET operations.

The stated background (the rationale), mission and overall objectives of UNIDO-ICHET as stated in the 2007-2008 Work Plan remained unchanged from the earlier 2005 Work Plan (where, as previously discussed, they had very usefully been updated from the original project design to better reflect the reality of hydrogen technology dissemination in developing countries).

In May 2007 the first meeting of the project’s Steering Committee was held to give the stakeholder oversight to the project that had been envisaged in the project document but that had never been operationalized since the project’s formal start in October 2003. This Steering Committee meeting considered and approved the new UNIDO-ICHET 2007-2008 Work Plan.

As of 18 May 2007 the project had available funds of USD 5.78 million from the first and second installment payments from the donor (Turkey) so it was able to make an immediate start to its new tangible hydrogen technology project based approach.

The third scheduled payment from the donor was paid on 14 June 2007 following donor (Turkey) approval in November 2006 of a revised UNIDO-ICHET work plan and associated budget dated 18 October 2006 (this payment had been scheduled to be paid on April 2006) and was approved by the Steering Committee on 04 May 2007.

As at 28 March 2008 the project had available funds of USD 14.1 million. In the 2007 year total expenditure had been USD 1,617,298 against the budget of USD 9,733,500. Of this shortfall of expenditure of USD 8,116,202, USD 4,740,500 was due to the lack of progress on the construction of the new campus, which was largely

out of UNIDO-ICHET direct control. However, this still gave a very low rate of non-campus expenditure compared to target levels, largely reflecting the time needed to get the “fresh start” moving and to understandably not fully meeting the acknowledged ambitious new goals set in April 2007.

In April 2008 a combined Annual Report for 2007 and a Work Plan for 2008 was produced. This report had an Introduction section that provided a useful and up-to-date wider energy context for hydrogen energy applications, and also continued the evolution towards an explicit realization that fuel cells using hydrogen were a longer term future and that interim technologies would be useful as an intermediate bridge towards this longer term future. However, this report’s Background section appeared to be unchanged from that of the 2005 Work Plan. A number of administrative issues were reported as being in progress, and a good start had been achieved for most of the projects specified in the 2007 Work Plan, although as was expected, there had been delays in fully implementing this ambitious list of projects. The permanent campus construction project budget had been reduced to USD 6.8 million (apparently primarily due to reduced construction costs) and had faced delays from the chosen site’s land being actually administered by the Turkish army and not by the Ministry of Energy and Natural Resources as had been thought to be the case. This involved many steps, and although mostly complete a number of further administrative steps were still needed before campus construction could start. The 2008 Work Plan was largely an update of the 2007 Work Plan with refinements of the various projects, greater detail provided, and a greater degree of realism stemming from operational experience in early implementation of the projects and an active programme of activity developing the portfolio of projects approach.

On January 2009 a separate 2008 Annual Review and 2009 Work Plan was produced. The 2008 Annual Review was for a partial year of 8 months (May to December 2008) as the UNIDO-ICHET year was now very usefully aligned with both the UNIDO and donor (the Turkish Ministry of Energy and Natural Resources) financial years. In this 8 month period UNIDO-ICHET expenditure was USD 3,056,616 (excluding a provision for USD 692,000 for architectural and engineering services for campus construction that seems not to have eventuated in practice). This increased level of UNIDO-ICHET expenditure (then running at around USD 4.5 million p.a.) showed that activity levels were picking up closer to that envisaged in the UNIDO-ICHET design. The campus construction still accounted for a large part of the unrealized UNIDO-ICHET expenditure, and the construction of the campus still seemed to be stuck. As October 2008 represented the end of the original five year duration of UNIDO-ICHET, the agreement needed to be extended, which was formally agreed to by the Turkish Cabinet decision in November 2008. The 2008 Annual Review contained a usefully increased level of detail on how project and other implementation were proceeding. Tangible demonstrations comprising the sea taxi, Indian three wheeler, Hydrogen Island, forklift, bus, Uninterruptible Power Supply (UPS) projects including a number of research projects were also well underway by December 2008.

**Table 2 – UNIDO-ICHET Work Plan 2009**

<b>Project Number</b>	<b>Project Title</b>	<b>Budget (USD)</b>	<b>Country of Implementation</b>
PR07-TR-03	Development of hydrogen fuelled vehicles in New Delhi	318,415	India
PR07-HE-02	Further Demonstration Projects	50,000	n.a.
PR07-HE-01	Bozcaada Island wind-solar Hydrogen	1,391,000	Turkey
PR09-HE-02	Kobold Turbine in the Bosphorus	212,000	Turkey
PR08-TR-01	IDO / Fuel Cell Passenger Ship	58,000	Turkey
PR09-TR-01	H2 Filling Station	1,500,000	Turkey
PR07-TR-02	HICE Bus	510,000	Turkey
PR08-TR-02	H2-FC Bus at airport	0	Turkey
PR09-TR-05	FC Boat	413,000	Turkey
PR08-TR-06	H2-FC Scooter	45,000	Turkey
PR08-TR-07	H2-FC-Passenger Cart	46,000	Turkey
PR08-UT-01	FC-based UPS	100,000	Turkey
PR07-UT-01	Fuel Cell Powered Forklift	40,000	Turkey
PR08-GN-01	Renewable House	36,000	Turkey
PR09-GN-01	CHP / 3 kW	200,000	Turkey
PR09-HE-01	Local FC production	305,000	Turkey
PR09-TR-07	H2-FC Hybrid Aircraft	105,000	Turkey
RD08-HP-05	H2 storage & transport	72,000	Turkey
RD08-HP-02	H2 production via coal gasification & biomass gasification	40,000	Turkey
RD08-HP-01	Photochemical H2 production	500,000	Turkey
RD08-HP-04	Bio-Electro H2 production from Biomass	125,550	Turkey
RD07-HP-04	H2 production from lignocellulosics via	151,000	Turkey
RD08-HP-06	H2 Production via Bacteria	500,000	Turkey
RD08-HP-03	Sea Water Electrolysis	201,000	Turkey
RD09-GN-02	Laboratory Infrastructure	44,000	n.a.
RD09-GN-01	External collaborations	63,000	n.a.
RD09-HP-01	Further R&D Projects with Developing Countries	15,000	n.a.
ED09-GN-01	Laboratory Training Programmes	126,000	Turkey
ED09-GN-02	Hydrogen Technology Meetings	28,600	Turkey
CC07-CC-01	Campus Construction	400,000	n.a.
GN09-GN-01	Office of the ICHET Director	236,000	n.a.
GN09-SM-01	Summit Meeting 2010	1,007,000	Turkey
AD-09	ICHET Administration	289,450	n.a.
<b>Total</b>		<b>9,128,015</b>	

Source: ICHET Annual Report 2008 and Work Programme 2009

The 2009 Work Plan usefully continued the trend of each successive Work Plan in providing a greater degree of relevant detail regarding each proposed project. At the third project Steering Committee meeting held on 04 February 2009, the 2009 Work Plan was discussed and endorsed. The shape of ICHET projects and activities reviewed in this mid-term review was clearly described in this 2009 Work Plan. It was also good that timing-wise the work plans and Steering Committee meetings were now just after the start of the financial year and that the calendar financial year used now was aligned with UNIDO and Turkish government financial years. However, the next logical step would be for the Work Plan to be produced in a draft form and to be considered by the Steering Committee before the start of the financial year so that any changes could then be reflected in the final Work Plan which would be in place before the next financial year started. This would then enable the Steering Committee to move towards a formal governance role (more on this later).

As can be seen from Table 2 above, within the ICHET project portfolio only one project to date has been implemented outside Turkey to date. While it is recognized that Turkey is a suitable country for ICHET to do proof-of-concept work and test new technologies, it is noteworthy that an international centre has not yet invested its resources more proactively in the development of a portfolio of international projects, in particular with relevance for developing countries. The proof-of-concept phase of projects could usefully be undertaken in Turkey if there were tangible plans in place for the projects to be replicated in developing countries in real applications, but such pro-active replication plans were not apparent during the mid term review.

The fourth budget Installment of USD 8.75 million was scheduled to be paid by the donor in May 2009 but does not appear to have been made, leaving UNIDO-ICHET in a looming cash crisis situation if it is not paid soon (as budgets apparently cannot easily be moved from one budget line to another). The fifth budget installment of USD 7.56 million was scheduled to be paid by the donor in May 2010. An overview of the ICHET budget situation is provided in Table 3.

**Table 3 – Overview of ICHET Budget situation**

<b>Installments</b>	<b>Amount (incl. 5 per cent support cost, USD millions)</b>	<b>Net amount, USD millions</b>	<b>Date</b>	<b>Status</b>
1st	1.50	1.43	Mar-04	paid
2nd	10.34	9.85	Apr-05	paid
3rd	11.84	11.28	Jun-07	paid
Subtotal (paid so far)	23.68	22.56		
4th	8.75	8.33	May-09	pending
5th	7.57	7.20	May-10	pending
Subtotal (pending for payment)	16.32	15.54		
Total	40.00	38.09		

Source: UNIDO reports

#### **4.1 Implementation of institution building activities**

As was shown in chapter 4, the original design of the UNIDO-ICHET project put a strong emphasis on the institution building aspect. During the first three years of ICHET operations many of the ICHET activities were in line with the planned institution building outputs, trying to mobilize project and long-term support and partnerships for ICHET activities (however, these activities were not very effective).

In contrast, a review of the more recent past of ICHET shows that institution building activities (see table 2) have all but vanished from the ICHET work programmes. Annual reports of ICHET provide information almost exclusively on a project-by-project basis, without describing the progress (or lack thereof) regarding the institutional development of the centre.

#### **4.2 Analysis of ICHET expenditures**

By October 2009 ICHET has spent USD 13.8 million of the USD 22.6 million received so far. As mentioned above, the capacity of ICHET to use the assigned funds has increased continuously, as can be seen from Table 4. It can be observed that the distribution of the expenditures across the main budget categories corresponds largely with the planned distribution as per project allotments. This indicates a more realistic annual implementation planning. The significant deviations from the original budget (only 61 per cent of the allotted amount has been spent so far) stems from two expenditure categories: personnel and equipment, reflecting the ongoing delay in constructing the ICHET campus and the fact that ICHET staff recruitment has only recently reached planned levels.

<b>Table 4 – Overview of ICHET expenditures</b>								
	<b>Total Allotment</b>	<b>Annual Expenditure</b>						<b>Total Expenditure</b>
		2004	2005	2006	2007	2008	2009 (0.ct)	
	By Oct. 2009							
Personnel	12,765,851	314,577	1,079,304	1,204,581	1,242,790	1,568,087	2,534,370	7,943,709
Contracts	1,487,386	0	20,000	3,570	19,173	672,000	436,929	1,151,672
Training	787,638	0	0	23,253	120,956	126,172	25,774	296,155
Equipment	6,139,918	297,006	467,696	933,752	143,440	1,093,976	609,127	3,544,997
Miscellaneous Cost	1,394,904	24,536	155,988	106,898	110,939	218,832	254,675	871,868
Recov + Contingencies	-20,409		-20,410	0	0	0	0	0
<b>Total</b>	<b>22,555,285</b>	<b>636,119</b>	<b>1,702,578</b>	<b>2,272,053</b>	<b>1,617,297</b>	<b>3,699,067</b>	<b>3,860,875</b>	<b>13,787,989</b>

Source: UNIDO Infobase, October 2009

# V

## Assessment

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### 5.1 Relevance

Hydrogen technologies are in principle relevant to developing countries both in terms of specific industrial and development applications and in terms of sustainable industrial development in general. The donor for UNIDO-ICHET, Turkey, is a middle income country that can serve as a bridge between developed and developing countries, and has a growing international development aid program. ICHET is a tangible way that Turkey can provide leadership in a particular area of technology in its overall aid program. Supporting international technology centres such as UNIDO-ICHET is an area of UNIDO competence compared with other UN agencies. Hence, in principle, UNIDO-ICHET is a relevant initiative for UNIDO and Turkey and their working together in the structure of UNIDO-ICHET is also in principle a relevant synergistic approach.

However, in retrospect, the project started off with important relevance weaknesses in its design. There were few realistic links in the original project design (as expressed in the 1998 signed Project Document and included verbatim in the October 2003 Trust Fund agreement) between the grand vision for the world to leapfrog to the “hydrogen economy” and:

- how hydrogen technologies were relevant to developing countries now and into the future;
- how hydrogen technologies would link to industrial development in developing countries;
- the necessary timescales for hydrogen technologies to be adopted in developing countries;
- how UNIDO comparative advantages would be used;
- how building an iconic campus in Istanbul would inevitably lead to financial donations to the centre from other countries in the absence of a strong technical applications support program;

- how hydrogen technologies would in practice first be applied in niche applications and then gradually spread to more mainstream applications;
- how hydrogen was already a mature large-scale industrial gas with large reductions in its cost being unrealistic to expect.

A large part of this limited relevance was the project design's legacy of its "hydrogen economy" visionary but unrealistic roots. However, to be fair, this idea of a rapid transition to the "hydrogen economy" where the desired technologies and cost reductions would appear if only enough people believed strongly enough in them and spent enough money to generate the necessary technical breakthroughs and drive down costs by orders of magnitude through economies of scale was not unusual amongst hydrogen economy advocates until quite recently. Many governments and major corporations even spent billions of United States dollars trying to leapfrog straight to demanding hydrogen applications without first going through intermediate technologies and deployment in niche applications.

The project's design improved with the January 2005 Work Plan's development of a much more relevant context for hydrogen technologies in its new Background section. The relevance was also improved in the 2005 Work Plan with a new explicit focus on demonstrations and pilot projects, and which were envisaged to take place in developing countries in different world regions. The relevance of these pilots and demonstrations is partly reflected by the successful track record of UNIDO-ICHET in obtaining co-funding for their development. A tangible example of this improving relevance was the development of a number of feasibility studies by the end of 2006.

With the "fresh start" of early 2007 and the changes that flowed from this, the relevance of UNIDO-ICHET activities has steadily improved. For example, the DELHY-3W project in India is: highly relevant to the host country (India); has high potential for replication in India and in other developing countries that use three wheelers for passenger and freight applications; uses conventional and affordable hydrogen technologies (internal combustion (IC) engines based on existing designs but properly adapted and characterised to run on hydrogen, and hydrogen storage tanks at similar pressures to existing Compressed Natural Gas (CNG) tanks); and can utilise real world less than perfect purity by-product hydrogen from the local chlor-alkali industry - hydrogen that is apparently currently being flared.

Other applications such as the hydrogen forklift and hydrogen UPS (Uninterrupted Power Supply) projects seem in principle to be very relevant hydrogen energy technologies where Turkey could serve as a bridge between existing developed country manufacturers and developing country applications.

However, so far there is a lack of a clear articulated development pathway to their

replication in appropriate niches, including in particular in developing countries. ICHET also has projects such as its fuel cell boat, fuel cell scooter, fuel cell golf cart, hydrogen fuel cell bus, and renewable energy – hydrogen mobile house that could be relevant in principle, but where a sufficiently robust needs analysis and development pathway was not apparent to assess their relevance to developing country and real niche applications.

Then there are other projects, in particular the Island Hydrogen demonstration in Bozcaada, that in principle are highly relevant future hydrogen applications, but in the particular demonstration context are not solving real energy or development or greenhouse gas reduction problems at the site chosen – and if this is not appropriately recognized and internalized (which seems only partly to be the case) then any subsequent hydrogen island replications seem likely to also not be fully relevant either. This is not to say that hydrogen island applications cannot be relevant, rather that demonstrating a grid-connected hydrogen “proof-of-concept” demonstration seems to introduce major issues of relevance and post-project sustainability at a site where the host hydrogen applications recipient has not invested any of their own resources, and the hydrogen application is not part of any discernable pre-determined green tourism or other marketing campaigns or similar value propositions.

However, it is recognized that at the present stage of development of ICHET that gaining experience and building up technical capacity is important. Projects like the one in Bozcaada are relevant in the sense that they help ICHET to accumulate experience in setting up hydrogen applications in “real life” conditions (in this case on a more or less remote island), including important learning steps like negotiating with the local community (who are sometimes very sceptical due to perceived risks from hydrogen), identifying sites with useable wind conditions, ensuring spare parts supply and arranging for installation of sophisticated equipment remote from major urban areas.

While recognizing the importance of this aspect of demonstration projects, it should be clear that in the future most or all of the UNIDO-ICHET projects should aim at not just producing “technical learning effects” but should also demonstrate the real benefits from hydrogen technology applications in terms of local or global environmental benefits or energy access and security or productive uses.

Therefore, although promising improvements in UNIDO-ICHET relevance have been achieved, there is still considerable room for improvement to link the hydrogen application pilots and demonstrations (that are increasingly the focus of UNIDO-ICHET funding) to a clear logic and explicit pathway towards solving real end user problems, meeting real development needs in developing countries, and having a clearer pathway towards (mass) replication in niche market applications.

With the passage of time without a permanent campus being built, alongside the

UNIDO-ICHET relevance steadily increasing, it is now time to question how relevant the campus in Istanbul really is to UNIDO-ICHET mandate to supporting the uptake of appropriate hydrogen energy technologies into suitable niche applications in developing countries. It may be that the permanent campus, let alone the idea of it being spectacular (in practice expensive) architecture and fully hydrogen powered, is no longer particularly relevant to UNIDO-ICHET work and that the permanent campus should now formally be put on hold until ongoing Turkish or other baseline operational funding is assured.

#### 5.1.1 *Relevance to UNIDO and other international organizations*

The ICHET field of activity is relevant to UNIDO in principle since it fits into the UNIDO programmes of renewable energy and energy efficiency. However, the way ICHET activities have been planned and implemented has sometimes reduced their relevance. ICHET work plans and ICHET project documents usually do not explain how the interventions are expected to contribute to the process of sustainable industrial development (e.g. through capacity building of institutions engaged in renewable energy, through the replication of demonstration projects, through the provision of off-grid energy for productive uses, and so forth.).

Furthermore, linkages of ICHET activities to other UNIDO technical cooperation initiatives are rarely explicit and, more importantly, there is no UNIDO energy strategy that explains how hydrogen energy technologies fit into any overall UNIDO programme. On the positive side it was observed that ICHET does participate in UNIDO global forum activities, such as global conferences on energy and the environment.

There is little evidence regarding the past cooperation of ICHET with other international institutions active in the field of renewable energy. However, recently ICHET facilitated (2009) UNIDO becoming a member of the Hydrogen Implementation Agreement of the International Energy Agency (IEA-HIA). A strong program of cooperation with the EU is also being developed. In addition, the first donor funded project has been approved in principle by the GEF (Cook Island renewable energy to hydrogen project). These are promising signs of ICHET becoming a relevant partner for international organizations in the field of renewable energy. Further efforts in this direction, e.g. partnerships with the Renewable Energy and Energy Efficiency Partnership (REEEP) and the International Renewable Energy Agency (IRENA) are recommended.

## 5.2 **Efficiency**

The efficiency of UNIDO-ICHET in its early operations was quite low as it was hard to see what the actual tangible outputs from its early activities were. Even where there were outputs, they were generally delivered late, and largely

comprised “soft” activities such as general advocacy, networking, enthusing about the grand “hydrogen economy” vision, and attempts to obtain pilot and demonstration funding without any matching funding being provided (which any experience in development projects would have shown was always unlikely to work). There also seemed to be little attempt to set up administrative systems that complied with UNIDO rules, which slowed down disbursement of funds and has subsequently hampered UNIDO-ICHET operations almost to the present. A large amount of effort was spent inefficiently trying to first identify and then obtain permission to use suitable land for a permanent campus for which there is still (as at November 2009) little tangible progress, still no clear credible timeframe to start construction, and growing doubts about the vital and urgent need for such a campus.

With the “fresh start” changes made to the UNIDO-ICHET project from early 2007, the efficiency of UNIDO-ICHET operations has steadily improved. The early UNIDO-ICHET funding of a range of pre-feasibility studies gave the “fresh start” phase of UNIDO-ICHET a useful basis of tangible projects to consider for more detailed support and a useful degree of accountability into why some projects were subsequently supported and not others. For example, the DELHY-3W project was selected after an evaluation that it was the most promising project concept among the 14 pre-feasibility project proposals received, and following a UNIDO-ICHET funded pre-feasibility study phase. Such funding of a wide range of promising concepts as pre-feasibility studies should be continued by UNIDO-ICHET into the future. However, the project support evaluation process should be further strengthened to become a proper formal and documented evaluation process, including with independent outside reviewers (such as is used by SDTC in Canada and other similar technology development support funding bodies).

ICHET has established a UNIDO-compatible administrative monitoring and operating system for project specific monitoring and for reporting on progress with its pilot and demonstration projects. Such pilot and demonstration projects are now being chosen on the basis of an explicit project appraisal system (although more could usefully be done to strengthen this system and its utilization); that is being initiated in a timely and pro-active manner; their implementation is suitably adaptive to changing circumstances; and significant co-funding support seems to be eventuating in line with plans (although the actual levels of co-funding being achieved does not yet seem to be reported on in UNIDO-ICHET Annual Reviews).

ICHET has made a considerable effort to establish procedures that are in line with standard UNIDO requirements for accountability. However, ICHET also needs to have project selection procedures that are sufficiently flexible to allow for the highly specialized field of activity of ICHET, i.e. in the choice of specialized partners for project implementation and allowing for speedy reaction to project opportunities in cooperation with the private sector. To this end, a special procedure has been

developed that is based on the signing of a Memorandum of Understanding (MoU) with project partners. Attached to the MoU is a Technical Annex containing a technical description of the project along with the expected inputs to be provided by the different partners. This approach allows the establishment of suitable partnerships with appropriate private sector project partners (for example with Mahindra Corporation in India) without going through the standard UNIDO procurement system (i.e. avoiding an international tender), which would make the necessary co-funding partnerships with the private sector difficult to realize.

However, it should be noted, that applying this approach, there is a risk that projects might be launched in a country without prior UNIDO quality assurance and without suitable consultations with the official UNIDO Government counterpart. Although this has not been a problem to date, with suitable close cooperation having been undertaken with the relevant UNIDO Country office (e.g. with the India UNIDO Country Office for the DELHY-3W project), this still poses a potential risk for UNIDO that projects might be implemented that are not fully compatible with UNIDO commitment to the principles of alignment and harmonisation. Therefore, UNIDO-ICHET should have a formal procedure (ideally through the proposed new STAC and signed off by the proposed new UNIDO-ICHET Governance Board) to ensure that the relevant UNIDO Representative (UR) signs off on suitable country coordination and agreement as being in place before a UNIDO-ICHET project moves into its implementation stage, with the relevant UR remaining as a formal project partner throughout the project's implementation.

The new MOU approach seems to work efficiently for pilot and demonstration projects with a number of counterpart partners, especially if they come from the private sector, supplying parallel project inputs to UNIDO-ICHET inputs. However, it is not clear why alignment of ICHET projects with the UNIDO quality assurance process, in particular for larger projects (such as the DELHY-3W project) is not possible.

Also, the ICHET is not a legal entity in its own right; hence it relies on UNIDO legal entity whenever it enters into agreements with third parties (i.e. agreements that ICHET concludes are actually UNIDO agreements). This means that – in order to avoid a conflict of interest between ICHET and UNIDO - either ICHET needs to create its own quality assurance process in line with UNIDO requirements and criteria (e.g. through the proposed new Scientific and Technical Applications Committee (STAC) reporting to a new Governance Board) or it needs to use established UNIDO processes and procedures (in particular the mechanisms for appraisal and approval of projects). In this regard it has also been observed that ICHET currently does not have suitable in-house expertise with regard to development issues, which makes internal quality review from a development organization's perspective difficult. This seems to be one of the reasons why typical UNIDO development objectives are not yet apparent in ICHET project proposals.

Another major area of concern remains regarding the efficiency of UNIDO-ICHET operations. Given the steady drift towards an exclusive focus on Turkish oriented and based projects, the international salary structure for staff including the complexity of UNIDO administrative rules means that the current structure of operations of UNIDO-ICHET is unnecessarily expensive.

The Indian DELHY-3W project is a notable exception towards this growing UNIDO-ICHET Turkish project funding focus but it appears to be the exception that proves the rule as there are no specific budget provisions to spend money implementing further projects in non-Turkish settings – although the DELHY-3W is clearly the flagship project for UNIDO-ICHET to date in terms of relevance and potential impact. The GEF funded Cook Islands project that is currently under active development could be seen as another significant non-Turkish project.

### **5.3 Effectiveness and Impact**

The effectiveness and impact of UNIDO-ICHET could best be summarised as a work in progress that is making steady progress from a slow start.

#### *5.3.1 Effectiveness in terms of institution building*

As was also pointed out in the assessment of efficiency, the performance of ICHET has increased in general from 2007 onwards. This has also produced a significantly higher effectiveness in terms of building up ICHET as an operational organization. The corresponding achievements can be summarized as follows:

- UNIDO-ICHET now fully complies with UNIDO administrative rules, and is equipped with an appropriate administrative manual
- ICHET now has a technically qualified team in place
- The Steering Committee and Scientific Advisory Committee have been established and are operational
- ICHET has developed an appropriate mix of new activities: demo projects, R&D, technology transfer, and training
- ICHET has initiated a portfolio of real and appropriate projects, proving that it is a potential partner for academic, public and private organizations willing to work in the hydrogen energy technology field
- ICHET has established a strong network of partners in Turkey including academia, local industry and public institutions
- A first project outside Turkey (DELHY-3W) has created useful experience and expertise in ICHET with regard to the development and implementation

of international projects that can now be utilised in the proposed GEF funded Cook Islands project

Most of these achievements fall under the immediate objective 2 “to lay the foundation for the long-term functioning of ICHET.

At the same time, major areas remain where effective institution building aspects have not yet been sufficiently addressed. The immediate objective 1 “to demonstrate international support for the Centre and to promote involvement of the international community in ICHET programme” has clearly not been achieved so far. Numerous activities carried out during the first three years of ICHET operations have not led to any international support of ICHET in terms of financial contributions. While the recent approval by the Global Environment Facility (GEF) of a project concept for the Cook Island project can be recorded as a likely first success, it should be clearly noted that this is at the project level. Similar attempts are being undertaken to establish project-level partnerships with the European Commission (EC), as shown in table 5.

**Table 5 – ICHET proposed projects for EU funding**

	ICHET Total (Euro)	ICHET Requested (Euro)	Proposal
Total (Euro)			
Forklift 2,991,088	702,270	505,703	
Back-Up Power 2,645,028	872,400	436,200	
Education 374,607	40,240	40,240	
Total 6,010,723	1,614,910	982,143	

Source: UNIDO-ICHET project manager, October 2009

While the development of the GEF project and funding applications to the EU are highly commendable at a project funding level, the issue of international support to ICHET as an institution (e.g. contributions to the core budget, establishment of branch offices in developing countries, partnership agreements with other important players in the hydrogen field, etc.) are also of fundamental importance and must not be neglected.

The issue of international support to ICHET as an institution is related to the issue of

the organizational form. As mentioned above, so far ICHET is using UNIDO's legal entity in the absence of its own. So far, the institution building efforts have not produced a clear understanding of what the institutional nature of ICHET is expected to be in the long-term.

### 5.3.2 *Outcomes and impact of ICHET work on developing countries*

Significant work has been done by ICHET in terms of awareness raising and short-term training throughout the implementation period. Within this review, it was not possible to assess the effectiveness of these training and awareness raising initiatives (this should be done within the terminal evaluation of ICHET). However, it was observed that training and awareness activities were carried out with a clear focus on ICHET core competencies and in line with the overall ICHET mandate, using qualified staff and trainers. This indicates a good level of quality, pointing towards likely effectiveness.

The early activities of UNIDO-ICHET would seem to have not been very effective nor to have made much impact in terms of the overarching goal of UNIDO-ICHET in fostering hydrogen technology applications in developing countries. Although the UNIDO-ICHET Project Document and Trust Fund agreement talked about UNIDO-ICHET being focused on developing country hydrogen applications, there was and has been little tangible linkage between the activities that UNIDO-ICHET has undertaken and real developing country needs. For example, hydrogen fuel cell powered forklifts are a promising hydrogen applications niche, but where and how are they applicable in developing countries? Equally, hydrogen fuel cell powered UPS are being supported by UNIDO-ICHET and would seem to be an excellent developing country niche application but they have not apparently been considered for UNIDO-ICHET replication support in areas where power supply is erratic, long power outages are common and extremely costly, loads are in the few kW range and battery based UPS are hard to maintain in remote areas in hot tropical climates, and clients in some applications have strong cash flow to support robust solutions (e.g. telecoms cell towers). Hence, UNIDO-ICHET projects have had a very passive approach to date in considering replication pathways, developing replication support activities, and pro-actively tracking the replication success or otherwise of its individual projects. As the management rule goes, "What is not recorded is not managed". In other words, UNIDO-ICHET is in danger of running highly effective pilot and proof-of-concept demonstration projects that have minimal development or market impact if their replications are not systematically tracked. With the first practical applications projects (outputs) of UNIDO-ICHET now being realized, this is an area that needs urgent attention.

Since the "fresh start" of early 2007, the effectiveness of UNIDO-ICHET operations has greatly improved. Tangible projects now make up the majority of UNIDO-ICHET

activities, and they have SMART objectives, UNIDO-ICHET and partner budgets, milestones, divisions of responsibilities, and they are being implemented in a proactive and adaptive fashion.

However, there is still much work to be done in translating the increasing efficiency of UNIDO-ICHET tangible activities into real hydrogen technology developing country impacts. In particular the understandable “get some runs on the board” focus of UNIDO-ICHET from 2007 (following its first three years of drift in tangible project focus terms) has not translated into a suitable focus on meeting real development needs (e.g. improved access to energy, reduced consumer energy costs, reduced need for energy subsidies, improved energy supply reliability, reduced local pollution, use of local low cost hydrogen resources, or reduced global GHG emissions), nor has a realistic view of real market uptake dynamics become apparent. In all cases the UNIDO-ICHET projects are proof-of-concept “one-off stunts” that are primarily focused on demonstrating H<sub>2</sub> technical viability, with a highly uncertain post-project end sustainability outlook and no clear pathways towards developing country niche application real needs focused replications.

An alternative approach of ICHET work would be to mainly focus on capacity building outcomes (i.e. strengthening of developing country institutions). This would justify to some extent the implementation of purely technical projects, that are designed to demonstrate to developing country partners how hydrogen systems are planned and implemented. But also in this case, the planning and design of projects would need to develop clear expected outcomes and impacts that are to be achieved in the long run through strengthened academic, public and private actors doing effective and real project focused hydrogen applications work in their (developing) countries.

In general, the effectiveness of ICHET in terms of capacity building (one of the main development objectives stated in the project document) has been limited to Turkey, where several innovative training initiatives have been carried out (including the training of secondary school teachers) and several companies and other partners have learned useful hydrogen applications lessons through their involvement in ICHET project activities.

To sustain effectiveness in UNIDO-ICHET operations into the future, and translate the technical effectiveness of individual UNIDO-ICHET projects into (development) impacts, UNIDO-ICHET still faces major challenges in establishing the basis for long-term multi-stakeholder operations establishing a solid basis for its operation as a future international funded institution

ICHET needs to move beyond its current science focused approach where proof-of-concept demonstration is the objective - to a science and engineering focus where a demonstration has to also have its operating incentives aligned to keep operating post project - and if it does not keep operating then it cannot be considered an engineering success. To give a specific example,, the Bozcaada Hydrogen Island

demonstration project was apparently aimed at storing excess renewable energy in the form of electricity (ICHET 2009 Work Programme) yet the chosen site is actually already connected to the Turkish mainland grid by a submarine cable. Thus unless the project is configured and is sufficiently valued as a UPS for critical functions at the governor's office, the project will save the Bozcaada Governor's office host more on their energy bills and provide greater GHG reductions when the hydrogen component breaks down than when it is maintained and continues to operate. So there is a considerable risk that the Bozcaada project will turn out to be a proof-of-concept science success but to be an hydrogen applications engineering failure as soon as UNIDO-ICHET support in Bozcaada ends and it no longer makes sufficient sense for the local partner (who has to date invested none of their own money in the project and so is a passive partner only) to continue to maintain the hydrogen parts of the systems as then their continued use will lead to less, not more, financial contribution to reduced electricity bills for the Bozcaada Governor's office from the solar PV and wind turbine parts of the system. There are similar potential concerns with the proposed GEF funded Cook Islands hydrogen project. This illustrates the need for future UNIDO-ICHET projects to be more explicitly designed to provide clear and planned adequate local development benefits before the project is implemented, rather than undertake proof-of-concept demonstrations without regard for the real buy-in and real incentives for project participants to keep the project operating once UNIDO-ICHET involvement ends.

In this context it is noted that the UNIDO project management has very usefully been initiating discussions with ICHET management to introduce appropriate "business planning" into the ICHET project cycle. This initiative is certainly a step in the right direction. However, a risk remains that business planning does not cover the complexity of technological developments in the mid- and long-term. Currently a mechanism for technology foresight is missing, which might be the relevant first step before moving into business planning at the project level.

In order to demonstrate the ICHET effectiveness in terms of outcomes and impact, an appropriate monitoring system would be required, that goes beyond the monitoring of the technical implementation of demonstration projects, i.e. activities and outputs. Currently no monitoring system is in place at ICHET that would allow the monitoring of the effects of ICHET work in terms of capacity building of counterparts, learning effects of companies and academic institutions, policy effects (e.g. government's policies on hydrogen energy technologies), energy security effects (e.g. increased productivity through more reliable energy supply) and so forth. Equally important is the monitoring of environmental benefits created through hydrogen applications. In this regard a clear distinction between global and local environmental benefits would appear to be useful for ICHET, with the former (e.g. reduction of green house gases) being an important prerequisite for access to GEF funding.

## 5.4 Sustainability

Overall, the last two and a half years since the “fresh start” have seen a significant improvement in the ICHET preparedness for sustainable operations. As mentioned under “effectiveness”, the institution building efforts have generated a solid organization, including qualified staff, relevant project and training expertise and appropriate administrative structures and systems.

The major weakness in terms of sustainability is the issue of long-term core funding for ICHET operations (as opposed to project funding). A key element of the UNIDO-ICHET project design was that the initial funding from Turkey of USD 40 million was to be used to both establish UNIDO-ICHET and build a permanent campus, and then on the basis of the new permanent campus in Istanbul fundraising would be undertaken to support the post-project operation of the centre.

The existence of a permanent campus was seen by Prof Veziroglu (the founding UNIDO-ICHET Director for its first three years operations) as being a pre-requisite for such fundraising's success. The Turkish side (the UNIDO-ICHET donors) clearly expected UNIDO to lead the fundraising efforts and may have expected this UNIDO generated funding (notwithstanding that UNIDO has never managed to obtain full international funding for such a center located in one country before or since) to eventually fund the majority of UNIDO-ICHET operations while they obtained the ongoing credibility and economic value of the UNIDO-ICHET centre being based in Turkey - in exchange for their initial USD 40 million contribution and the promised (but not yet realized) supply of land for ICHET permanent campus.

However, the explicit need for such active fundraising has been getting less prominence over time in UNIDO-ICHET Work Plans. This is a dangerous development as the review team found that there were still very strong Turkish expectations that UNIDO would lead and would be successful in fundraising to support UNIDO-ICHET ongoing operations, and UNIDO did not present concrete plans to address this issue. As a result it appears that UNIDO and Turkish Govt. expectations of ICHET remain unclear and divergent – especially with regards to who will lead efforts to raise international operational and/or project funds. Obtaining co-funding from other partners and donors such as GEF on a project-by-project basis seems very promising and UNIDO-ICHET has been achieving good early results in this area, but obtaining ongoing funding for the operation of a UNIDO-ICHET centre in Istanbul that primarily undertakes projects in Turkey (as is the steady thrust of UNIDO-ICHET operations funding) hardly seems realistic.

The solid basis created in terms of capacities, expertise and experience to date allows ICHET to now enter into negotiations with potential partners on more solid grounds than during the first three years, where practically no track record of ICHET effectiveness existed beyond meetings attended and proposals generated.

Summarizing the situation of ICHET in terms of sustainability, the review team considers that the time has come for UNIDO and the Turkish Government to undertake renewed efforts to work out and really agree on long-term funding scenarios. An important element of this will be the strategy paper and long-term work plan that UNIDO is already developing and the discussion and approval of this strategy and long-term work plan by a suitable high level tripartite review meeting between UNIDO, ICHET and relevant representatives of the Turkish government.

# VI

## **Next phase: Issues to consider**

Many of the issues related to the next phase of UNIDO-ICHET have already been canvassed in this review report, but it is still important to assemble these issues in one place and in one coherent list. The issues can broadly be divided into issues of relevance, efficiency, effectiveness and impact, and sustainability.

In terms of relevance, UNIDO-ICHET has made great strides, but still needs to do more work to update its stated context and mission to a realistic forward looking view of the current status and future prospects for hydrogen energy technologies. This updated view needs to be developed, debated and agreed in the context of:

- the funds that UNIDO is realistically likely able to raise for general external to UNIDO-ICHET operational funding - beyond funding from Turkey;
- the constraints of operating within UNIDO financial and administrative rules;
- a need to obtain co-funding on a project-by-project basis;
- what a center such as UNIDO-ICHET can realistically achieve at a budget level of say USD 5 to USD 10 million per year when compared with funding by other hydrogen focused public agencies and private players that are funded at a USD 100 million per year scale;
- the need for ongoing Turkish core government UNIDO-ICHET funding of at least USD 5 million per year if UNIDO-ICHET is to remain viable (and based in Turkey);
- the need for a clear focus on activities that have a developing country and real applications focus;
- obtaining a clear Turkish government direction on the issue of building of a permanent campus or deferring or cancelling the idea for good to avoid further distraction from this issue.

In terms of efficiency, UNIDO-ICHET has made good progress but more needs to be done in two key areas: solving the issue of the permanent campus; and working predominantly on projects in developing countries as per the original design, as only in this case can paying international salaries and working within UNIDO complex administrative and management rules be justified.

In terms of effectiveness and impact, UNIDO-ICHET has clearly improved its operations in this area since its early days, but its pilots and demonstration projects still have quite a way to go to: link to real development needs in developing countries; to move beyond its 2007 “fresh start” proof-of-concept demonstration and pilots to a new emphasis on real hydrogen technology applications that will continue to operate once UNIDO-ICHET support ends; to projects with a clear, articulated and believable pathway to replications; and to tracking the replication of UNIDO-ICHET projects post-intervention and providing further support or learning from those applications that did not lead to replication to improve the success rate in future operations. Furthermore, the originally planned institution building work, especially the mobilization of international support, needs to be urgently enhanced.

In terms of sustainability, the key issues to address going towards the next phase are: reversing the drift towards UNIDO-ICHET undertaking projects almost exclusively in Turkey; getting a more realistic view accepted by Turkey that UNIDO on its own is highly unlikely to be able to raise significant funds to provide the complete baseline funding for a UNIDO-ICHET based in Istanbul; that ongoing Turkish support is likely to be required into the future for a continuation of an ICHET based in Istanbul; and aligning the Turkish support of UNIDO-ICHET for developing country projects and working more closely with the general development aid rationale support provided by the Turkish International Cooperation and Development Agency (TIKA).

### **6.1 Adapting ICHET to a more realistic hydrogen paradigm**

As mentioned before, the last decade has seen a significant change in how the potential for hydrogen energy applications are assessed by the main international players. Generally speaking, the original euphoria has given way to a more realistic approach, with hydrogen technologies now being seen as playing the role of providing niche solutions to concrete problems. A useful question for UNIDO-ICHET now is how has and how will UNIDO-ICHET reorient its objectives and operations to move forward in the new light of day where it is recognized that hydrogen technology applications in developing countries will be more like any other new technology, where: -

- most technical developments move forward in an incremental step-by-step fashion from known and proven technology bases, and do not rely on multiple ambitious technology performance and cost breakthroughs;
- there is a clear understanding of the difference between: science; proof of concept at lab scale; proof-of-concept one-off demonstrations; demonstrations of real development problems in real applications; small scale demonstrations of early series production devices in niche applications; mass market commercial applications in developed countries;

and mass deployment in developing countries;

- demonstration and pilot projects involve real world engineering and in-service use of multiple units built to standard designs and applied to solve real development problems (which is very different from one-off proof-of-concept demonstrations such as ICHET current focus) and that demonstrations and pilot projects must be part of a planned and explicit step-by-step development path towards commercial niche market applications.

Two good examples of the new approach (although in a mass scale personal transportation hydrogen technology application where UNIDO-ICHET is not personally operating) that would seem to be needed for the real world uptake of hydrogen technologies are the Honda and Daimler fuel cell car programmes. Honda is already producing (from 2007) and Daimler has announced (but not yet delivered) that it will produce (from 2010) 200 each of their FCX Clarity and B-Class Hydrogen model fuel cell cars respectively to be leased for use by real world drivers and refuelled from a limited number of hydrogen refuelling stations. These limited series production vehicles provide close to a Honda Accord or Mercedes-Benz B-Class weight, drivability and performance (sustained 100kW power output) and a realistic range for a limited series production vehicle (400km). The development focus for these vehicles has been in the fuel cell side where major progress has been achieved in reducing the weight, volume and use of precious metals of the fuel cell power units. It is important to note that these vehicles use real-world developments of current technology high pressure hydrogen storage tanks with around 3 minute refuelling times, instead of waiting for hydride storage systems (low cost and high net hydrogen storage hydride storage systems were a core assumption of the original “hydrogen economy” hype) to become commercially available and fully relevant for mass-market automotive applications. The deployment of these two vehicle models will approximately triple the number of hydrogen cars ever built. Such real series production of real working hardware that will be used by normal drivers in normal driving situations is a major development breakthrough after years of one-off concept cars shown at motor shows and breathless technology breakthrough announcements that rarely subsequently eventuate in practice. However, a word of caution is still needed that as these vehicles are to be leased there is still no clarity as to even limited series production real costs for such fuel cell vehicles. In addition, in practice the hydrogen to be used in such vehicles will still be produced from steam reforming of natural gas, so overall greenhouse gas emissions will be similar to the best current petrol and diesel vehicles. So true global zero emission fuel cell cars are only really applicable in those rare countries with a surplus of renewable based electricity supply or with the successful eventual development and commercialization of domestic scale and affordable renewable energy powered (esp. photovoltaic) hydrogen electrolyzers. Fuel cell hydrogen vehicles are now finally getting close to being a commercial (but undoubtedly still expensive) hydrogen application although this is 35

years after the more enthusiastic proponents of the “hydrogen economy” claimed that hydrogen vehicles were a proven and commercial technology that were already (35 years ago) ready for mass market deployment.

In this context, the UNIDO-ICHET DELHY-3W project is a highly relevant and extremely promising intermediate, real and applicable developing-world relevant automotive hydrogen energy technology niche application where UNIDO-ICHET can add value, and at an appropriate small and local scale where the Honda’s and Daimler Benz’s of the world are highly unlikely to operate. As detailed elsewhere in this report, the DELHY-3W project is developing a real world and low cost intermediate technology niche solution based on existing Mahindra and Mahindra three wheeler commercial technology - it uses mainstream CNG technology compressed gas tanks, it uses a development of the standard and developing world relevant conventional technology single cylinder 400cc Mahindra and Mahindra spark ignition CNG internal combustion engine, it solves a real world problem of Nitrogen Oxides (NOx) pollution in Indian urban areas, and it may be able to utilise low value hydrogen gas produced by the Indian Chlor-Alkali industry without excessively expensive hydrogen gas clean up being required. This project is very promising and should be strongly followed up and supported into its deployment phase by UNIDO-ICHET. This is the sort of appropriate intermediate technology and developing world real needs focused project that UNIDO-ICHET should strive to emulate in its future development projects - alongside more long-term high technology future oriented fundamental work on fuel cells and fuel cell purity hydrogen production technologies – all the while being acutely and explicitly aware of the difference and complementary nature of these two approaches.

## **6.2 ICHET as a systems integrator**

In a complex and globalised world with many players working in any given technology field at the same time, it is sensible for individual international technology centres to focus on clearly differentiated core service delivery areas. Such service delivery areas could include basic research, applied research, short-term training, long-term (e.g. post graduate) training, meetings and conferences for technology coordination purposes, management of intellectual property, supporting tangible applications, and so forth. In its first three years, ICHET was rather unfocused and was trying to be active in most of these areas at once, without providing sufficient critical mass to make much of a contribution in any single area. However, in a crowded field like hydrogen technology RD&D, where annual cumulative budgets worldwide amount to hundreds of million dollars, ICHET should pick a niche focus to maximise its contribution vis-à-vis the hundreds of other research institutes, universities, corporations and niche technology development companies that are active in the hydrogen field worldwide. Since ICHET “fresh start” in early 2007, it has been focusing more clearly on becoming primarily a “systems integrator”, with some early promising results.

This new ICHET hydrogen applications systems integrator role is where existing hydrogen technologies are integrated into working real world and relevant developing country hydrogen systems in formal partnership with a number of relevant private and public sector organizations and where technology elements are combined in novel or low cost or niche market applicable ways. This is a very promising area for ICHET to focus on, although this will require ICHET to explicitly focus on identifying, understanding and working towards such niche applications, and in particular the pathways from “proof-of-concept” demonstrations, initial sustainable market pilots and then through multiple steps to mass niche market take-up, for applicable and focused hydrogen technologies in developing countries. Notably, at the moment, ICHET is primarily undertaking “proof-of-concept” and/or “technological learning” focused demonstrations and pilots with limited apparent explicit / planned links to further replication and market applications in developing countries. This is a good first step, but ICHET needs to do more to link its system integrator activities, in a structured way, to mass market take up of the applicable hydrogen technologies. This should be done in suitable developing country niches of real world applications where specific hydrogen technologies have particular compelling market advantages.

ICHET has made some useful first moves towards considering the market aspects of the technology applications that it is supporting, but the reviewers consider that much more still needs to be done to properly formalise such analysis and planning for existing and new ICHET projects. This is already an explicit part of other institutions that support clean technology applications; a good example familiar to one of the reviewers is Sustainable Development Technology Canada (SDTC2) where technology status, Intellectual Property (IP) status, the status of the consortia proposed, market understanding, and the track record of key personnel are all documented, independently reviewed and scored before a decision is made by SDTC to fund proposals. There is also the emerging field of technology forecasting that would seem to be relevant as ICHET starts to explicitly map out the expected pathways of a proposed new hydrogen technology’s development, demonstration, replication and commercial dissemination, whilst also accounting for the parallel development of competing technologies (e.g. batteries for energy storage, use of biofuels for transportation, improvements in pollution control characteristics of internal combustion engines, and so forth). It is proposed that technology forecasting becomes a formal requirement for future ICHET projects before any significant ICHET project funding is approved, with the recast Scientific and Technical Advisory Committee (STAC) having a formal role (including out-of-session as required) in reviewing all proposals’ documentation in this area before significant amounts of funding are approved.

The review team considers that the role of a system integrator is a very relevant focus for ICHET. The focus on practical hydrogen technology applications that

comes with a systems integrator role can be linked well to allied work in the field of applied hydrogen technology research and training. The latter will be especially important to strengthen ICHET relevance for developing countries. Fellowships, seminars and short-term training will need to be continuously delivered, focused on real hydrogen technology systems integration issues, to make ICHET more effective in terms of its hydrogen technology capacity building in developing countries.

### **6.3 What kind of institution should the ICHET be in the future?**

The review team considers that there are four broad relevant scenarios for the continued future operation of ICHET, all of which will require Turkish base funding of USD 5 to USD 8 million per year for the foreseeable future: -

#### *6.3.1 ICHET as an independent legal entity international organization*

This is the scenario that was originally implicitly envisaged for ICHET, although it was not explicitly spelled out in the project document what kind of organizational form ICHET would have following its five year Turkish Trust Fund supported establishment phase. So far, UNIDO has produced only one example of successfully contributing to the establishment of such an independent organization: the International Centre for Genetic Engineering and Biotechnology (ICGEB) with headquarters in Trieste, Italy.

Outside UNIDO, another relevant recent example of a similar new international independent legal entity organization is the establishment of the International Renewable Energy Agency (IRENA) with its headquarters in Abu Dhabi. The history of the establishment of both ICGEB and IRENA demonstrates that the establishment of such an independent international institution can be expected to require very significant preparatory work over many (in practice 10 – 20) years, including extensive consultations with potential member states. In this scenario, UNIDO support and Turkish base activity funding would almost certainly still be needed for many years, with special attention needing to be being given to the “institutional engineering” of ICHET as a suitable independent international organization.

#### *6.3.2 ICHET as an integral part of UNIDO*

This scenario would be precedent setting, since UNIDO has not yet had any project successfully becoming an integral part of its own organizational structure. The most comparable cases are the UNIDO Investment and Technology Promotion Offices (ITPOs). These offices are usually funded from non-core budget sources (usually the host country provides the funds) and they are linked to UNIDO strategy, programme and budget through a dedicated ITPO coordination unit. UNIDO strategy of investment promotion has the ITPO network as one of its core elements.

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<sup>2</sup> For access to SDTC funding applications see [http://www.sdte.ca/en/funding/SD\\_Tech\\_Fund/advice/soi\\_application.htm](http://www.sdte.ca/en/funding/SD_Tech_Fund/advice/soi_application.htm)

So far, no similar development has taken place in the case of International Technology Centres supported by UNIDO. The ICHET situation shows the differences quite clearly. UNIDO currently does not have a strategy for ITCs and there is no coordination function to ensure the alignment of ITCs work to UNIDO strategies and objectives. Similarly to the ITC's, ICHET is currently managed as a technical project with little attention being given to its institutional aspects.

The narrow technical focus (on hydrogen) of ICHET limits the relevance of this scenario, since linkages to UNIDO Technical Cooperation are bound to be rather limited. More importantly, as in the case of the ITPO's, stronger links of ICHET work and UNIDO technical cooperation in the field of energy and environment would be required. ICHET could therefore become the first of a new series of clean energy and/or climate change mitigation industrial technology centers under a new UNIDO Clean Energy / Climate Change Mitigation programme.

### *6.3.3 Continue relying on Turkish trust fund support as a UNIDO project*

ICHET is currently approximately midway through its initial USD 40 million Turkish Government Trust Fund supported initial phase. No work has yet been undertaken to form ICHET into an independent legal entity international organization, and the ICGEB and IRENA examples suggest that it would take many years for ICHET to realize such full independence, even if serious efforts started now on developing this option.

Unless ICHET becomes an integral part of UNIDO, one of the two default options is that ICHET would continue with new Turkish Government Trust Fund support once the initial current USD 40 million Trust Fund is fully utilised. Under this scenario, ICHET would continue to undertake international projects only where significant co-funding could be obtained (as in the case of the DELHY-3W sole international ICHET project to date and in the proposed GEF funded Cook Islands project) with most of its projects being in Turkey, and the Turkish government would continue funding support of ICHET as a UNIDO project with a timely replenishment of the ICHET Trust Fund.

The ICHET project could be the subject of UNIDO fund raising efforts, but it would seem that without a significant "ownership" stake being offered that other countries would at best support specific projects and not provide the base funding requirements of USD 5 to USD 8 million per year that would be needed for ongoing useful ICHET operations. Critically, for continuity of ICHET operations, this scenario depends on a timely replenishment by Turkey of the ICHET Trust Fund well before the current Trust Fund allocation becomes fully utilised.

#### 6.3.4 *ICHET as a Turkish national organization (the TCHET option)*

This is the other of the two scenarios that ICHET is currently on track to achieve by default on current trends. In this scenario, the wide network of partnerships within Turkey and the demonstrated capacity of ICHET to implement national projects would provide a sound basis for continued operations in Turkey.

Most of the ICHET staff is of Turkish nationality. Although a continuation of the current strong trend towards Turkey-focused operations should in principle pose no major problems, it is expected to be a challenge politically and financially in the long-term to continue to pay international salaries for Turkish staff working only on Turkish projects.

There are also significant risks involved in this scenario, Firstly, there are other organizations in Turkey that are potential competitors for such a Turkish-oriented ICHET funding, in particular TUBITAK's Marmara Research Centre which also works on Turkish-focused hydrogen projects but pays local Turkish salaries. Secondly, the conversion of ICHET into a national institution is likely to cause a "brain drain" of the best Turkish and the international staff away from ICHET, given the significantly lower salary level applicable in national institutions

# VII

## **Recommendations**

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### **7.1 Taking a decision on the long-term institutional future of ICHET**

It is recommended that the institutional scenarios described in chapter VI be discussed comprehensively, and without delay, between UNIDO, the Government of Turkey, and ICHET management at an upcoming tripartite meeting on the progress and future perspectives for ICHET. At the tripartite meeting a clear decision should be taken as to what the medium- and long-term institutional perspectives of ICHET should be. The review team recommends that UNIDO, the Turkish government and ICHET adopt either scenario (a) of ICHET as an independent legal entity international organization as its long-term vision and scenario or (b) of ICHET as an integral part of UNIDO operations as part of a proper long-term UNIDO programme for International Technology Centres or climate change mitigation industrial technology centers under a new UNIDO Clean Energy / Climate Change Mitigation programme. This recommendation recognizes that scenario (a) is likely to take many years to be realized even if UNIDO, ICHET and the Turkish government work hard and effectively together towards realizing this independent legal entity international organization long-term vision - and that the number of years it will actually take in practice is not particularly predictable either.

### **7.2 Improving UNIDO-ICHET formal governance structures**

The current UNIDO-ICHET governance structure does not yet fully meet the requirements of an effective institution that responds to its clients needs. Given the hybrid nature of ICHET as a mixture of a UNIDO project and an autonomous institution, the roles and responsibilities of the UNIDO backstopping officer, the Managing Director, the Steering Committee, and the Scientific Advisory Committee do not seem to be completely clear, in particular with regard to strategic decision making, project prioritization and budget approval. The current structure also provides no governance role for the project co-funders, or recipients of, and key participants in, UNIDO-ICHET activities.

Therefore, it is recommended that the Steering Committee be recast over time into an ICHET Governance Board with ICHET main stakeholders being represented on this new Board. Turkey would seem to logically be represented by the Ministry of Energy and Natural Resources (MENR), other relevant Ministries related to science

and technology and the Turkish International Cooperation and Development Agency (TIKA). UNIDO would need to provide a high-level representative commensurate with the funding importance of UNIDO-ICHET to UNIDO. Additional representatives should come from developing countries such as India that are actively co-operating with UNIDO-ICHET and that are promising long-term ICHET cooperation partners. These developing world representatives should have a practical real world and mass market hydrogen applications orientation and may include private sector representatives, not just government officials and those who work in hydrogen research and science applications.

### **7.3 Improving ICHET real applications, deployment and replication focus**

As UNIDO-ICHET is supposed to be about fostering practical hydrogen technical applications in developing countries, it is recommended that the current Scientific Advisory Committee be recast and repopulated into a Scientific and Technical Applications Committee (STAC) which would focus on establishing criteria and reviewing projects for the development, tangible applications, post-project support sustainability, and long-term replication aspects of the hydrogen technologies that are proposed to be supported.

It is recommended that such a new STAC would include key private sector hydrogen representatives relevant to UNIDO-ICHET projects' success (e.g. Air Products as a major international merchant hydrogen supplier with a pivotal role in the replication of the DELHY-3W project - UNIDO-ICHET largest and most promising project in replication terms).

To reinforce this focus on real applications and the real deployment of hydrogen technologies, UNIDO-ICHET also needs staff with international, developing country and applications qualifications/experience/orientation and for these new staff to apply this new orientation to existing and future projects. It is therefore recommended that recruiting experts with such skills be a priority when ICHET is recruiting new staff and when replacing any attrition of existing staff.

There has been a promising start in developing formal procedures for project selection be extended with: explicit criteria for applicability / replicability; explicit logical application pathways - for all projects - from proof of concept to mass replication; the process for selection of projects being as transparent as possible; hence it is recommended that the proposed new Science and Technical Applications Committee (STAC) would review and rank proposed UNIDO-ICHET supported projects and then the Governance Board would review and sign off on the projects to be supported. This should also greatly speed up UNIDO-ICHET general operations funders (who would be represented on the ICHET Governance Board) providing their promised funding then actually materialises in a timely fashion.

#### **7.4 More realistic ICHET funding plans and mobilisation**

There seems to be a significant divergence between the expectations of the donor (Turkey) and the expectation of the provider/project manager (UNIDO) - and what UNIDO-ICHET is actually delivering. UNIDO has so far not been actively engaged in fundraising to cover the cost of UNIDO-ICHET core operations but the Turkish Government seems to expect this. ICHET is in principle focused on developing country applications, yet to date, ICHET budget has been almost exclusively used for projects in Turkey. However, it is not clear whether all relevant elements of the Turkish Government expect that expenditure on projects should be directed solely to Turkey because ICHET is using Turkish money. Furthermore it is not clear whether the proposed 2010 Hydrogen Summit should be organised as planned or not.

It is therefore recommended that UNIDO urgently and seriously engage its Turkish Government partners to reach an understanding of (a) whether Turkey wants ICHET to focus on projects in Turkey, (b) whether Turkey is prepared to pay its remaining contributions on time, and (c) whether Turkey is prepared to continue to provide baseline funding of USD 5-8 million/year once the current USD 40 million Turkish government funding has fully utilised. This is an initial estimate of the minimum amount required for an integrated and relevant UNIDO-ICHET operation into the future - further analysis would be required to more accurately determine this amount for UNIDO-ICHET operations once the current USD 40 million Trust Fund budget is used up.

It is also recommended that UNIDO and UNIDO-ICHET develop a SMART3 plan to attract donor funding (TIKA, GEF, Multilateral Development Banks such as Asian Development Bank and World Bank, etc.) for the replication of existing projects and for the mass replication of future demonstration and pilot projects.

It is further recommended that UNIDO and UNIDO-ICHET identify the most promising developing country partners for UNIDO-ICHET (e.g. India with its highly relevant and comprehensive National Hydrogen Energy Road Map) and get them involved in UNIDO-ICHET in a formal governance role if / when they provide significant operational funding in the future.

Finally, it is recommended that ICHET/UNIDO and Turkey develop an agreed funding diversification and extension plan, and start to seriously implement this plan in 2010. It is recommended that ICHET, UNIDO and the Turkish government urgently consider whether the planned October 2010 Hydrogen Summit could or should be recast into a suitable high level event focused on future ICHET funding mobilization.

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<sup>3</sup> SMART stands for Specific, Measurable, Achievable, Relevant, Time-bound

## **7.5 Defer permanent ICHET campus and extend project end date**

This review has already discussed at some length the original argument and focus in ICHET first three years of operations that establishing a new permanent campus for UNIDO-ICHET was its single most important output, and how this was expected to inevitably lead to significant amounts of UNIDO-ICHET ongoing baseline international funding being provided. A further nearly three years of effort (absorbing a large part of UNIDO-ICHET limited management resources and focus) have been devoted to realizing the new permanent campus since the 2007 UNIDO-ICHET “fresh start” with little to show for this further effort in terms of being able to actually start construction of the proposed new campus. It is also not clear if the Turkish Government really wants this campus to be built, nor whether they will in practice release the required 100 per cent of construction funds that would be required under UNIDO rules before construction could start.

It is therefore recommended that UNIDO urgently engage its Turkish Government partners to find out whether they really want the construction of a new campus to proceed and accordingly will release the construction funds required. If a suitable clear undertaking to provide the land and the funds for a permanent UNIDO-ICHET campus is not forthcoming in the near future, then all plans to build a campus should be deferred or cancelled. If the permanent campus is deferred or cancelled, then work should immediately start on moving the campus funding allocation into the UNIDO-ICHET operational budget and the UNIDO-ICHET first phase project end-date should be extended accordingly.

Based on the available evidence and under the current circumstances, the review team recommends giving priority to the re-directing of the funds reserved for the campus building to further build up the expertise and reputation of ICHET through – primarily international – project work. The construction of a new campus should be envisaged only if and when the institutional perspective of ICHET (see chapter VI on institutional scenarios) has been clearly defined and agreed. It is important to recognize that the technical requirements for a campus might change significantly once other partners (countries) join ICHET (noting the case of IRENA where the long standing proposal for it to be headquartered in Bonn was changed instead to Abu Dhabi very late in the IRENA formation process).

## **7.6 Reinforce ICHET international and real project focus**

Although UNIDO-ICHET has made great strides since its “fresh start” in 2007 towards implementing tangible hydrogen applications projects, there is still considerable room for improvement in linking the projects to real-world productive use needs in developing countries and linking pilot and demonstration project “proof-

of-concept” outputs to the specific post project sustainability of any “proof-of-concept” projects, let alone their replication into suitable market niches and having a clear and articulated pathway to mass applications for the technologies concerned (albeit in niche areas). There is also a steady drift apparent towards projects in Turkey (a middle income country), and not towards projects located in developing countries. This is the slippery slope to ICHET in practice becoming “TCHET” (the Turkish Center for Hydrogen Technologies), even if it is still called ICHET and even if it is still administered by UNIDO.

It is therefore recommended that UNIDO-ICHET explicitly move towards the majority of its project expenditure being in developing countries and being targeted to addressing real development needs. This process would need to start by identifying key co-funding and technology or delivery partners, key developing countries with high potential for real hydrogen applications and replications, and key real problems where hydrogen technology applications would be a real solution in the developing world; e.g. UPS for cell phone towers in areas with unreliable grid electricity supply.

In the same context, it is recommended to develop and implement a monitoring system for ICHET activities, which goes beyond measuring financial and technical implementation of projects (inputs, activities, outputs), to also capturing the outcomes and impact dimensions of ICHET work. This should especially cover the effects of ICHET in terms of institutional capacity building, policy development, and global and local environmental benefits. Wherever relevant and possible, poverty reduction effects should also be monitored. The implementation of such a monitoring system will require dedicated resources, most preferably supported by a full time monitoring officer at ICHET with relevant development qualifications and developing country experience.

With such a stronger focus on international projects, ICHET will then need to adopt formal procedures of development cooperation, in particular the alignment with host country policies and priorities and the harmonisation with other development agencies’ activities. In this context it is recommended that ICHET establishes a clear mechanism to ensure project quality. This can either be achieved by channelling ICHET projects through the UNIDO QAG/PAC process or it can take the form of an in-house quality assurance system that applies UNIDO quality criteria and that is linked to the UNIDO quality assurance process.

## **7.7 Articulating a new strategic rationale for ICHET**

The original strategic and development rationale for ICHET in its 1998 Project Document and repeated verbatim in its 2003 Trust Fund agreement contains a now very dated hydrogen economy “grand vision”, a focus on building a new campus (“build it and they will come – with open cheque books”) and a permissive range of ICHET potential activities that provides little guidance to the practical prioritization of

necessarily limited resources. Updated and simplified articulations of a context and vision for ICHET can be found in the ICHET Work Program for 2005 and were slightly updated in the 2007 Work Program and the combined 2007 Annual Report and 2008 Work Program. The 2008 and 2009 Annual Reports and the 2009 Work Program contain the “what” of what ICHET is to do and has done, but not the “why”.

ICHET therefore is undertaking a range of activities but has no current relevant articulation of the problem that ICHET is the answer to, and why it is undertaking certain activities and not others. Not unexpectedly, some critical differences in such views were noticed amongst key ICHET staff during the evaluation. Such an articulation, and particularly obtaining genuine consensus and buy in to it, will take time, and it needs to start well in advance of it being needed for any renewed Trust Fund agreement negotiations with Turkey.

It is therefore recommended that a process should now be initiated to start again from scratch defining the problem that ICHET is the answer to, and articulating what ICHET should do, and not do, to deliver its hydrogen technology support function in developing countries. Although ICHET staff and stakeholders should be strongly involved in the exercise, it is recommended that an experienced outside consultant should drive this process. Some familiarity by the consultant with ICHET and its operations would be desirable, but the key prerequisite is a practical new energy technology application in developing countries focus, rather than a hydrogen R&D academic focus that assumes that hydrogen technologies are the answer to most energy problems.

In this context, one option to consider is carrying out a technology foresight exercise, including the preparation of an ICHET specific technology roadmap that shows clear scenarios of potential application focus areas and the respective assumptions and implications for ICHET and its activities within Turkey.

# VIII

## Lessons learned

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### **8.1 New organizations need a clear institutional perspective**

UNIDO projects that aim at building up (semi-) autonomous institutions need clarity of who will do the necessary fundraising, and also need realistic expectations of timescales and in terms of the ultimate organizational form (legal entity, international or national) of the new institutions if general longer term operations focused support funding (“core budget funding”) is being sought.

### **8.2 Demonstrations must solve real problems**

Technology demonstrations and pilot projects (such as hydrogen energy applications) naturally tend to focus on scientific and technical feasibility and technology-oriented proof-of-concept demonstrations. However, the world is full of such one-off “proof-of-concept” demonstrations that do not keep working much beyond their hand over to locals, and are not actually part of a conscious pathway to real world mass (but niche) applications. Further, when implemented by an international development agency such as ICHET, the developmental and environmental effects of such projects must not be neglected; to the contrary, they need to be the most important aspects to be taken into consideration. Hence, projects need to be designed in a way that they solve real development problems, have a realistic prospect of being cost effective for the recipient or host to keep the project operating post intervention, and have a clear pathway to wider take up (replication).

### **8.3 New technologies start in “killer” niche applications**

New technology co-operation areas, such as the dissemination of hydrogen technologies in developing countries, generally start in niche (“killer”) applications and then gradually move into mass market applications. It is rare for technologies to jump straight to mainstream mass market applications without an intermediate step of deployment in niche applications. This was forgotten in the overselling of the “hydrogen economy” hype underlying the inception of UNIDO-ICHET. This lessons should be considered in similar UNIDO interventions that aim at advancing innovative technologies.

#### **8.4 New technologies do not develop in a vacuum – they compete with other developing technologies**

The development and deployment of new technologies (such as the hydrogen technologies that are the ICHET focus) takes time and does not occur in a technological development vacuum. The ICHET hydrogen technologies for low GHG / sustainable productive uses in developing countries are competing with grid extensions fed by new renewable energy, other energy storage technologies that are themselves steadily developing over time such as batteries, battery-combustion engine hybrids, increased use of natural gas, and biofuels such as ethanol from sugar cane, biodiesel from oilseeds, and even the use of raw coconut oil in diesel engines in Pacific Island countries. Hydrogen technologies are also competing with energy efficiency. The rationale for hydrogen is also shifting over time and is not the same for every country. This aspect has not been adequately addressed in ICHET to date.

# Annex A: Terms of reference



## UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

### Terms of Reference

#### Independent Mid-Term Review of the UNIDO Project:

Establishment and operation of the International Centre for Hydrogen Energy Technologies (ICHET), TF/INT/03/002

### I. PROJECT BACKGROUND

Located in Istanbul the International Centre for Hydrogen Energy Technologies (ICHET) is a United Nations Industrial Development Organization project whose statutory mission is to demonstrate viable technologies for the implementation of a hydrogen inclusive economy as well as to facilitate their widespread use, more particularly in developing countries. It was founded in 2003 under the authority of UNIDO and the patronage of the Turkish Ministry of Energy. UNIDO-ICHET currently employs twenty highly qualified staff (scientific, administrative and technical).

When ICHET started operation on the 19th May 2004, some sixteen years of behind-the-scenes lobbying, negotiation and diplomacy finally came to fruition. The Centre was the brainchild of Dr. Nejat Veziroğlu, Director of the Clean Energy Research Institute in Miami University and was conceived as the result of a report he had been commissioned to prepare for UNIDO. Dr Veziroğlu set to work persuading a series of Turkish Governments as to the attractions of hosting an international centre dedicated to fostering the cause of hydrogen energy. Finally, in October 2003, a treaty establishing the centre was signed by the Minister of Energy on behalf of the Turkish Government and UNIDO. Ratification of the treaty soon followed paving the way for the centre's commencement with Dr Veziroğlu as its founding director.

The objectives of ICHET are:

- a) to develop and strengthen the scientific and technological capabilities in closing the gap between research and development organizations, innovative enterprises and the market place, so as to stimulate appropriate applications of hydrogen energy technologies in industrial development throughout the world in general and in developing countries in particular;
- b) to further, for the benefit of developing and developed countries, the application of hydrogen for peaceful aims, as well as the development and transfer of hydrogen energy related technologies, including the associated technology management processes;

- c) to further the advancement of applied research and development on hydrogen energy, with direct involvement of developing countries' scientists and technologists; and
- d) to support the strengthening of developing countries' research, development and technology transfer centres and programmes, including mechanisms for supporting existing enterprises and the creation of new industrial enterprises, all involved with the application of hydrogen energy technologies.

There is a clear vision to establish ICHET as an autonomous institution (under UNIDO auspices) with contributions other than the one from Turkey supporting the Centre.

The vehicle to establish and support the Centre is a UNIDO technical cooperation project. The project has a five year duration and is funded by the Government of Turkey, through an special purpose contribution with a total budget of USD 40 million, including 5 per cent support cost.

At present the UNIDO project and the Centre are de-facto identical, i.e. funds for the operation of the Centre come almost exclusively from the project and there is no explicit distinction between the operation of the Centre (staffing, materials, etc.) and the UNIDO capacity building support to the Centre.

However, the UNIDO capacity building support is described in the project objectives:

- 1) to demonstrate international support for the Centre and to promote involvement of the international community in ICHET programmes; and
- 2) to lay the foundation for the long-term functioning of ICHET.

## **II. MID-TERM REVIEW PURPOSE**

The purpose of the independent mid-term review is to facilitate decision making for the Government of Turkey and UNIDO on the basis of up-to-date information with regards to the following:

- (a) the past and continuous relevance of ICHET and of the activities promoted, outputs produced and outcomes achieved;
- (b) the past and continuous relevance of the UNIDO support to ICHET
- (c) summary of information available on the following aspects of ICHET and UNIDO activities:
  - the efficiency of implementation: quantity, quality, cost and utilization of resources, timeliness of UNIDO/ICHET inputs and activities, and ICHET management and coordination, including the roles of the Steering Committee and of the International Scientific Advisory Committee;
  - the extent to which outputs have been produced and objectives achieved, as compared to those planned (effectiveness);
  - the impact and sustainability of results, effects and benefits.

It is envisaged that the mid-term review will focus on the assessment of the relevance of ICHET and of the support provided by UNIDO to ICHET and on the formulation of recommendations regarding the future operations of ICHET and the

future UNIDO support. The mid-term review will also seek to draw lessons of wider applicability for the replication of the experience gained by ICHET for UNIDO network of international technology centres. The findings of the mid-term review will feed into the wider thematic evaluation of international technology centres, equally planned for 2009

### **III. METHODOLOGY**

The mid-term review is to be conducted in compliance with UNIDO Evaluation Policy and the Technical Cooperation Guidelines. It will assess the achievements of the Centre against its objectives and outputs, established in the original project document and in annual Work Programmes and include a re-examination of the relevance of the objectives and of the design. It will also try to identify factors that have facilitated or impeded the achievement of the objectives.

The mid-term review will be carried out through analyses of various sources of information including relevant ICHET documents such as annual reports, work programmes, publications, self evaluation reports, survey data, reports of Expert Group Meetings, workshops and training programmes, training material, feed-back forms of participants in workshops/seminars, minutes of meetings of the Steering Committee and of the International Scientific Advisory Committee and interviews with various stakeholders such as ICHET and UNIDO staff members, representatives of the Turkish Government and beneficiaries and through the cross-validation of data. Internet Surveys might be conducted targeting past beneficiaries of ICHET activities and representatives of partner institutions. The emphasis of the analysis will be on the period covering the last two years (mid 2007 to mid 2009).

The mid-term review team will also visit selected projects and partner institutions of ICHET in Turkey and other countries in order to assess actual or potential interactions and synergies with these institutions and to draw from the experience gained by them.

The analysis will include a review of relevant UNIDO policies and strategies, activities implemented, outputs produced, management mechanisms applied (in particular planning and monitoring) and project specific conditions. While maintaining independence, the mid-term review will be carried out based on a participatory approach, which seeks the views and assessments of all parties. It will address the following specific issues:

### **IV. KEY MID-TERM REVIEW QUESTIONS**

#### **Relevance**

The mid-term review will verify in how far:

- The ICHET mandate, function and research activities have been and are in line with the strategies and priorities of developing countries, UNIDO (e.g. mandate, medium term planning framework, long-term vision statement, etc.) and the Turkish Government;
- The research promoted and developed is being demanded, used and beneficial for developing countries;

- Hydrogen technology in general and the activities of ICHET in particular are relevant for the promotion of industrial development;
- The “right” participants were targeted for various events
- The ICHET mandate and the established objectives of UNIDO support to ICHET are still valid;
- There are linkages to UNIDO technical branches and to UNIDO thematic priorities;
- ICHET complements efforts of other national or international institutions, public as well as private;
- The work programmes are in line with ICHET objectives and selection of projects is done in a transparent manner, applying results-oriented criteria;
- Other donors contribute to ICHET activities and/or there are other cost-sharing interventions.

### **Design, coordination and management**

The mid-term review will verify in how far:

- A clear intervention logic exists, including a causal chain from activities to outcomes, explicit assumptions and risks, measurable indicators and means of verification;
- The design is based on a comprehensive process of consultations involving all relevant stakeholders;
- The centre’s organizational structure and management, the steering and scientific advisory committees and approval mechanisms of the centre/project are appropriate with regard to the objectives of ICHET.
- The UNIDO HQ based project management, coordination, substantial guidance, quality control and technical inputs have been appropriate and in line with ICHET requirements.
- The budget and staffing are adequate.
- There has been cooperation with other international technology centres and whether this has led to the achievement of objectives and synergy effects.
- ICHET uses a network of partner institution in academia and industry, including institutions in developing countries
- The selection of researchers, fellows and workshop participants followed established criteria
- Gender and environmental issues are mainstreamed.

### **Issues related to effectiveness, impact and sustainability**

- What are the ICHET core outcomes and impacts?
- Are ICHET activities/outputs such as research, demonstration projects, training, expert group meetings, workshops, publications, fellowships effective means to produce outcomes and contribute to impact?
- Were the planned outputs produced and objectives achieved or are likely to be achieved?
- Are systems for monitoring, reporting and self-evaluation in place and do they produce useful information, based on suitable indicators for outputs, outcomes and impact?

- Is ICHET gaining international support beyond the Turkish contributions and is there a good basis for long-term sustainability of ICHET?

#### **The future**

- The mid term review will produce a set of recommendations to UNIDO, the Turkish Government and other stakeholders (if applicable) with a view to improved relevance, performance and sustainability.
- The mid term review will identify lessons learned, benchmarks and good practices, applicable to other UNIDO interventions, in particular international technology centres.

### **V. MID-TERM REVIEW TEAM**

The mid-term review team will be composed of the following:

- One independent international evaluation consultant (team leader)
- One representative of the Turkish Government
- One representative of UNIDO Evaluation Group

The international evaluation consultant will be contracted by UNIDO. The consultant will act as team leader of the evaluation and will coordinate the work with the other team members. The specific tasks of the international evaluation consultant are specified in the job description attached to these Terms of Reference.

The members of the mid-term review team must not have been directly involved in the design and/or implementation of any ICHET related activities. The staff of ICHET as well as UNIDO/PTC staff at Headquarters will provide support to the mid-term review team.

### **VI. TIMING**

The mid-term review is scheduled to take place in the period October to December 2009. The mission to Turkey (including visits to ICHET and project sites) is planned for the last week of September 2009 (28 September to 3 October), following a possible Mission to India in the first week of October (5 to 9 October).

The draft report will be submitted within eight weeks of completion of the field mission and shared with the Government of Turkey, ICHET management and UNIDO management. A final report will be submitted within six weeks after receipt of feedback on the draft report.

### **VII. REPORTING**

To the extent possible, the mid-term review team will present its preliminary findings to the ICHET management, Steering Committee members, management at UNIDO Headquarters and to representatives of the Turkish Delegation to UNIDO. A draft mid-term review report will be circulated for validation and comments. The evaluators will take comments into consideration when preparing the final version of the report. The reporting language will be English. The format for the report will be based on the template in Annex 1 to this TOR and will be adapted as necessary.

## Annex B: List of documents consulted

Documentation available for the independent evaluation of the International Centre for Hydrogen Energy Technologies (ICHET) in Turkey

<b>1. Project: Background documentation</b>
<b>1.1 Agreement – Project document</b>
Cover note: Trust Fund agreement (09-03-2004)
Executive Board decision (24-10-2003)
Executive Board decision, List of approved projects (22-04-2004)
Internal correspondence: Extension of project expiration date (29-09-2008)
IOM, Briefing note, TF agreement (2003)
IOM, Request for approval by EB members (24-03-2004)
Project document
Trust Fund agreement
Trust Fund agreement (2003-12)
Trust Fund agreement (signed by all parties)
Project details (from UNIDO Infobase)
<b>1.2 Finance-related documents</b>
Corr., Payment of 3rd installment (26-08-2006)
Corr., Reminder: 3rd installment (06-09-2006)
CRV-4005468 (20-04-2005)
CRV-4008804 (18-06-2007)
Donation cheque to ICHET (27-02-2007)
Internal corr., Note EB (20-10-2003)
Internal corr., Project No.
IOM to EB (25-03-2004)
IOM, Approval of PAD (25-03-2004)
IOM, Notice of approval (16-04-2004)
IOM, Request for issuance of revised PAD (21-04-2005)
IOM, Request for issuance of PAD (19-04-2004)
Proj budget rev_Cover letter_proj_ext_080505.pdf
Project budget rev., UNIDO-ICHET protocol regarding extension of project (16-01-2009)
Project budget rev.-B (24-04-2004)
Project budget rev.-C (24-11-2004)
Project budget rev.-D (14-12-2004)
Project budget rev.-E (16-02-2005)
Project budget rev.-F (12-05-2005)
Project budget rev.-H (05-09-2005)
Project budget rev.-I (07-09-2005)
Project budget rev.-J (09-02-2006)
Project budget rev.-K (02-03-2006)
Project budget rev.-L (21-04-2006)
Project budget rev.-M (25-04-2006)
Project budget rev.-N (24-05-2006)
Project budget rev.-O (22-06-2006)
Project budget rev.-P (19-07-2006)
Project budget rev.-Q (27-07-2006)

Project budget rev.-R (11-08-2006)
Project budget rev.-S (06-09-2006)
Project budget rev.-S (16-10-2006)
Project budget rev.-S, Note
Project budget rev.-U (16-01-2007)
Proj budget rev-V, Gov. Approval (03-07-2007)
Proj budget rev-V (09-07-2007)
Proj budget rev-W (28-04-2008 to 11-2008)
Proj budget rev-W, PAC approval (08-04-2008)
Proj budget rev-X, (17-11-2008)
Proj budget rev-Y (12-12-2008)
Proj budget rev-Z (09-03-2009)
Snapshot detail report (09-05-2005)
Snapshot detail report (01-08-2006)
Snapshot detail report (28-11-2006)
Snapshot_detail report (31-12-2004)
Statement of account 2004
Statement of account 2005
Statement of account 2006
Statement of account 2007
<b>1.3 ICHET</b>
ICHET-Brochure
RS, Visit by Min. for Energy and Natural Resources
<b>1.4 Steering Committee</b>
1st SC Meeting (04-05-2007)
2nd SC Meeting (15-04-2008)
2nd SC Meeting , Note for file (24-04-2008)
3rd SC Meeting (04-02-2009)
<b>1.5 Work programmes</b>
ICHET WP 2008-2010
WP-0501
WP-2009

## Annex C: List of persons met and site visits

Thursday 24<sup>th</sup> September

Enver Khan, Project Manager and Cahit Gurkok, consultant, UNIDO; Cem Ulusoy, First Secretary, Turkish Permanent Mission to the UN Office in Vienna

Friday 25<sup>th</sup> September Adrie de Groot - Funds Mobilization Manager, Andrew Ingram - ICGEB consultant, Pradeep Monga - Head of Energy and Climate Change, Dolf Gielen - Head of Energy Efficiency and Climate Change, UNIDO, Vienna

Monday 28<sup>th</sup> September Mustafa Hatipoglu - Managing Director, James Weaterilt - Administration Director; Nikolaos Lymberopolous - International Projects Director, Suha Yazici – Fuel Cell R&D and Education Director, ICHET, Istanbul

Tuesday 29<sup>th</sup> September Oktay Erbatur - National Project Director, ICHET and tour of ICHET labs; Atilla Ersöz – Chief Senior Researcher, Energy Institute, Marama Research Centre, TÜBİTAK; Ahmet Kazokoglu, General Manager and Figü Kilic , Manager Projects, BELBİM; Sibel Irmak, Principal Investigator, Çukurova University/ ÇUMİTAŞ; Osman Nuri Aksoy, Project Manager, İDO; Adnan Celik, General Manager, İSTANBUL ENERJİ; Tansu Bayraktar, R&D Engineer, Çukurova University / ÇUMİTAŞ; Ali Ata, Professor, GYTE Institute of Technology; visit of H2 UPS demonstration site at İDO Sea Ferry Terminal, Ayasofya, Feshane; Istanbul.

Wednesday 30<sup>th</sup> September

Mayor and Governor; Head of Hospital; Chief of Electrical Authority; ICHET project assistant, Bozcaada Island

Thursday 1<sup>st</sup> October İnci Eroglu, Professor, Middle East Technical University; Hasan Z Sarikaya, Undersecretary, Ministry of Environment and Forestry, Ankara

Friday 2<sup>nd</sup> October Budak Dilli, Ministry of Energy & Natural Resources; Sibel Müderrisoğlu, Ministry of Foreign Affairs; Yavuz Topçu, General Manager, HİDRONERJİ, Ankara

Monday 5<sup>th</sup> October Philippe R. Scholtes, UNIDO Representative and Regional Director for South Asia; Prof. L. M. Das, IIT-Delhi; Delhi

Tuesday 6<sup>th</sup> October R.K. Malhotra, Executive Director, Indian Oil Corporation R&D

Centre, Faridabad (Haryana); S.K. Chopra, Adviser, Ministry of  
New & Renewable Energy, Delhi

Wednesday 7<sup>th</sup> October B.M.S. Bist, Scientist “G”, Ministry of Renewable Energy, Delhi

Thursday 8<sup>th</sup> October Abraham Mathew, General Manager, Alternative Fuels and  
Advanced Technologies, Mahindra & Mahindra; Amjad Khan,  
Deputy General Manager, Prodair Air Products India; V K  
Gumba, Officer on Special Duty and NK Sekhgal, General  
Manager, Rajiv Yadav, Executive Director, ITPO, Pragati  
Maidan, Delhi; T. Nejat Veziroglu, United States of America (by  
phone).



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