全球可再生能源状况报告

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REN21 是一个全球性的政策网络,旨在为国际可再生能源的领导层提供一个平台。它的目标是在制定地方、国家、国际等层面的政策及决策上提供支持，使可再生能源在发展中国家和工业化国家快速发展。

REN21 面向所有相关方和参与者提供服务，并是一个有能力且一直致力于创建一个促进全世界可再生能源发展环境的网络，在此环境中思想和信息被分享、合作和行动得到鼓励。REN21 将政府、国际机构和组织、合作伙伴以及政治层面的其他相关者以共同的基础联系起来，它本身不是一个参与者，而是一个以对可再生能源的承诺为中心的各方面关系疏导者。

建立一个全球性政策网络是在 2004 波恩国际可再生能源大会的政治宣言中 提出的，2005 年 6 月在哥本哈根正式起动。

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主要内容概要

本报告提供了全球 2005 年可再生能源状况概述，内容涉及市场、投资、产业、政策和发展中国家的农村（离网）可再生能源。本报告不提供分析、建议或推论。经过 100 多位研究人员数月的调研和复审，本报告的误差已基本降至最低。REN21 将此报告视为积极交换观点和信息的一个良好开端。

本报告展示了一些关于可再生能源的令人吃惊的事实：这些事实反映出可再生能源的强劲增长趋势以及相对于传统能源与日俱增的重要性。

- 2004 年全世界可再生能源领域的投资约为 300 亿美元（不包括大水电），而传统电力领域的投资大概为 1500 亿美元。另外，大水电方面的投资为 200～250 亿美元，大部分发生在发展中国家。
- 全世界可再生能源总发电量是 160GW（不包括大水电），占全球发电量的 4％。其中发展中国家占 44％，也就是 70GW。
- 不计大水电（其本身就占世界电力的 16％），2004 年全世界可再生能源发电量是世界核发电量的 1/5。
- 世界上发展最迅猛的能源技术是并网光伏（PV）发电。自 2000－2004 年其装机量年增长率为 60％。其已在日本、德国及美国的 400 000 户屋顶安装。风能装机容量位居第二，年增长率达到 28％，德国装机容量为世界第一，2004 年装机总容量为 17GW。
- 屋顶太阳能集热器为全世界将近 4 千万的家庭提供了热水，大部分是在中国；还有分布于 30 个国家的 200 万个地热泵为建筑制热和制冷。尽管如此，全球生物质燃料供热量仍然五倍于太阳能和地热能的总和。
- 2004 年生物质燃料（乙醇和生物柴油）的产量超过了 330 亿升，大约是全球消耗的 1 亿 2 千万亿升汽油的 3％。2004 年巴西所有机动车（非柴油车）燃料的 44％由乙醇提供，美国所有售出汽油的 30％也混合了乙醇。
- 2004 年欧洲、美国、加拿大、澳大利亚和日本的绿电消费者超过 450 万，方式为基于零售渠道或认证证书自愿购电。
- 2004 年全世界由可再生能源制造、运行和维护直接带来的就业机会就超过 170 万个。其中 90 万个由生物质燃料生产提供。
- 可再生能源（尤其是小水电、生物质能和太阳能光伏）为发展中国家数千万的农村人口提供了电能、热能、动能和提水，满足了农业、小工业、家庭、学校及其他社会需要。1600 万个家庭用沼气做饭和照明，200 万个家庭在使用太阳能照明系统。

促进可再生能源的政策在过去几年中迅速发展，目前全世界已至少有 48 个国家制定了各种形式的可再生能源促进政策，其中包括 14 个发展中国家。2005 年至少有 32 个国家和 5 个地区/省施行强制上网政策（Feed-in Policy），其中一半以上从 2002 开始施行。至少有 32 个地区/省建立了可再生能源配额制（RPS），其中一半建立于 2003 年。还有 6 个国家于 2001 年确立了国家可再生能源配额制。至少 30 个国家提供了直接资金投入补贴、赠款或折扣优惠。美国大多数的州以及其他至少 32 个国家为可再生能源提供了多种形式的税收激励和减免制度。自 1995 年以来，超过 5.4GW 的风电装机受惠于美国联邦生产税减免制度。

全世界至少 45 个国家具有可再生能源发展的政策目标，包括 10 个发展中国家，欧盟 25 国和美国、加拿大的很多州/省。大多数的目标是占发电量的份额，一般为到 2010－2012 年达到 5～30％。欧盟的目标是到 2010 年可再生能源发电量占到总发电量的 21％，中国的目标是 10％（不包括大水电），这意味着可再生能源发电量从目前的 37GW 提高到 2010 年的 60GW。

全世界很多市政当局也设定了未来可再生能源在政府能耗或城市能耗中所占的份额目标，一般为 10～20％。许多城市制定了多种多样的旨在促进太阳能热水和太阳能光伏发展的政策，并将可再生能源纳入城市规划。

巴西在过去 25 年中领导推动生物质液体燃料的发展，要求所有售出的汽油必须混合乙醇，所有的加油站都同时供应纯乙醇和乙醇-汽油混合物。除了巴西，向机动车燃料中混合生物质燃料的规定在全世界至

少 20 个地区/省及两个国家（中国和印度）中实行。

可再生能源已成为一个大型产业。大型商业银行开始重视该市场，有几个已经将可再生能源投资作为其贷款组合的主流。其它大的投资者也正在进入可再生能源市场，包括风险基金和数一数二的投资银行，诸如摩根士丹利（Morgan Stanley）和高盛（Goldman Sachs）。近年来主要的投资和采购都发生在业界领先的跨国公司，如通用电气、西门子、壳牌、英国石油、三洋和夏普(GE、Siemens、Shell、BP、Sanyo 和 Sharp)。中国五大电力设备和航空公司都已决定进军风电。综合来看，排名在前的 60 个可再生能源上市公司或大型公司的可再生能源分部至少具有 250 亿美元的总市值。

在可再生能源项目、培训和市场支持方面，每年约有 5 亿美元的援助资金流入发展中国家。这些资助的大部分来自德国复兴银行（KfW）、世界银行集团（WB）和全球环境基金（GEF），其余部分来自捐赠和项目。

2004 年美国和欧洲为可再生能源提供的政府支持总和在百亿美元量级，方式有直接支持（预算内）和基于市场的政策机制支持（预算外）。其中研发费用投入超过 7 亿美元。

很多可再生能源技术的成本随着技术进步和产业规模化而开始降低。太阳能和风能发电的成本都只是 10～15 年前的一半。很多可再生能源技术在良好的条件下可以同传统能源的零售甚至是批发的价格相竞争，即便传统技术的成本也在降低（因燃料价格增长有所抵消）。

市场促进组织（MFOs）致力推动可再生能源市场、投资、产业化的增长，主要方式包括网络、信息交换、市场研究、咨询、融资、政策建议及其他技术支持。粗略统计显示，全世界至少有 150 个这样的组织，包括行业协会、非政府组织、多边和双边发展机构、国际合作伙伴、网络和政府机构。

1. 全球市场概览

世界一次能源使用中可再生能源比例达到 17%，其中包括传统生物质、大型水利发电及新兴可再生能源（小水电、现代生物质、风能、太阳能、地热能和生物质燃料）[*][†]（见图 1）。传统生物质主要用于家庭炊事和取暖，其在全球一次能源使用中比例为 9%。由于更高效的使用方式或被新的能源形式所替代，传统生物质所占比例增长缓慢，甚至在某些地区呈下降趋势。大型水利发电多见于发展中国家[‡]，所占比例接近 6%，也同样增长缓慢。新兴可再生能源所占比例为 2%，但它在发达国家和部分发展中国家保持飞速增长。显然，这三种形式的可再生能源具有各自的特点和发展趋势。该报告关注点将主要放在新兴可再生能源，原因有两点：一是它们巨大的未来发展潜力；二是新兴可再生能源商业化应用的加速发展迫切需求市场和政策的支持。[§][注 1、2][**]

可再生能源与传统燃料在四个不同市场存在竞争：发电、热水及取暖、交通运输燃料以及农村(离网)能源(见表 1)。在发电方面，可再生能源在总装机容量中占有 4%，同时在全球总发电量中占 3%(未包括大型水电)。太阳能、生物质能和地热能为数以千万计的建筑提供热水及取暖。太阳能集热器单独一项已在全球约四千万家庭中使用。在供热方面，生物质能和地热能同时为工业、农业和家庭提供服务。交通运输用生物质燃油市场份额虽然很小，但其比例也在增长。特别是在巴西，交通运输用生物质燃油占有巨大份额：甘蔗中提取的乙醇现已为全巴西 44%的机动车(非柴油)提供燃料。在发展中国家，已有 1600 万家庭使用生物质燃气替代煤油和其他炊用燃料满足照明及炊事需求；超过 200 万家庭使用太阳能光伏产品照明；越来越多的小工业（如农产品加工）开始使用小型沼气池获取热能和动能。[††][注 3]

世界上增长最快的能源技术就是光伏并网发电：其现有装机容量已从 2000 年初始时的 0.16GW 增至 2004 年末的 1.8GW，在 5 年期间年平均增长率达到 60% (见图 2、图 3) 。在这五年中，其他可再生能源技术也同样快速增长，年平均增长率分别为：风能 28%(见图 4)，生物质柴油 25%，太阳能热水器/供暖设备 17%，离网光伏 17%，地热取暖 13%，乙醇燃料 11%。其它可再生能源发电技术，如生物质能、地热能和小水电，相对比较成熟，增长率与传统能源相比相差不大，约为 2~4%。虽然没有相关数据支持，但生物质供暖的增长实际也类似这些较成熟技术。另外，石油发电装机容量增长率约为 3~4%(在部分发展中国家会高于此数字)，大型水电年增长率为 2%，核能发电在 2000－2002 这三年期间年增长率为 1.6%。[注 3]
不算大型水电，2004 年世界范围内现存可再生能源发电总装机容量为 160GW(见图 5)。其中，小水电和风力发电的比例为 2/3。需要说明的是，全球的发电总装机容量为 3 800GW。这 160GW 中有 77GW 在包括中国的发展中国家，主要为生物质发电和小水电。欧盟共计有 57GW，主要为风力发电。另外，排名前五位的国家分别是：中国(37GW)，德国(20GW)，美国(20GW)，西班牙(10GW)，日本(6GW)。[注 4、5]

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[*] 除非特别说明，本文所用“可再生能源”均指“新的”可再生能源。目前暂时没有普遍接受的可再生能源的统一定义，但使用“可再生能源”代指“新的”可再生能源是普遍认可的惯例。例如，BP 公司在其有关世界能源情况的年度统计评估报告中规定“可再生能源”不包括大水电。大水电一般是指容量大于 10MW 的电站，但本报告中涉及的小水电统计数据包括中国 50MW 水电站及巴西 30MW 水电站，因这两个国家所定的分界线分别为 50MW 及 30MW。

[†] 根据大水电及其他可再生能源技术归类方法的不同，可再生能源在全球一次能源中的份额亦可计为 13~14%。差别产生于是否按照等效一次能源或等效电力计算，详细解释请参见注 2。

[‡] “发展中国家”并无定量区分标准，但一般指人均收入较低的国家。也有根据其是否为世界银行援助对象来加以界定。本文所指发展中国家为非 OECD 国家及 OECD 成员国中的墨西哥和土耳其，但不包括俄罗斯及其他过渡之中的前计划经济国家。

[§] 本报告仅涉及在全球较大范围商业化应用的可再生能源技术。许多其他技术也显现出较好的商业前景或已有少量商业化应用，如主动太阳能制冷（亦称为“太阳能辅助建筑空调”），聚焦式太阳能发电（使用菲涅耳(Fresnel)透镜），海洋热能转化，潮汐发电，波浪发电，热干/湿岩发电，从纤维素中提取乙醇等。据报告，太阳能炊具已在超过一百万家庭中应用，但尚无数据用以预测其趋势。另外，被动太阳能供暖/制冷已被证明具有商业可行性，且已在建筑设计中广泛应用，但本报告中并未涉及。本报告的后续版本可能会涵盖这些技术及应用。

[**] 本报告中的注解及引用会在引用段落后用方括号括起，如：[注 1]。全部的注解及引用均可在 REN21 网站找到，具体链接为 www.ren21.net/globalstatusreport.

[††] 离网光伏应用包括住宅、商业建筑、信标及通讯和消费类产品。2004 年，全球约有 70MW 用于消费类产品，80MW 用于信标及通讯，180MW 用于住宅和商业建筑。

大型水利发电依然是低成本能源技术之一，但其引起的环境问题、居民安置问题、选址问题在很多国家限制了它的进一步发展。2004 年，大型水利发电在全球总发电量中的比例已从 10 年前的 19%降至 16%。截至 2004 年，大型水电累计总装机容量为 720GW，年平均增长率略高于 2%(发达国家为该数字的一半)。挪威是几个完全依靠水利发电的国家之一。2004 年水利发电量排名前五的国家分别是：加拿大(全球总量的 12%)，中国(11.7%)，巴西(11.4%)，美国(9.4%)，俄罗斯(6.3%)。中国的水利发电与其快速增长的能源领域同步发展。2004 年中国大型水利发电装机容量约为 8GW，使中国在总装机容量方面跃居世界第一(74GW)。其它发展中国家在大型水利发电方面也有巨大投入，大量电站在建设之中。

在世界范围内，小水电的发展已超过一个世纪。中国拥有超过一半的世界小水电总装机容量。2004 年，中国小水电建设迅猛发展，装机容量达到 4GW。其它在此方面积极努力的国家有澳大利亚、加拿大、印度、尼泊尔和新西兰。小水电多用于自给型(非并网)村落发电，以替代柴油发电机或其它小规模电站，或为无电农村人口供电。在过去几年中，为了减少对环境的影响，小水电使用新的技术和运作方式，将发展重点放在电站与河流系统的环境集成方面。

风电市场主要集中在少数几个国家，其中 2004 年西班牙、德国、印度、美国和意大利在市场增长方面处于领先地位(见图 6)。现在一些国家已经开始发展大规模商业市场，主要包括俄罗斯以及一些过渡性国家，如中国、南非、巴西和墨西哥。就中国而言，历来的大部分风电投资来源于捐助或政府支持，但近年来也在向私有投资转变。其它一些国家尚处在建设示范风电场的阶段，将在未来寻求发展商业化市场。[注 6]

近海风电是一个新生市场。全球约有 600MW 的近海风力发电，它们全部位于欧洲。第一个大规模近海风电场(170MW)于 2003 年在丹麦建成，而且欧洲还有 40GW 的庞大计划，主要位于德国、荷兰和英国。[注 6]

生物质发电及供热在欧洲发展较慢，主要由澳大利亚、芬兰、德国和英国的发展推动。近年来在德国迅猛发展的废弃木材利用现已趋于平缓，主要是由于大部分的原材料资源已被开发利用。英国最近在“混合燃烧”(即在使用煤燃料的火电场混合使用少量生物质)方面有所增长。丹麦、芬兰、瑞典、美国和其他几个 OECD 国家在生物质技术方面持续投入资金。在一些国家，利用生物质进行社区供暖及热电混合供应也有所增长，其中包括澳大利亚和德国。在瑞典，生物质满足了超过 50%的社区供暖需求。在发展中国家中，利用农业废弃物进行小规模供电采暖比较常见，例如利用米糠或椰壳。在拥有大规模制糖产业的国家，如巴西、哥伦比亚、古巴、印度、菲律宾和泰国，利用甘蔗废弃物（蔗渣）热电联产的应用较为多见。逐渐增长的小规模生物质气化应用正在农村市场寻找机会(在发达国家亦有高效组合循环生物质气化电站的示范应用)。各国在生物能“联产”方面的兴趣也逐渐增加，该生产方式是指在一次生产过程中同时输出能源及非能源产品(例如饲料和工业纤维)。[注 6]

类似小水电，地热能用于供电采暖也有一个世纪的历史。现今至少有 76 个国家使用地热取暖，24 个国家使用地热发电。在 2000－2004 年间，地热发电容量增长超过 1GW，这些增长主要发生在法国、冰岛、印度尼西亚、肯尼亚、墨西哥、菲律宾和俄罗斯。在发达国家中，地热发电主要集中于意大利、日本、新西兰和美国。[注 6]

从 2000 年至 2005 年，地热直接取暖总量大约翻了两番，共增长 13GWth，其中至少 13 个国家是首次进入地热领域。冰岛在地热直接取暖方面处于领先地位：地热满足了其 85%的采暖需求。自 2000 年，土耳其在地热直接取暖方面增长了约 50%，现已能满足约 70 000 户家庭的采暖需求。现有的地热采暖设备约有 50%为地热泵，也叫做地源热泵。这些设备的使用日益增多，主要用于建筑供暖、制冷。现有近 2 000 000 热泵应用于 30 多个国家，主要为欧洲和美国。

通过支持性政策推动，并网光伏装机主要集中于 3 个国家：日本、德国和美国。截至 2004 年，在这 3 个国家有超过 400 000 家庭安装了屋顶光伏，并为电网供电。2004 年，光伏市场增长了约 0.7GW，累计装机容量从 1.1GW 增至 1.8GW。世界上建筑集成光伏的商业/公众示范应用也有所增长。典型范例包括：地铁站（100kW）、加油站（30kW）、太阳能光伏生产车间（200kW）、消防队（100kW）、市政厅（50kW）、

展览中心（1000kW）、博物馆（10kW）、大学建筑（10kW）和监狱（70kW）。[注 7]

集中式太阳能热发电市场从上世纪 90 年代初就开始停滞不前，世界上仅有加利福尼亚建成了一座 350MW 的电站，也是由于那时加州优惠的税收政策。最近，以色列、西班牙和美国的一些商业计划又重新唤起了人们的兴趣及相应的技术革新和潜在投资。2004 年，亚利桑那州开始建设一个 1MW 的抛物槽式热电站，亦是继 90 年代加州 350MW 电站之后世界上第一个太阳能热电站。2005 年，由于有投资商正在考虑建设 2 个 50MW 的项目，西班牙的市场开始涌现出来。一些发展中国家，如印度、埃及、墨西哥和摩洛哥，开始计划通过多边合作建设相应项目，但其中一些项目还存在不确定性。

太阳能热水/供暖技术的应用日益广泛，其在中国、欧洲、以色列、土耳其和日本的热水/供暖市场份额较大。几十个其他国家也具有相对较小的市场。中国占有全球安装总量的 60%（见图 7，图 8），欧盟占有 11%，紧随其后的是土耳其 9%，日本 7%（所有数字仅针对涂层型集热器）。中国 2004 年总销量为 13 500 000 ㎡，增长幅度达到 26%。真空管太阳能热水器现占据中国市场的主导地位，在 2003 年市场份额就已达到 88%，在日本，由于更新淘汰较少，现有市场开始下滑。在欧洲，2004 年安装总量为 1 600 000 ㎡，由于存在旧系统的淘汰更新，该数字可能会有一定偏差。110 000 000 ㎡的集热器安装面积（77GWth 的供热能力）为全球近 40 000 000 家庭提供太阳能热水，为全球约 1 600 000 000 家庭的 2.5%。*[注 8]

太阳能供暖正在一些国家开始发展，但主要应用依然是太阳能热水。在瑞典和澳大利亚，每年安装的集热器有超过 50%的面积为热水/供暖组合系统。在德国，组合系统的份额为年安装总量的 25～30%。中国有少于 5%的系统同时提供热水和采暖。

相对全球汽油 1 200 000 000 000 L 的年产量，生物质燃料在 2004 年的产量为 33 000 000 000（见图 9）。巴西在过去 25 年中一直是乙醇燃料的世界领导者（和主要用户）。巴西 2004 年乙醇燃料产量为 15 000 000 000L，占世界总产量的近一半。巴西所有加油站同时销售纯乙醇（E95）、汽油醇、25%乙醇/75%汽油混合燃料（E25）。2004 年在巴西，几乎与汽油相当的乙醇被用于机动车燃料（非柴油），所销售的混合燃料中的乙醇及纯乙醇占所有机动车燃料的 44%。相对于汽油来说，乙醇燃料在 2005 年的需求相当强烈。近年来，乙醇燃料全球交易量剧增，其中巴西为最大的出口国。2004 年巴西出口的 2 500 000 000L 乙醇占全球交易量的一半多。[注 9]

巴西的交通运输燃料市场和机动车市场共同发展。继 90 年代纯乙醇燃油机动车销售锐减后，该市场于 21 世纪初开始回暖，原因在于乙醇价格的大幅降低、汽油价格的上涨及巴西汽车制造商所谓“柔性燃油（Flexible Fuel）”车的投产。这种汽车即可使用纯乙醇也可使用乙醇/汽油混合燃料。截至 2003 年，大部分汽车制造商都有这种车型销售而且价格相对于纯乙醇燃料车和汽油车也有一定竞争力。柔性燃料车被驾驶者广泛接受，部分出于燃料供应不确定性的考虑(如 1989 年乙醇供应短缺及未来动荡的石油供应)。柔性燃料汽车销售量迅速增长，截止 2005 年，巴西销售的汽车中有超过一半为柔性燃料车。[注 10]

美国为世界第二大乙醇燃料消费生产国。美国市场在最近一段时间呈现增长趋势。乙醇生产能力从 1996 年 4 000 000 000L/年增至 2004 年的 16 000 000 000L/年。近年的年增长率为 15～20%。截止 2005 年，有近 400 家加油站（大部分位于美国中西部偏北地区）销售 E85（85%乙醇与 15%汽油的混合物），更有大量加油站销售汽油醇(E10)。2005 年，美国售出的 140 000 000 000G（加仑）机动车（非柴油）燃料中的 3%为乙醇。另外，美国售出的汽油中有 30%混入乙醇(E10)以替代 MTBE（甲基叔丁基醚）作为汽油添加剂。很多州已经要求停止使用 MTBE。其他生产乙醇燃料的国家有澳大利亚、加拿大、中国、哥伦比亚、多米尼加共和国、法国、德国、印度、牙买加、马拉维、波兰、南非、西班牙、瑞典、泰国和赞比亚等。[注 9]

2004 年，德国生物质柴油的产量增长了 50%，世界总产量增至 20 多亿升。纯生物质柴油（B100）在德国享有燃油税全免的优惠，B100 在德国 1500 多家加油站有售。其他生物质柴油主要生产国有法国和意

* 太阳能热水/供暖一般称为“太阳能制热/制冷”，以指出太阳能制冷（太阳能辅助空调）亦是商业化技术。本报告使用太阳能热水/供暖一词，原因在于太阳能热水器占总安装容量的绝大部分。世界范围内，特别是在欧洲，确有一些装机用于采暖，但即使算上组合系统，供暖所占份额依然很小。太阳能制冷尚未开始大范围商业应用，但很多人都确信其前途光明。

大利。另有一些产量较小的国家，如澳大利亚、比利时、捷克共和国、丹麦、印度尼西亚、马来西亚和美国等。一些国家计划在未来几年开始生产生物质柴油或扩大产能。[注 9]

表 2 为几种应用最广的可再生能源技术的成本数据，其中很多技术的应用成本仍高于传统能源技术（典型传统能源技术基本负载用电成本在 2～5 美分/kWh，但高峰用电成本会相当高，离网柴油机*发电成本也很高。）高成本及其他市场方面的障碍意味着大部分可再生能源技术依然需要政策支持。然而，两者经济性方面的竞争并不是静态的：就在可再生能源技术成本降低的同时，传统技术成本也在下降（例如气燃机技术的改进）。未来两者竞争力强弱的不确定性主要在于石油价格对传统能源成本的影响。

目前，国际能源机构对可再生能源成本价格竞争力的看法是："除了大水电、燃烧用可再生能源和废物处理厂，可再生能源电力的平均成本现在还无法与批发电价竞争。然而，根据所采用技术、具体应用和地点的不同，某些可再生能源发电成本还是可与电网零售电价或商业采暖价格竞争的。在最理想情况下—最优系统设计、最佳地点和充足的资源—生物质发电、小水电、风电和地热发电的成本可降至 2～5 美分/kWh。某些特定地点的生物质应用和地热供暖也很有价格竞争力。"太阳能热水器在技术成熟地区已与传统热水器展开全面竞争，但在气候寒冷地区稍逊一筹。除了在某些零售电价极高（超过 20～25 美分/kWh）的地区，并网光伏发电目前还缺乏竞争力。乙醇燃料在巴西已完全可与汽油展开竞争。†[注 11]

表 1：可再生能源数据指标

	2004 年末装机容量	**比较指标**
发电	**（GW）**	
大水电	720	世界总发电能力 = 3 800
小水电	61	
风电	c48	
生物质发电	39	
地热发电	8.9	
离网光伏	2.2	
并网光伏	1.8	
太阳能热发电	0.4	
海洋能（潮汐）发电	0.3	
总计（除大水电）	160	
热水/供暖	**（GWth）**	
生物质供暖	220	
太阳能热水/供暖	77	
地热直接供暖	13	
地热泵	15	
使用太阳能热水器的家庭	40 000 000	全世界共有家庭：1 600 000 000
使用地热泵的建筑	2 000 000	

* 除非另外注明，价格数据均指美元。

† 成本比较基于经济成本，未计入外部成本。财务成本比较会相当复杂，因为须考虑因素包括政策支持、补贴、税务及其他市场条件。历史成本降低是由一系列因素造成的，不在本报告讨论范围内。例如，由于生产效率提高及市场增长，巴西乙醇燃料成本已持续 20 年走低。

交通运输用燃油	**(升/年)**	
乙醇产量	31 000 000 000	汽油总产量 = 1 200 000 000
生物质柴油产量	2 200 000 000	
农村（离网）能源		
家用沼气池	16 000 000 个	全部未接入电网家庭= 360 000 000
小型生物质气化器	n/a	
户用太阳能光伏系统	2 000 000 套	
太阳能炊具	1 000 000 件	

表 2：可再生能源技术现状——特点与成本

技术名称	**特点**	**成本（美分/kWh）**	**成本走向及降低可能**
发电			
大水电	电站容量: 10 MW–18,000 MW	3–4	稳定
小水电	电站容量: 1–10 MW	4–7	稳定
陆地风能	风机功率: 1–3 MW 叶片尺寸: 60–100 m	4–6	全球装机容量每翻一番，成本降低 12~18%，现已降至 1990 年的一半。风机功率相对于 10 年前的 600~800kW 亦有较大提升。未来将通过优选风场、改良叶片/电机设计和电子控制设备来降低成本。
近海风能	风机功率: 1.5–5 MW 叶片尺寸: 70–125 m	6–10	市场依然较小。未来将通过培育市场及改良技术来降低成本。
生物质发电	电站容量: 1–20 MW	5–12	稳定
地热发电	电站容量: 1–100 MW 类型: 双流式，单闪蒸式，双闪蒸式，自然蒸汽式	4–7	成本从 19 世纪 70 年代开始降低。通过先进的勘探技术、低廉的钻井手段和高效的热利用，成本可进一步降低。
太阳能光伏(组件)	电池类型及效率 单晶硅: 17% 多晶硅: 15% 薄膜: 10–12%	---	全球装机容量每翻一番，成本降低 20%，每年约降低 5%。2004 年由于市场的影响，成本有所提高。未来将通过在材料、设计、工艺、效率和规模等方面做出改进来降低成本。
屋顶光伏	峰值功率: 2–5 kW	20–40	由于光伏组件价格降低、逆变器及系统平衡部件的改进，成本持续走低。

太阳能热发电	电站容量: 1–100 MW 类型: 塔式、碟式和槽式	12–18 (槽式)	相对 19 世纪 80 年代第一座电站的 44 美分/kWh，成本已有所降低。通过扩大规模、改进技术，成本将进一步降低。
热水/供暖			
生物质供暖	电站容量: 1–20 MW	1–6	稳定
太阳能热水/供暖	面积: 2–5 m^2 类型: 真空管/平板 功能: 热水/采暖	2–25	基本稳定。因规模效益、新材料应用、集热器面积增大及质量提升，成本会有小幅降低。
地热供暖	电站容量: 1–100 MW 类型: 双流式，单闪蒸式，双闪蒸式，自然蒸汽式,热泵	0.5–5	参见地热发电部分
生物质燃料			
乙醇	原料: 甘蔗，糖用甜菜，谷物，小麦 (未来将使用纤维素)	25–30 美分/等效汽油升	在巴西，生产效率的提高使成本有所降低，现价格为 25~30 美分/等效升（甘蔗提炼)。美国价格则稳定于 40～50 美分（谷物提炼）。其他原料则成本更高，最高至 90 美分。来源于纤维素的乙醇将有望降低成本，预计 2010 年后，成本将从今天的 53 美分降至 27 美分。其他原料的成本会有些微降低。
生物质柴油	原料: 大豆，油菜籽，芥菜籽，废弃植物油	40–80 美分/等效柴油升	2010 年后，以油菜籽及大豆为原料的生物质柴油的成本有望降至 35～70 美分/等效柴油升，而以废弃植物油为原料的成本将保持现今的 25 美分。
农村（离网）能源			
微小水电	电站容量: 100–1,000 kW	5–10	稳定
超小水电	电站容量: 1–100 kW	7–20	因效率提升，成本稳步小幅走低。
极小水电	电站容量: 0.1–1 kW	20–40	因效率提升，成本稳步小幅走低。
沼气池	尺寸: 6–8 m^3	n/a	因建造成本及产出结构的变化，成本稳步小幅走低。
生物质气化器	功率: 20–5,000 kW	8–12	通过技术改良，成本将可能大幅降低。
小风机	风机功率: 3–100 kW	15–30	技术进步可小幅降低成本。
户用风机	风机功率: 0.1–1 kW	20–40	技术进步可小幅降低成本。
乡镇规模小电网	系统功率: 10–1,000 kW 后备系统: 蓄电池或	25–100	随太阳能及风能系统部件价格降低，成本也将降低。

	柴油机		
户用太阳能光伏系统	系统功率: 20–100 W	40–60	随太阳能系统部件价格降低，成本也将降低。

*注：*所有成本均指排除补贴和政策激励等因素的经济开销。表中成本数据亦是根据理想情况（系统设计、选址及资源/原材料）计算。某些情况下成本会更低，如地热及大水电最低至 2 美分/kWh，生物质发电最低至 3 美分/kWh。较差条件下，成本可能会比表中数值高出很多。表中太阳能并网光伏成本是按大多数发展中国家 2 500kWh/ m^2 的年辐照度计算的。若年辐照度为 1 500kWh/ m^2（如南部欧洲），成本会升至 30~50 美分/kWh，1000kWh/m^2 则达到 50~80 美分/kWh。

Figure 1: Renewable Energy Contribution to Global Primary Energy, 2004
图**1: 2004** 可再生能源占一次能源份额

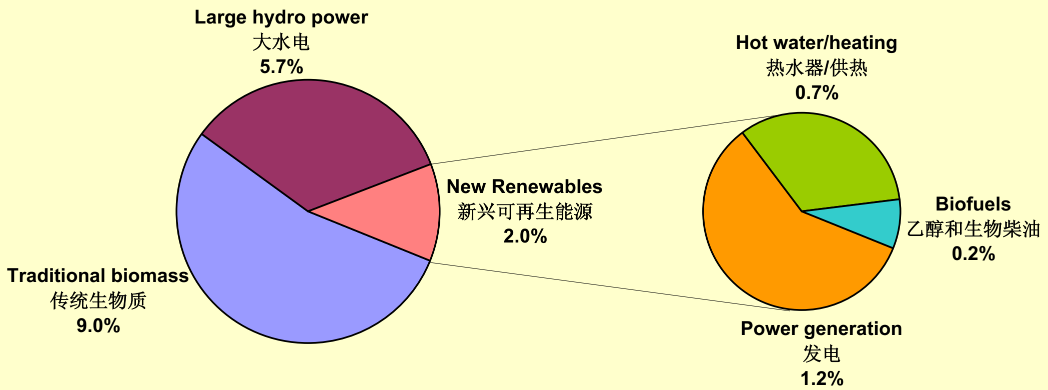


图2：可再生能源总量平均年增长率，2000-2004

Figure 2: Average Annual Growth Rates of Renewable Energy Capacity, 2000-2004

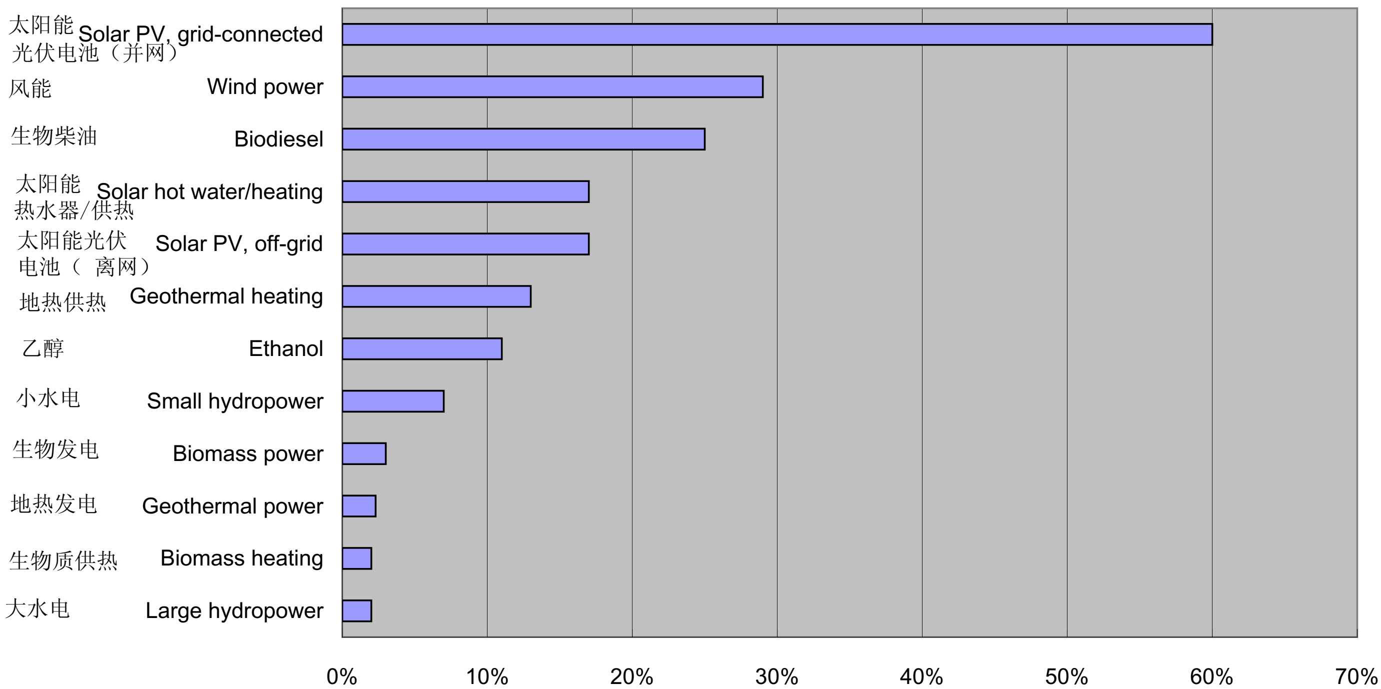


图3：世界太阳能光伏电池容量，1990-2004（MW）

Figure 3: Solar PV, Existing World Capacity, 1990-2004 (MW)

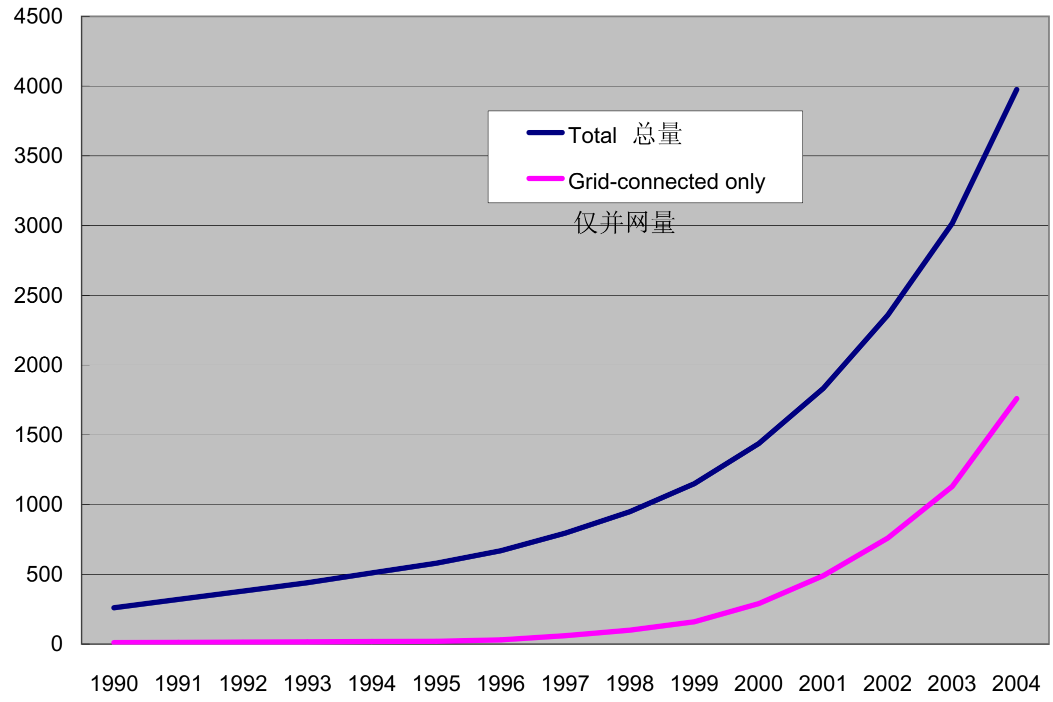


图4：世界风能容量，1990-2004（GW）

Figure 4: Windpower Existing World Capacity, 1990-2004 (GW)

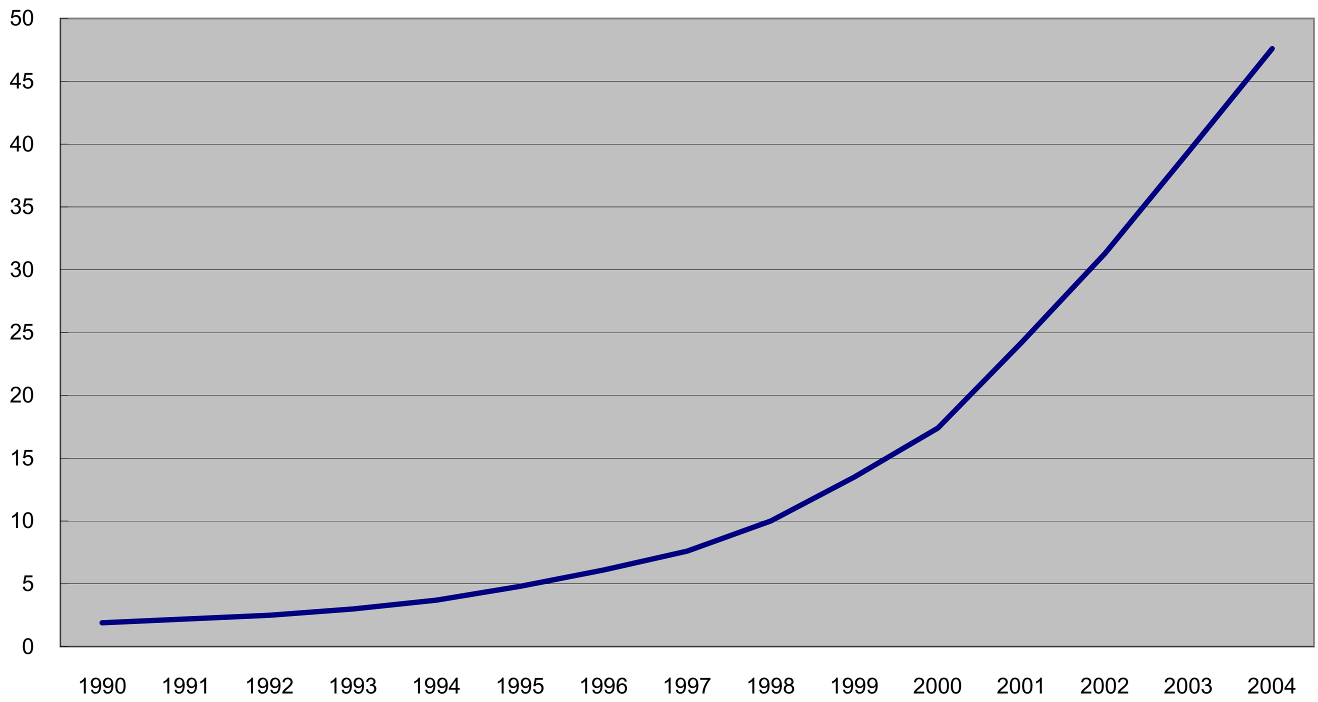


图5：2004年可再生能源容量（GW），发展中国家，欧盟和前5名国家（不含大水电）

Figure 5: Renewable Power Capacities in 2004 (GW) for Developing Countries, EU, and Top Five Individual Countries (excluding large hydropower)

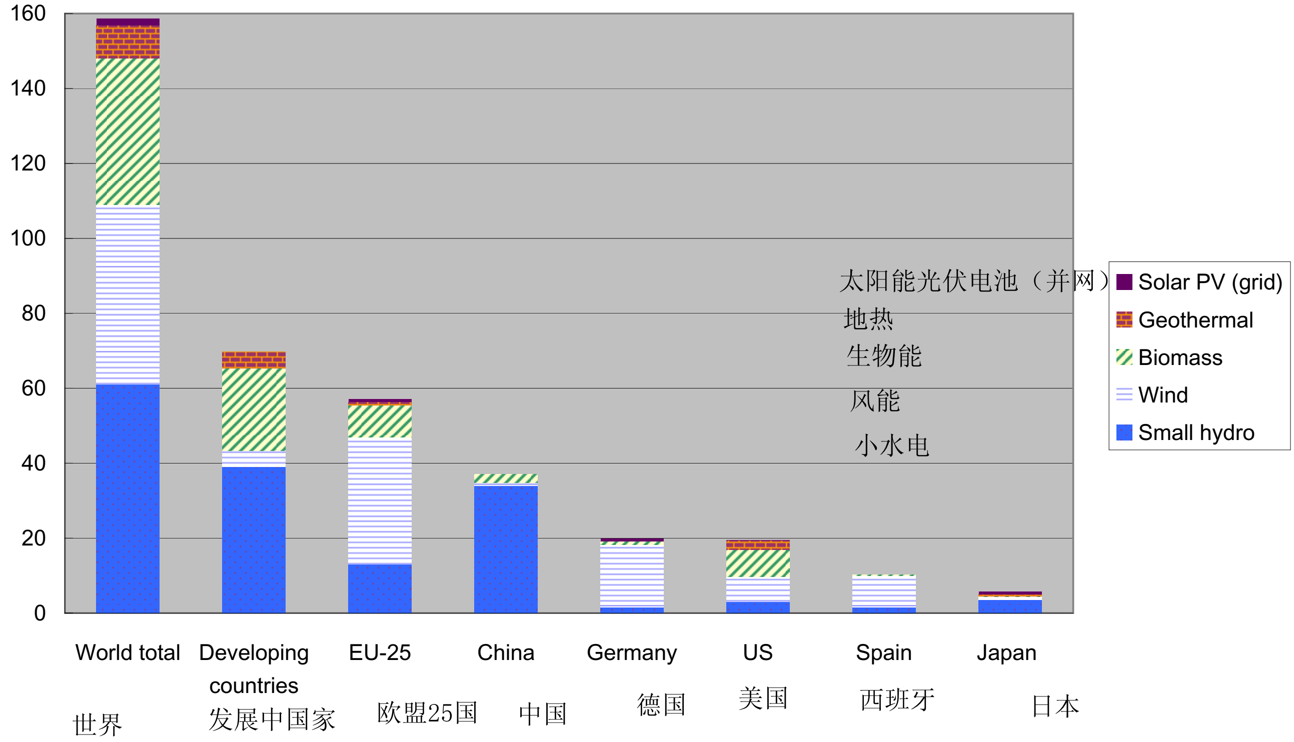


图6：2004年风能容量前10名国家（MW）

Figure 6: Wind Power Capacity, Top 10 Countries, 2004 (MW)

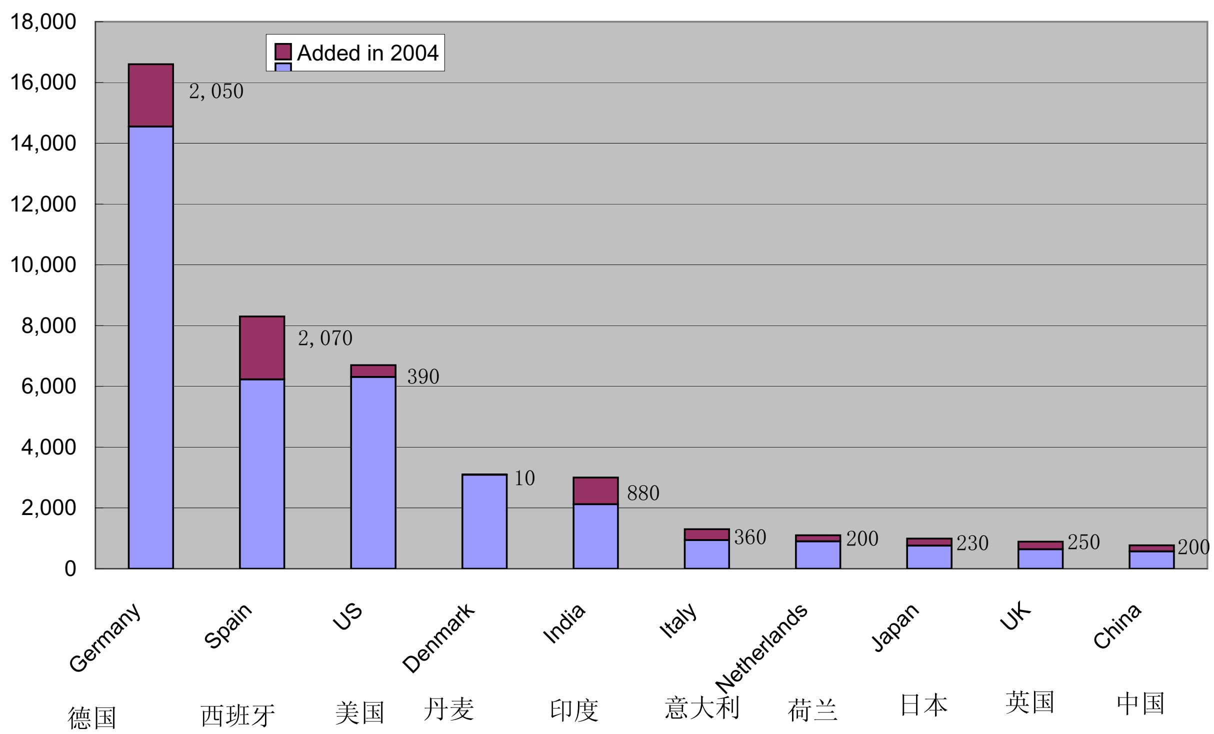


图7：2004年太阳能热水器/供热容量（总容量＝77GWth）

Figure 7: Solar Hot Water/Heating Capacity Existing in 2004
(Total = 77 GWth)

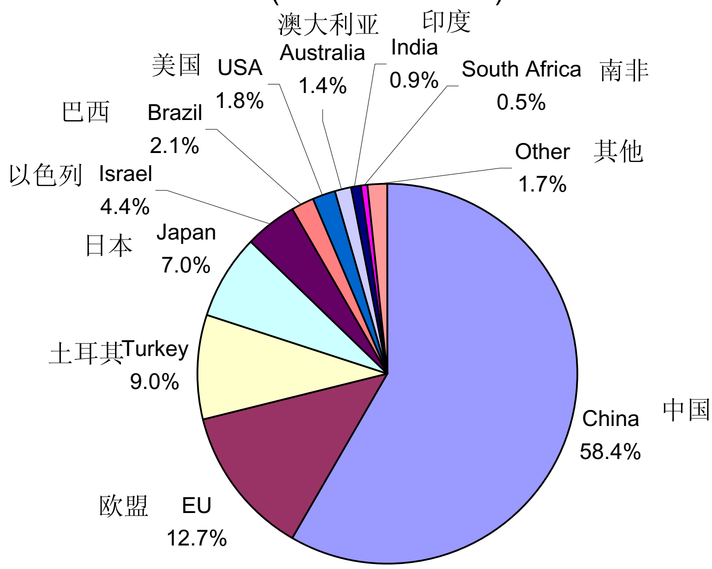
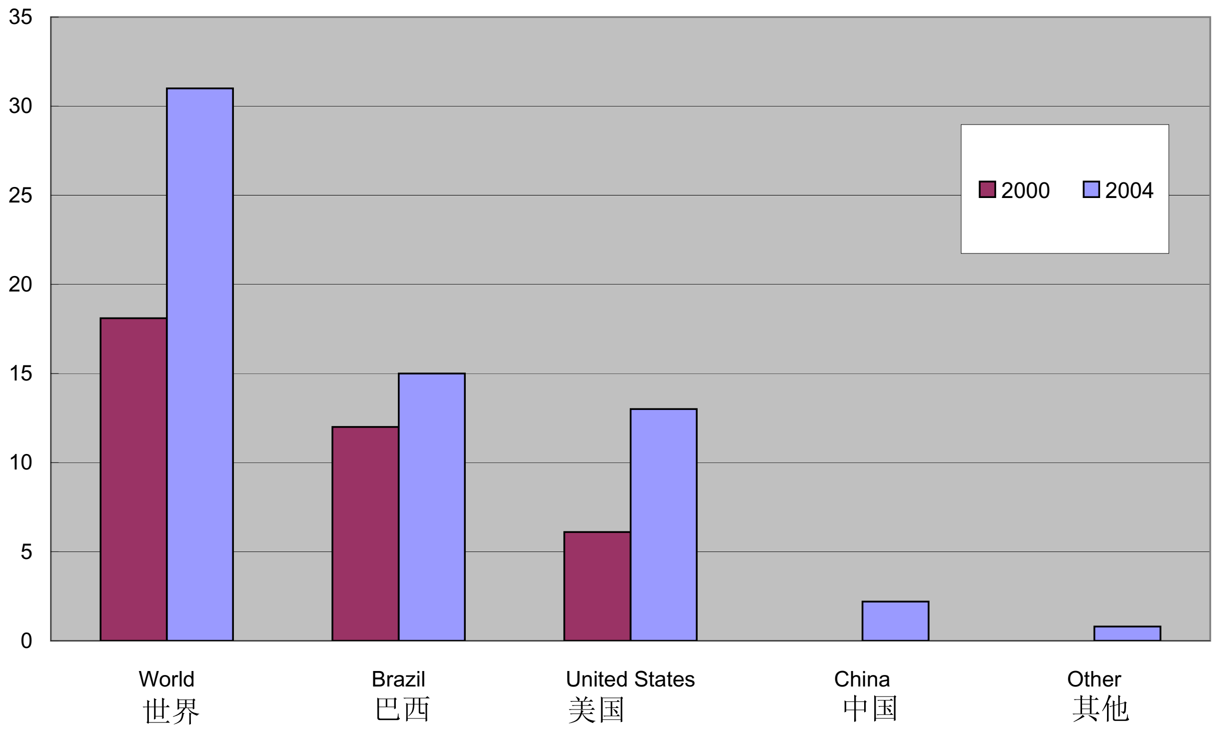


图9：2000年和2004年燃料乙醇生产量（10亿升/年）

Figure 9: Fuel Ethanol Production, 2000 and 2004 (billion liters/year)



2. 投资状况

2004 年，约有 300 亿美元投向可再生能源扩容及安装(见图 10)。 除此以外，2004 年太阳能光伏制造企业投资 40～50 亿美元用于建设新的工厂及购买设备，至少数亿美元投向乙醇产业用于建设新的工厂。而全球每年在发电领域投资约 1100～1500 亿美元，因此可再生能源投资额占世界电力领域投资额的 20～25%。的确，国际能源机构在其最近的“世界能源投资展望”中预测在未来的三十年中 OECD 国家至少三分之一的发电投资是可再生能源。可再生能源年投资额自 1995 年的约 70 亿美金稳步增长。2004 年，风力发电投资额约为 95 亿美元，太阳能光伏投资额为 70 亿美元，小水电投资额为 45 亿美元，太阳能热利用投资额为 40 亿美元，地热和生物质发电/供热的投资额为 50 亿美元，除此以外每年有大约 200～250 亿美元投资于大型水电。[注 12]

目前可再生能源投资来自从公共到个人的多种渠道。从千亿美元风电厂的商业投资到家庭规模的小额贷款，投资得益于可再生能源技术的标准化及金融从业人员对可再生能源的认可和熟悉。最近的趋势之一是大的商业银行开始注意到可再生能源的投资机会。这些大型银行，即所谓的“主流可再生能源投资机构”的代表有 HypoVereins Bank, Fortis, Dexia, Citygroup, ANZ Bank, Royal Bank of Canada,和 Triodos Bank, 他们均活跃于可再生能源投资领域。 过往对可再生能源投资不甚感冒的传统电力公司现也逐渐成为“主流”。活跃于可再生能源投资的电力公司有：法国电力、美国佛罗里达电力及照明公司、苏格兰电力及西班牙的 Endesa 公司。*

其他大型投资者也正在进入可再生能源市场，包括业界领先的投资银行。主流的投资团体越来越相信可再生能源是一个重要的商业机会。例如，摩根士丹利公司投资西班牙的风电厂项目，高盛银行，世界最大的投资机构之一，收购了 Zilkha 可再生能源公司（美国一家正在开发 4 兆瓦风机的风能开发公司）。GE 的商业及消费者金融支持机构也开始了可再生能源投资。商业再保险机构正在针对可再生能源开发新的保险产品。

风险资金投资者也开始注意到可再生能源。2004 年风险资金大约投资 10 亿美元于美国清洁能源技术公司。尤其要指出的是，从 2001－2004 年太阳能光伏的风险投资及权益投资每年都有 100％的增长。驱使风险资金投资可再生能源部分是由于其未来的市场前景，有资料显示在 2010－2014 年期间太阳能光伏和风能市场将增至 400～500 亿美元。[注 13]

公立银行机构融资对刺激私人投资及行业积极性起到了非常重要的作用。欧洲投资银行是为可再生能源提供融资的首要公立银行机构，在 2002－2004 三年间，每年平均提供 6.3 亿美元的融资额（几乎是欧盟所有的项目）。欧洲投资银行计划在 2002－2007 年期间加倍其对能源领域中可再生能源的贷款，从 7% 到 2007 年时的 15%。银行同时计划在 2008－2010 年对可再生能源发电的贷款增至欧盟新装机容量总投资额的 50%，高于现在的 15%的比例。[注 14]

近几年在发展中国家为新的可再生能源进行的多边、双边及其他公共融资几乎每年都达到 5 亿美元。这些资金很大一部分用于支持培训、政策开发、市场促进、技术援助和其他非投资需求。最大的三个资金来源是德国复兴银行（KfW）、世界银行集团（WB）和全球环境基金（GEF）。2004 年 KfW 批准了大约 1.8 亿美元用于可再生能源，包括来自公共预算基金的 1 亿美元和来自市场基金的 8 千万美元。世界银行承诺在 2002－2004 三年内平均每年向新兴可再生能源投资 1.1 亿美元。†GEF 则为 2002－2004 年可再生能源共同投资项目分配了年均 1 亿美元，这些项目都是由世界银行、联合国开发署（UNDP）、联合国环境规划署（UNEP）及其他一些机构共同实施的。间接的或联合的私人融资经常与来自这些机构的公共融

*此报告不包含碳基金或清洁发展机制（CDM）项目。以后的版本有望出现这些融资手段。在几个国家都有将这些用于可再生能源融资手段进行一体化的计划，并且都建立了行政制度和程序。

†世界银行对新能源可再生能源的融资加上 GEF 每年对世界银行项目的 4500 万美元的共同投资将使世界银行/GEF 融资总量达到每年 1.55 亿美元以上。世界银行也许诺 2002－2004 三年间平均每年向大水电投入 1.7 亿美元（不计 GEF），这样世界银行/GEF 对所有可再生能源的年融资额将超过 3.25 亿美元。

资相当，甚至数倍于此，很多项目也明确地被策划为鼓励私人投资。 此外，受援国家的政府也为这些开发项目提供了部分资助。[注 15]

其他的公共融资来源包括双边援助机构、联合国机构和受援国家政府。一些机构和政府每年对可再生能源（一般）提供 500～2500 万美元的资助，其中包括亚洲开发银行（ADB），欧洲复兴开发银行（EBRD），美洲开发银行（IDB），联合国开发署（UNDP），联合国环境规划署（UNEP），联合国工业发展组织（UNIDO），丹麦（Danida），法国（Ademe and FFEM），德国（GTZ），意大利，日本（JBIC）和瑞典（SIDA）。这些捐助者中有的正在建立结合额外私人资金的专用投资基金和贷款。[注 15]

这些公共投资在过去几年相对比较稳定，但最近许多组织承诺未来几年将增加投资总额。2004 年在德国波恩可再生能源大会上，170 个国家通过的《波恩行动计划》包含了许多政府、国际组织和非政府组织对将来的承诺（见工具栏 1）。同时，德国政府承诺 5 年内向 KfW 提供 5 亿欧元用于发展中国家的可再生能源和能源效率。同样是在 2004 年，世界银行承诺 5 年内将用于新兴可再生能源和能源效率的投资额翻倍，这意味着可再生能源每年又增加了 1.5 亿美元的投资。欧盟同约翰内斯堡可再生能源联盟一起建立了一个“全球可再生能源母基金”用于提供长期投资资金，最初的融资额大概在 7500 万欧元。

工具栏 1: 国际背景下的波恩行动计划

一个对 2004 年通过的波恩行动计划的分析给出了 5 个关于计划内容的关键指标。以下是这些指标同全球现状的比较。

指标	波恩行动计划内容	全球现状 (2004)
1.装机容量	增加 163GW 可再生能源发电	现有的可再生能源装机容量是 160 GW，加上 720 GW 的大型水电
2. 投资	意味着 3260 亿美元的总投资	全球可再生能源的投资为300 亿美元，加上 200–250 亿美元的大型水电的投资
3. CO_2 减排	意味着到2015 年二氧化碳每年的减排量为12 亿吨	可再生能源减少二氧化碳的排放量为9 亿吨/年，加上大型水电减少37 亿吨/年的 二氧化碳排放量
4. 捐赠资金支持	捐赠资金占投资总额的16%，即约 520 亿美元	5 亿美元/年流入发展中国家
5. 农村电力情况	签署MDG 目标，即到2015年，将有10亿人可得到可再生能源的服务	数千万农村家庭得到了小水电的服务，1600 万使用沼气，200 万拥有太阳能家庭照明，还有很多家庭受益于生物质气化技术

发展中国家当地的再生能源融资渠道在国际开发机构深入到省时，也就发展起来了。捐赠者和市场促进者越来越重视帮助扩大当地可再生能源融资渠道并寻找减轻私人投资者投资风险的途径。最好的例子就是印度可再生能源开发机构（IREDA）。它自 1987 成立以来，为 2.5GW 的可再生能源提供了将近 15 亿美元的融资。在农村，孟加拉的 Grameen Shakti 作为一个户用太阳能系统信贷和销售的地区承包者，也是最好的例子之一。还有很多其他的例子：乌干达发展银行借助 Shell 基金会的支持提供农村微型贷款；UNEP、联合国基金会和 E+Co 正在通过农村能源企业开发计划（REED）为非洲、巴西和中国的中小规模可再生能源项目进行融资；Triodos 银行的“可再生能源发展基金”为亚洲和非洲的可再生能源企业家提供了种子基金、贷款和商业发展支持；2003 年，印度最大的商业银行中的两家 Canara 和 Syndicate 银

行连同他们的地区合作银行开始为农村家庭使用可再生能源提供千元贷款，两个州的 2000 个支行从始至终地参与了活动。总之，针对家庭和商业金融服务的能力建设已经被许多机构优先考虑。

这些融资渠道通过许多其他的行业协会、非政府组织、国际合作者、网络以及私人基金会的努力会得到扩张和促进。这些“市场促进组织”有数百个之多并且在世界上和地方上都很活跃。（见注 45 以获取这些机构的网站列表）以下是五个国际合作伙伴：全球农村能源合作伙伴（GVEP)、可再生能源和能源效率合作伙伴(REEEP)、全球能源可持续发展网络 (GNESD)、 UNEP 可持续能源资助计划和 REN21 可再生能源政策网络。

美国和欧洲2004 年对可再生能源的政府支持在100 亿美元的量级。这些支持有多种形式，“预算内”的支持包括像研发基金机制、直接投资、资本成本补贴、课税扣除和出口退税等形式。*研发是预算内支持的重要一部分。1999－2001年期间，国际能源机构成员国每年平均共有7.3亿美元投入研发。“预算外”的支持包括基于市场的激励和调节机制，这些支持不会影响政府预算（例如，强制上网政策和可再生能源配额制)。欧洲环境署估计欧洲在2001年至少为可再生能源提供了8亿美元的预算内支持和60亿美元的预算外支持。预算外支持的一大部分归因于强制上网，同时还有采购义务和竞争性投标等其他形式。美国1999年对可再生能源的联邦预算内支持是11亿美元，包括7.2亿美元的联邦乙醇减免税和3.3亿美元的研发利用。2004年研发利用的开支降低了但乙醇免税增加至17亿美元，连同产品课税扣除（另有2亿美元），每年的预算内支持超过了20亿美元。美国州立政策和计划可以另外增加10亿美元或更多，包括公共受益基金每年提供的约3亿美元（预算外）。和这些数字相比，联合国和国际能源机构建议的全球基础上的化石燃料的能源补贴/支持在每年1500～2500亿美元，而核能大约是每年160亿美元。[注16]

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*出口信用以前很少应用于可再生能源，但是现在形势改变了。经济合作组织最近决定给予可再生能源特别的待遇，即在经济合作组织内部正式支持出口信用，包括延长还款期限从 12～15 年。这个特殊的待遇可以帮助出口信用机构同其他参与发展中国家可再生能源项目的资金协调一致，潜在地增加出口信用机构在可再生能源领域地投资。

图10：1995-2004年可再生能源年投资量（10亿美元）

Figure 10: Annual Investment in Renewable Energy, 1995-2004 (billion dollars)

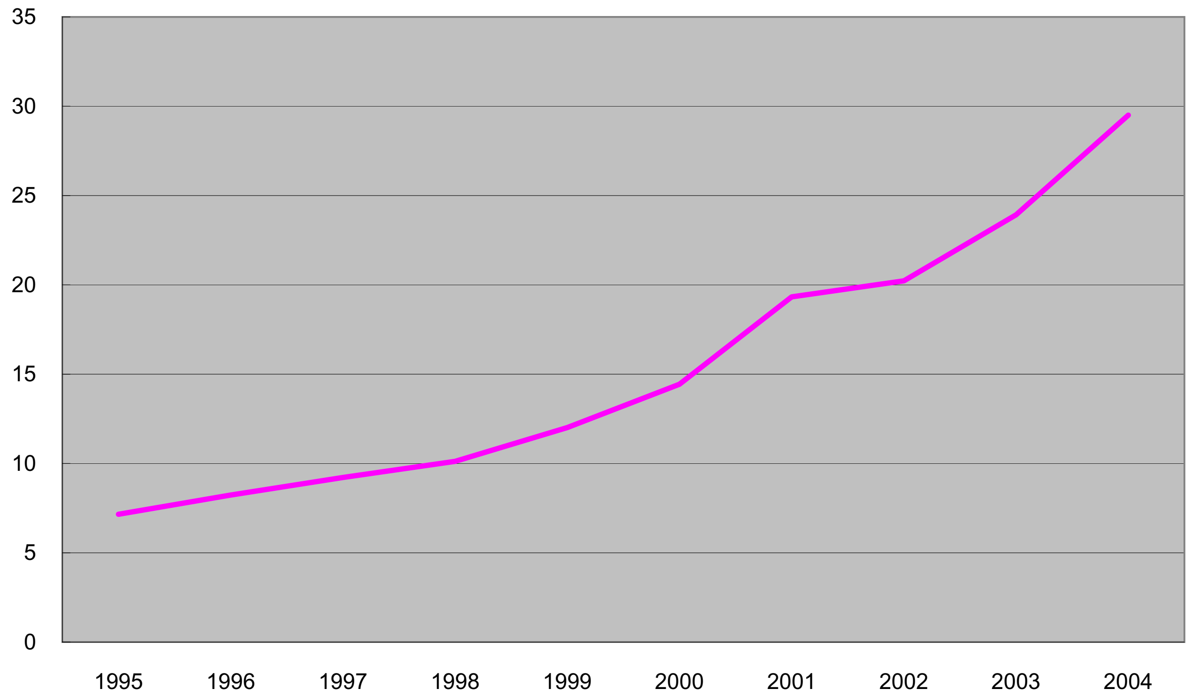
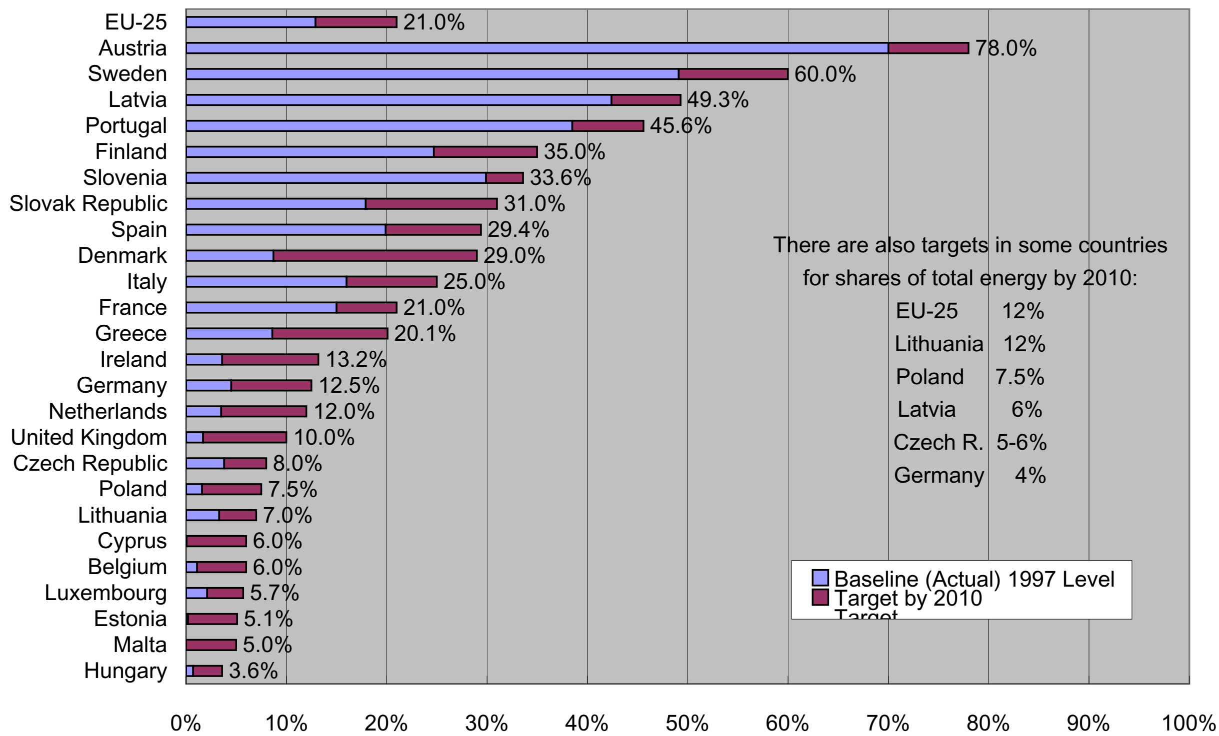


图11：欧盟可再生能源发展目标——2010年发电份额

Figure 11: EU Renewable Energy Targets -- Share of Electricity by 2010



3. 工业发展趋势

这些投资走向说明可再生能源现在已经成为一个很大的产业。全世界范围内，至少有 60 家可再生能源上市公司或者大型公司的可再生能源部门 2005 年的市值已经超过了 4000 万美元，据估计，这些公司和部门的总市值已经超过 250 亿美元。除了这些公司，排名在前 100 位的的可再生能源公司和部门的总市值也达到数十亿美元。光伏正在成为世界上增长速度最快，收益最多的一个产业。2005 年预计投资约 50~70 亿美元，在 2005－2008 年期间产能将增加数百兆瓦。[注 17]

世界上最大的工业巨头开始进入风能市场，这个市场以前完全由专门制造风机的公司占据，这恰恰证明可再生能源已经成为一个很大的产业。电气设备公司，如通用和西门子即是近年来进入风能市场的杰出代表，进入方式都是并购 (通用在 2003 年收购了美国的 Enron Wind 公司，西门子在 2004 年收购了丹麦的 Bonus 公司)。而在中国，5 家最大的电气、航空和发电设备公司在 2004 年开始发展风机技术。他们已经和国外公司签订了四份技术转让合同，并且计划在 2005 年生产出他们第一个风机原型。这些工业巨头的加入，显然会在金融、销售和生产规模等方面带来新的竞争，同时也会增加这些的技术的可信度。

2004 年，风电工业生产了超过 6000 台风机，平均功率达到 1.25 兆瓦。排在前六位的生产厂家分别为：Vestas (2004 年和丹麦的麦肯公司合并)、 Gamesa (西班牙)、Enercon (德国)、通用能源 (美国)、 西门子 (2000 年和丹麦 Bonus 公司合并)和 Suzlon (印度)。在中国，金风和西安维德是两个主要的风机生产厂家，分别占据中国风机市场的 20%和 5% (进口占 75%)。风机规模的扩大，体现了全球工业的进步。从 1995 到 2004 年，风机的平均功率从原来的 500 千瓦增大到 1300 千瓦。美国和欧洲现已能生产 1000 千瓦到 3000 千瓦规模的风机，欧洲的生产厂家甚至能生产出 5000 千瓦的风机原型。但在印度和中国，风机规模仍停留在 600 千瓦到 1000 千瓦。风机产业中，制造规模更大的风机仍然是首要的技术。产业界也不断在材料、电子、叶片和发电机设计以及优化安装位置等方面开发创新，这些创新为进一步降低成本提供了可能 [注 18]。

光伏产业在 1999 年曾为总产量达到 1GW 而欢欣鼓舞，但在 5 年后的 2004 年年底，光伏产业累计产量已经翻了四番，突破了 4GW。2004 年，全球总产量持续快速增长，年产量已超过 1100MW。根据大型生产厂家发布的计划，2005 年全球产能至少增加 400MW，随后的三年(2006－2008)将再增加数百兆瓦。2004 年全球前三位的生产厂商分别为：Sharp、Kyocera 和 BP Solar (但大量厂家的产能增长迅猛，排名因此每年都有改变) 。[注 19]

中国和其他发展中国家也逐渐成为光伏产业的重要参与者。在光伏产业中，2004 年中国组件产能翻倍，从原来的 50 兆瓦到现在的 100 兆瓦；电池片产能增加到 70 兆瓦。而且从发布的工业计划看，2005 年产能将再次翻倍。印度有 8 个电池片生产厂家，14 个组件生产厂家。Tata BP Solar 作为印度主要的光伏生产厂家，产能从 2001 年的 8MW 增至 2004 年的 38MW。菲律宾的 Sun Power 公司计划在 2004 年将电池片产能翻倍，增加至 50MW。泰国的 Solartron 公司发布计划要在 2007 年使电池片产能达到 20MW。纵看整个产业，设计和工艺的改进，还有大规模的生产，都会进一步的降低成本。

和风能和光伏相比，生物质发电和供热以及小水电产业已非常成熟，本地化和多样化程度较高。投资生物质发电、供热多是木材厂、造纸厂和糖厂等产生生物质能源资源的厂家。欧洲继续保持着小水电领域的主导地位，近些年则特别关注对现存电厂的升级和更新。低落差(低于 15 米)和小容量(小于 250 千瓦)发电是目前小水电主要需改进的技术。中国生产小水力发电机的厂家至少有 500 家，与之形成鲜明对比的是，控制世界地热能工业的却只有五家大公司(Ansaldo、Fuji、Mitsubishi、Ormat 及 Toshiba)。 [注 20、21]

全球乙醇工业的中心在巴西和美国。2004 年，巴西生产乙醇的制糖厂/酿酒厂超过 300 家，2005 年年初，又有 39 家新的酿酒厂注册。美国 2004 年有 12 家新的乙醇生产工厂建成，总数已经达到 80 家。同时 2004 年还有 16 家新的工厂开始动工。2005 年，德国和美国的几个大的乙醇生产工厂也开始投产。巴西已成为主要的乙醇出口国，2004 年出口占世界乙醇交易量的一半。欧盟也有可观的生物质燃料(乙醇和生物柴油)贸易量。其他几个国家也在计划发展它们的乙醇工业。 [注 22]

每年，可再生能源产业的各个环节日益完善。例如，小风机制造厂家提供更易装配、并具有太阳能以

及其他技术互补接口的产品。离网光伏产业开始开发用于太阳灯和户用系统的标准“即插即用”包。有些公司正在开发互补系统打包。例如，一个美国公司将光伏和小风机在集装箱里进行组合，配上先进的电池和控制，从而提供完全预封装系统。通过将更完善的控制系统、性能监测和通信都集成到系统里，使其实现更好的耗电计量和更完善的记帐付费机制。

可再生能源产业持续快速增长，2004 年，全世界由可再生能源提供的制造、操作和维护等直接工作机会已超过 170 万，其中 90 万来自生物质燃料产业。其提供的间接工作机会更是几倍于此。这只是粗略估计，因为只有少数产业和国家发布了相关统计。这些统计包括：巴西乙醇产业的 40 万，中国太阳能热水产业的 25 万，德国全部可再生能源的 13 万，欧洲风能产业的 7.5 万和光伏产业的 1.5 万，美国光伏产业的 1.2 万，尼泊尔生物质燃气产业的 1.1 万，日本可再生能源的 3400 以及欧盟小水电的 2200。*[注 24]

* 文献中没有对全球可再生能源提供的工作机会的记载。注 24 有对此报告的详细分析，主要包括小水电、生物质发电，风电，地热发电，光伏，太阳能热水，乙醇和生物柴油，但是不包括地热和生物质采暖。

4. 政策规划

在上世纪 80 年代和 90 年代初，只有少数几个国家制定了相关政策促进可再生能源发展。但是在 90 年代后期和本世纪初，许多国家、州、省和城市都制定了相关的可再生能源政策。由前文可知，这些政策中很多都在市场发展中发挥了实际的作用。本节讨论现有的促进可再生发电，太阳能热水/供暖和生物质燃料的目标和政策，也讨论地方性政策和自愿绿电/定价。*

本报告不详细分析政策的影响和教训。尽管存在无数的制定和执行问题，不过政策文件清楚表明，这些政策还是主要影响可再生能源发展的速度和广度。国际能源机构在 2004 年关于 IEA 国家的市场和政策趋势的重大事件纪事中评述：市场的显著增长不是某个单一政策作用的结果，而是各种政策综合作用的结果；非常重要的还有政策支持的长期性、可预见性及当地、州/省以及有关的权力机构的积极参与；个别的政策机制要推广到国家级，积累更多的经验。IEA 认为，虽然旧政策有着宝贵的经验，但是因为大部分的政策都是在 2000 年后制定的，现在评估许多政策的作用为时尚早。

可再生能源的政策目标

全世界至少有 45 个国家制定了可再生能源的政策目标。在 2005 年中期，至少 43 个国家制订了支持可再生能源的国家级目标，其中就包含所有 25 个欧盟成员国(见图 11 和表 3)。欧盟也制定了其欧洲发展目标，即可再生能源达到总电力的 21%，总能源的 12%。除了这 43 个国家，美国的 18 个州(包括哥伦比亚特区)和加拿大的 3 个省也制定了基于可再生能源配额制的目标(尽管美国和加拿大都没有一个全国性的目标)，加拿大的另外 7 个省也正在制定它们的目标。大部分的国家目标都是关于可再生发电所占份额，一般这个份额范围是 5~30%，全球各个国家实际所占电量份额从 1%到 78%不等。有的目标是包括供暖在内的占总的一次能源供应的份额，或具体的装机容量，或可再生能源的总产量。这些目标大部分都定在 2010–2012 期间实现。 [注 25]

在 43 个制订了国家级目标的国家中，有 10 个是发展中国家：巴西、中国、多米尼加共和国、埃及、印度、马来西亚、马里、菲律宾、南非和泰国。一些其他发展中国家不久也将发布他们的目标。中国的目标是到 2010 年，可再生能源占发电总装机容量的 10% (不包括大水电)，这意味着 60GW 的可再生能源装机容量。中国 2020 年的目标是可再生能源占一次能源的 10%，占发电装机容量的 12.5%，2 亿 7 千万平方米太阳能热水器集热面积以及风电和生物质发电装机容量达到 20GW†。泰国的目标是到 2011 年可再生能源占一次能源的 8%(不包含传统的生物质能)。印度预期到 2012 年增加 10%的发电装机容量，或者至少 10GW 的可再生能源‡。菲律宾设定的目标是到 2013 年可再生能源达到 5GW 的总装机容量，或者是现有容量的两倍。南非 2003 年设定的目标是到 2013 年来自可再生能源的发电量增加 10TWh，大概为总装机容量的 4%。墨西哥立法部门正制定一个新的关于可再生能源的法律，其中将包含可再生能源的国家目标。

* 本节旨在说明全面的政策规划。列举的政策通常应该已经由立法机关颁布。有些列举的政策可能还没有开始执行，或者需要详细的执行规则。掌握所有的政策显然太困难了，所以有些政策可能无意中遗漏了，或者列举的不正确。有些政策已经废止，或者刚刚颁布不久。在网页注记中会对此节及时的更新，那会包含更多的政策细节。

† 可再生能源发展计划草案中介绍了中国的目标，这个草案正在等待政府的批准。但在 2004 年 6 月德国波恩的 2004 年可再生能源大会上已经公开宣布了中国的目标。2005 年 2 月制定的中国可再生能源法需要政府在 2006 年 1 月公布包括目标的可再生能源发展计划后才能实行。

‡ 印度国家目标是一个计划性或指导性的目标，但未得到法律的支持。.

表 3：非欧盟国家的可再生能源目标

国家	目标
澳大利亚	到 2010 年达到每年 9.5 TWh
巴西	到 2006 年风能，生物质能和小水电增加 3.3GW
加拿大	4 个省的目标是达到总电力的 3.5%~15%，6 个省实行其它形式的目标
中国	到 2010 年达到发电装机容量的 10%(预期 60GW)，到 2010 年达到一次能源的 5%，到 2020 年达到一次能源的 10%
多米尼加共和国	到 2015 年达到 500MW 的风电装机容量.
埃及	2010 年达到总电力的 3%，2020 年达到 14%
印度	在 2003 到 2012 年间增加 10%发电装机容量(期望值为 10GW).
以色列	2007 年达到总电量的 2%，2016 年达到总电量的 5%
日本	2010 年达到总电量的 1.35%，包括地热能和大水电(RPS)。
韩国	包括大水电，2010 年达到电力的 7%，2011 年达到 (0.3GW)的 1.3GW 的在网光伏，包含 100,000 家家庭型。
马来西亚	2005 年达到总电量的 5%。
马里	2020 年达到总能源的 15%。
新西兰	2012 年总装机容量增加 30PJ(包括加热和交通燃料)。
挪威	2010 年集热和风能达到 7TWh。
菲律宾	到 2013 年具有 4.7GW 总容量。
新加坡	2012 年达到 50,000m^2(~35MWth)的太阳能集热面积.
南非	2013 年增加 10TWh 最终能源。
瑞士	2010 年达到 3.5TWh 的电力和集热。
泰国	2011 年占总的一次能源的 8%(包括传统的乡村生物质能)。
美国	在 20 个州占总电力的 5%到 30%(包含 DC)。

发电促进政策

全世界至少有 48 个国家(34 个发达或过渡性国家和 14 个发展中国家)制订了若干形式的可再生能源发电促进政策(见表 4)。最常见的现有政策是分类电价法，近几年许多新的国家和地区都颁布这个法令。1978 年，美国第一个颁布了全国分类电价法(PURPA)(一些州积极实施 PURPA，但是在 90 年代大部分都废止了)。90 年代初，丹麦、德国、希腊、印度、意大利、西班牙和瑞士相继采用分类电价政策。到 2005 年，至少 32 个国家和 5 个地区/省采用了这个政策，其中有一半国家和地区是 2002 年颁布的(见表 5)。

表 4：促进可再生能源政策

国家	分类电价	可再生能源配额制	资金补助，赠款或优惠	投资减免，或其它减免措施	减少收购税,能源税或者 VAT 税	可交易的可再生能源证书	能源产品补偿或减税	净流量	公众投资，贷款或融资	公开竞价
发达国家和过度国家										
澳大利亚		X	X			X			X	
奥地利	X		X	X		X				
比利时		X	X	X		X		X		
加拿大	(*)	(*)	X	X	X			(*)	X	(*)
塞浦路斯	X		X							
捷克	X		X	X	X	X		X		
丹麦	X			X		X		X		
爱沙尼亚	X				X					
芬兰			X		X	X	X			
法国	X		X	X	X	X			X	X
德国	X		X	X	X				X	
希腊	X		X	X						
匈牙利	X				X	X			X	
爱尔兰	X		X	X		X				X
意大利		X	X	X		X		X		
以色列	X									
日本	(*)	X	X			X		X	X	
韩国	X		X		X					
拉脱维亚	X								X	
立陶宛	X		X	X					X	
卢森堡公国	X		X	X						
马耳他					X					
荷兰	X		X	X		X	X			
新西兰			X						X	
挪威			X	X		X				X
波兰		X	X		X				X	X
葡萄牙	X		X	X	X					
斯洛伐克	X			X					X	
斯洛文尼亚	X									
西班牙	X		X	X					X	

瑞典	X	X	X	X	X	X	X			
瑞士	X									
英国		X	X		X	X				
美国	(*)	(*)	X	X	(*)	(*)	X	(*)	(*)	(*)
发展中国家										
阿根廷			X				X			
巴西	X								X	
哥伦比亚			X							
中国	X		X	X	X				X	X
哥斯达黎加	X									
危地马它				X	X					
印度	(*)	(*)	X	X	X				X	X
印度尼西亚	X									
墨西哥				X				X		
尼加拉瓜	X			X						
菲律宾				X	X				X	
斯里兰卡	X									
泰国	X	X	X					X		
土耳其	X		X							

注: (a)表中只包含已颁布的政策。但是，因为具体的执行措施还没有建立或者生效，有些政策还没有执行或者没产生作用。(b)加了(*)号的表示在这个国家只有有州/省级的政策，还没有全国性的政策。(c)表中的有些政策不仅仅应用在发电，还应用于其它市场。(d)表中忽略已废止的政策，例如挪威 2003 年废止对风能的分类电价政策，丹麦 2002 年废止的资金补贴政策和比利时 2003 年废止的分类电价政策(Green Frank system)。(e)有几个非洲国家执行补助政策支持小型乡村光伏(还有小水电)，包括马里、塞内加尔、坦桑尼亚和乌干达。南非给现在发展停滞不前的光伏技术制定了乡村能源特许服务的补助政策。(f)几个发展中国家正在计划制定可再生年能源发展战略和/或预期不久将颁布新的补充政策，包括阿尔及利亚、亚美尼亚、哥伦比亚、埃及、危地马拉、约旦、马其顿王国、墨西哥、秘鲁、南非、越南和也门。

发展中国家中，印度第一个建立了分类电价政策，接着是斯里兰卡和泰国(仅对小规模发电)、巴西、印度尼西亚和尼加拉瓜。因为 2003 年印度需要新的地方性政策(旧的分类电价政策在 90 年代渐渐废止了)，所以 2004 年，印度的三个地区采用了新的分类电价政策。2005 年上半年，中国、爱尔兰、土耳其和美国的华盛顿颁布了各自的分类电价政策。中国的分类电价政策是 2005 年 2 月颁布的促进可再生能源的综合法律的一部分。[注 26、27]

在过去的几年里，特别是在德国、西班牙和丹麦等国家，分类电价政策明显的带动了创新，提高了投资者的兴趣，增加了投资。例如，在分类电价法的带动下，德国符合规定的可再生能源发电 2004 年比 2000 年增加了一倍多，分别是 37TWh 和 14 TWh。在有些国家，分类电价政策对风能产生的影响最大，同时也影响着生物质能和小水电的发展(大部分法律限定了适用的水电的最大规模，例如德国是 5MW)。就在最近，西班牙的分类电价政策给新的太阳能热发电的投资计划提供了很大的帮助(预期决定在 2005 年建成两个 50MW 的电厂)。

表 5：颁布了分类电价政策的国家/州/省的总数

年份	国家/州/省的总数	该年新增的国家/州/省
1978	1	美国
...		
1990	2	德国
1991	3	瑞士
1992	4	意大利
1993	6	丹麦，印度
1994	8	西班牙，希腊
1995	8	
1996	8	
1997	9	斯里兰卡
1998	10	瑞典
1999	13	葡萄牙，挪威，斯洛文尼亚
2000	14	泰国
2001	16	法国，拉脱维亚
2002	20	奥地利，巴西，捷克，印尼立陶宛
2003	27	塞浦路斯，爱沙尼亚，匈牙利，韩国，斯洛伐克，马哈拉施特拉(印度)
2004	33	意大利，以色列，尼加拉瓜，爱德华王子岛省(加拿大),安得拉邦省和中央邦省(印度)
2005 (上半年)	37	土耳其，华盛顿(美国)，爱尔兰，中国

各个国家的分类电价政策各不相同，有些政策仅仅应用于特定的技术或者最大容量的发电技术。大部分政策通常根据发电的成本，对不同的技术制定不同的返税，比如离岸风电和在岸风电的政策就不尽相同。有些政策也区分位置/地区，电厂运转的年份和当年的季节。对于某一电厂的返税会随着时间减少，一般持续 15~20 年。有些政策提供固定的返税，但是其他的政策根据市场或成本相关的返税提供固定的补贴(或者两种政策同时实行，例如西班牙)。

在美国、加拿大和印度，可再生能源配额政策(RPS)正在推广到地方/省级(见表 6)。至少 32 个地区或省已经颁布了 RPS 政策，有一半地区是从 2003 年开始颁布的。2004-2005 年，美国有 8 个州颁布了 RPS 政策，使美国施行 RPS 政策的州达到 20 个。同样，在 2004–2005，印度有 5 个州颁布了 RPS 政策，使印度实行 RPS 政策的州达到 6 个(印度 2003 年的电力法规定印度的州可自己设定电力占可再生能源的最小的份额)。加拿大有三个省在实行 RPS 政策(更多其他的省正在制定目标)。上述的大部分 RPS 政策要求可再生电力所占份额范围为 5~20%，一般要求于 2010–2012 年间实现。现在大部分的 RPS 政策的目标都转变成吸引更多的未来投资。有研究表明美国现有的州立 RPS 法律要求到 2020 年增加 52GW 的可再生能源，这是其现在可再生能源的两倍多*[注 28]

* RPS 的比例高低不应与投入力度或努力程度相关联，因为有些州/省已经很接近他们的目标，但是其它有些地方却离他们的目标很远。更进一步的是，有些 RPS 政策对符合要求的合格水电制定了上限。参见注 25 有关单个国家的要求的百分比或容量目标的列表。

表 6：颁布了 **RPS** 政策的国家/州/省的总数

年份	国家/州/省的总数	该年新增的国家/州/省
1997	1	马萨诸塞州(美国)
1998	3	康涅狄格州，威斯康星州(美国)
1999	7	缅因州，新泽西州，得克萨斯州(美国)，意大利
2001	12	亚利桑那州，夏威夷，内华达州(美国)，佛兰德斯(比利时)，澳大利亚
2002	16	加利福尼亚，新墨西哥(美国)，瓦龙(比利时)，英国
2003	20	明尼苏达州(美国)，日本，瑞典，马哈拉施特拉(印度)
2004	34	科罗拉多州，马里兰，纽约，宾尼法尼亚, 罗德岛(美国); 新斯科舍，安大略湖，爱德华王子岛省(加拿大), 中央邦省，马哈拉施特拉省，安得拉邦省，奥里萨邦(印度)，波兰，泰国
2005	38	哥伦比亚特区，蒙大纳，特拉华(美国)，古吉拉特(印度)

全球有六个国家同时在 2001 年实施 RPS 国家政策。澳大利亚的 RPS(2001)政策要求电力公司每年提交一定数量的可再生能源证书(2004 年达到要求产电的 1.25%，或者大约 2600GWh 的总电量)。这些要求每年都会有所调整，但最终要在 2010 年达到 9500GWh 的国家目标。英国的 RPS 政策(2002)要求到 2010 年达到总电量的 10%，在 2015 年达到 15%，直到 2027 年。日本的 RPS(2003)政策同样要求电力公司提供一定的比例，这个比例将随着时间增长，并在 2010 年达到总电量 1.35%。瑞典的 RPS(2003)政策要求消费者或者供电者通过购买电力或者购买可再生能源证书完成指定份额，该份额将逐年增长(瑞典对违规者按照平均认证价格的 150%进行惩罚)。波兰的 RPS(2004)政策要求在 2010 年达到总电量的 7.5%。泰国的 RPS (2004)政策要求新增的产能中 5%是可再生能源。*

现今可再生能源发电的政策支持存在许多形式，如直接的投资补贴或者优惠、税收激励和减免、销售税和 VAT 税的免除，直接产品支付或者减税(按每 kWh)、绿色证书交易、净流量、直接公共投资或融资和定量发电公开竞价(见表 4)。目前至少有 30 个国家提供各种形式的投资补贴、赠款或者优惠。其他财政支持的方式通常还包括税收鼓励和减免，美国大多数的州和其它至少 32 个国家都为可再生能源提供税收鼓励和减免的政策。

一些国家正在实行发电量支付或减免税政策。这方面美国联邦实行的生产税减免政策做的尤为突出。从 1995 年到 2004 年，超过 5400MW 的风电装机容量受益于减免税政策。随通货膨胀，1994 年开始是 1.5 美分/kWh 的减税随着时间增加，最终在 2005 年减税增加到 1.9 美分/kWh，其间还经历几次废止和再施行。现在施行的将在 2007 年终止。生产减税吸引了金融家在风电方面的兴趣，使风电成为美国近年来一个“主流”投资方向。其它实行生产激励政策的国家有芬兰、荷兰和瑞典。†

一些国家实行资本补贴、分类电价政策或两个政策同时实行(同时实行净流量政策)，来促进屋顶并网

* 表 3 和图 11 中的国家目标可以认为是“将要达成”，“计划中的”或“预计的”目标，但是并不代表对指定级别的电力公司或者消费者具有法律效力的国家 RPS 政策。

† 能源生产激励政策按单位产能(也就是 kWh)给生产者提供一定的费用，和分类电价政策很相像，有时候甚至就被称作分类电价政策。但是两者间还是有较大区别的，因为生产激励的资金来自电力附加费或者先前的税收。美国的生产税减免制度在某些定义中可以看成购电法。但我们这里使用的定义是：分类电价是与政府无关的收入，这种税收由大众用户自己直接支付(德国和西班牙的情况)，而不是通过专项税(荷兰的情况)或者已收税款(芬兰的情况).

光伏。这些政策无疑对近年来并网市场的迅速增长起了很大的作用。日本的屋顶光伏政策本定于 2005 年结束。其在 1994 年提供的资金补贴是 50%，到 2003 年下降到 10%左右，2005 年是下降到 4%左右。这些政策影响了 20 多万个家庭及 800 MW 的装机。德国现有超过 16 万家庭在其屋顶安装了太阳能光伏发电设备，总装机容量达到了 700MW。德国施行一种最低限价的分类电价政策，并为消费者提供低息贷款直至 2003 年。其它持续实行这种政策的地方还有加利福尼亚及美国一些其它州和其它几个国家(包括法国、希腊、意大利、韩国、卢森堡、荷兰、葡萄牙和西班牙)，他们提供投资补贴(一般为 30~50%)以及/或者利于电力购买的税制。韩国进行的“百万屋顶”计划预期到 2011 年屋顶光伏达到 300 MW，开始提供 70%的资本补贴，然后随着时间逐渐降低。包括匈牙利和泰国在内的几个国家已经宣布实行新屋顶光伏计划。[注 29]

有些国家或州/省已经建立了可再生能源基金用来直接进行金融投资，或提供低息贷款，或以其它方式如研究、教育、制定标准和投资公共设施等推动市场发展。该类基金最大者是美国 14 个州建立的“公共利益基金”。这些基金不仅用于可再生能源，还用于提高能源效率。基金的来源多种多样，最常见的是收取购电附加费。这 14 个基金在 1997—2001 年间开始启动，并且每年集资及花费在可再生能源上的款项超过 3 亿美元。预计在 2012 年他们将为可再生能源汇集超过 40 亿美元的资金。与这些基金的功能类似，印度可再生能源开发机构(IREDA)也提供贷款和项目融资。2005 年，中国的可再生能源法也呼吁建立一个这样的基金。墨西哥也考虑在 2005 年建立“绿色基金”，为可再生能源项目提供融资。[注 30]

全球至少有 7 个国家及美国 35 个州和加拿大若干省执行净流量政策。美国另外的四个州有一个或多个电力公司提供净流量服务。日本也施行一种基于自愿的净流量政策。该法律正在陆续被颁布施行：2004 年，美国又有六个州通过了净流量法。就在最近，一个 2005 年颁布的美国联邦法律要求所有美国电力公司必须在三年内提供净流量服务。净流量法在促进美国和日本并网光伏市场方面成效卓著。[注 30]

在 90 年代，英国开始使用可再生能源发电的特许权招标制度。现在实行这个制度的国家至少有以下七个：加拿大、中国、法国、印度、爱尔兰、波兰和美国。中国在 2003—2004 年间通过特许权招投标共建设了 850MW 的风电项目，并计划在 2005 年通过该方式建设共计 450MW 的项目。2004 年加拿大安大略省通过特许权招标建设了 1000MW 的风电项目，其它各省也开始采用此方式。而许多国家的电力公司也通过参与特许权投标以达到 RPS 的要求。 [注 31]

包括可交易可再生能源证书政策在内的其它政策，一般与自愿绿电购买政策或可再生能源配额制结合使用。至少 18 个国家有证书交易的模式和/或市场。许多其它规章制度手段，如建筑规范、监管规则和程序以及输电途径和定价等，在促进可再生能源发电方面也有重要作用。这些规章制度手段是走向未来可再生能源市场的途径之一，对发展中国家来说更是如此(例如，墨西哥和土耳其正在采取这种手段)。电力部门结构调整、碳排放税、矿物燃料税等方面的政策也会影响可再生能源的经济竞争力。

太阳能热水/加热促进政策

世界最大的太阳能热水器市场在中国，2004 年其已占全球市场的 80%。中国的国家目标是 2005 年达到 6500 万平方米的太阳能集热面积(2004 年几乎已经达到这个目标)，到 2015 年这个数字将增加到 2 亿 3 千万平方米。80 年代，太阳能热水器在小型村镇中开始应用。该市场主要由以下因素推动：热水的大量需求、经济性及远低于发达国家价格的热水器系统。虽然没有相关促进政策推动太阳能热水器在城市多层建筑中应用，但随着能源价格的上升及公共需求的增加，特别是在当前建筑业非常景气的时期，开发商在设计和建设阶段已经开始考虑安装太阳能热水器。有关技术标准，建筑规范及测试和认证中心等政府项目也在帮助这个产业走向成熟。[注 32]

除了中国，有 18 个或更多的国家为太阳能热水/供暖的投资提供赠款、优惠或投资税减免等支持。这些国家包括澳大利亚、奥地利、比利时、加拿大的某些省、塞浦路斯、芬兰、法国、德国、希腊、匈牙利、日本、荷兰、新西兰、葡萄牙、西班牙、瑞典、英国、美国的很多州和美国联邦政府。赠款一般为系统成本的 20~40%。投资税减免政策会减除全部或部分的投资纳税义务。(意大利的可再生能源证书同样适用于太阳能热水，即所谓的“白色认证”。) 以色列是唯一一个制订国家政策要求在新建筑中使用太阳能热水器

的国家。自 1980 年以来，以色列的大部分建筑都被要求安装太阳能热水器。技术要求随建筑物规模和类型不同而不同，如某些工业、医疗和高层建筑物可免于安装。欧盟正考虑制定太阳能等可再生能源供热技术的促进政策，有可能为此出台一个新的指令。

世界上许多大城市颁布了地方层面的法令，要求新建筑中必须安装太阳能热水器，或者对太阳能热水器投资提供激励或补助，如巴塞罗那（西班牙）、牛津(英国)以及波特兰和俄勒冈(美国)。其中巴塞罗那颁布了一项长远政策。从 2000 年开始的巴塞罗那太阳热能法令成为城市能源政策一个重要里程碑。该法令要求：一旦新建筑的规模超过指定值(292 MJ/天的热水能耗)，那么其热水能耗至少有 60%应由太阳能热水器提供的；游泳池加热必须是 100%的太阳能。大规模整修的建筑一样适用于这个法令。规模类别中表明，所有商业建筑和 16 户或更多的住宅建筑，都适用于该法令。由于这个法令的执行，现在 40%的新建筑都安装了太阳能热水器，并且人均装机容量(m^2/1 000 人)有了 15 倍的巨大飞跃：从 2000 年的 1.1 增长到 2004 年的 16.5。该城市的目标是到 2010 年安装的集热器面积达到约 10 万平方米。

由于巴塞罗那的带头作用，西班牙的其它市镇也开始采用太阳热能法令，其中包括马德里、巴伦西亚、塞维利亚、布尔戈斯和潘普洛纳。市政当局的强烈兴趣促使 IDEA 在 2003 年基于巴塞罗那的太阳热能法令精心制作了一个太阳热能法令的模版，这个模板可以作为城市和乡镇制订自己的法令的基础。到 2004 年 11 月，34 个直辖市和一个区采用了太阳热能法令，另有 10 个区(总数为 17)正在制定之中。这些法令的采用意义重大。例如，潘普洛纳的太阳能法令在 2004 年中期生效，致使太阳集热器的使用在一年里增加了 50%。一个全国性的太阳能法令正在考虑之中，并准备于 2005 年颁布实施。

生物质燃料促进政策

巴西的”ProAlcool”项目已经进行了 25 年，这使巴西在生物质燃料领域具有领先地位。”ProAlcool”项目中的政策包含强制混合要求、零售分销要求、生产补贴以及其它措施。自 1975 年以来，巴西要求在所有出售的汽油中混合乙醇。虽然混合程度频繁地在调整，但是基本都保持在 20~25%的范围内，所有加油站都要求出售混合乙醇的燃料(E25)和纯乙醇(E100)。而使用纯乙醇的车辆则享有优惠的税率。几家汽车制造厂制造的“灵活燃料”车辆新近上市，并且非常畅销，首要的因素不是政府制定了对应的政策，而只是因为政府对车辆执照税特惠政策的范围的扩大，除了原先包括的纯乙醇燃料车辆*，现在也包括了使用灵活燃料的车辆。巴西最近开始在其国内着力推广使用生物柴油，来源主要是其国内豆油生产过程。巴西新近通过的一个法律允许从 2005 年 1 月开始，在柴油燃料中混合 2%的生物柴油。这个比例可能还会在 2013 年增加到 5%或者更多[注 33]。

近些年，除巴西之外，其他几个国家也要求在车辆燃料中混合生物质燃料。需要特别提出的是，至少 20 个州/省和 2 个国家已经要求在所有出售的车辆燃料中混合乙醇和/或生物质柴油。从 2003 年开始，印度政府要求，所有 28 个州中的 9 个州和 7 个联邦地区中的 4 个地区(均为甘蔗产区)在车辆燃料中混合 10%的乙醇(E10)。在中国，已经有四个省要求进行 E10 燃料混合，2005 年另外五个省将执行类似的政策。在美国†，有三个州也进行 E10 燃料混和，他们分别为夏威夷(2006 以前主要还是汽油)、明尼苏达(在 2013 年增加到 20%)和蒙大拿。在其它州和国家正在考虑 2%的生物柴油混合(B2)政策时，明尼苏达目前已经要求实行这个政策了。加拿大的安大略省要求在 2007 年以前实行 E5(平均)燃料混和。哥伦比亚(E10)和多米尼加共和国(2015 以前实行 E15 和 B2 混合)在要求执行全国性的燃料混和政策。泰国制订了一个 2011 年的生物质燃料占总能量的份额的目标，为此泰国正在考虑 E10 和 B2 混和的政策。在从巴西进口的基础上，日本正在考虑 E5 混和政策。[注 33]

美国在生物质燃料税收激励方面最为突出。过去 25 年中，许多州级和联邦级的政策已经颁布。1979 年颁布的能源安全法规定，联邦乙醇减税额最高为 60 美分/加仑，该额度正比于混合的百分比(例如，E10

*由大众汽车（Volkswagen）领导的巴西汽车制造厂商的自愿举措推动这个转折点：2005 年销售的新车一半是灵活燃料车辆。通过推行灵活燃料汽车而不是单一的纯乙醇汽车或汽油汽车，汽车制造商简化了供应链及配件。

† 由于 2003 年到 2004 年甘蔗减产，印度只有进口乙醇来实现国家混合燃料目标。而且推迟了下一步目标的实现，直到国内的乙醇供应满足市场需求。中国各省因为乙醇短缺也不得不暂停混合燃料强制要求。

混合的燃料为 6 美分/加仑)。在 2004 年，通过法案使这种减税制度延长到 2010 年。现在增加了对生物柴油的减税，大约每百分比的混合生物柴油就有 1 美分的减税(也就是说，B2 混合的每加仑为 2 美分)。美国有若干个州也为乙醇生产和销售提供减税和其它激励措施。加拿大提供 10 美分/公升的国家燃料免税，许多省提供相近的或更高的免税(最高为 25 美分/公升)。很多欧洲国家针对生物质燃料减免燃料税或 VAT。这些国家包括奥地利(生物质燃料免税 95%)、法国、德国(生物质燃料免税 100%)、匈牙利、意大利(生物质燃料免税 100%)、西班牙、瑞典和英国。

欧盟的目标是在 2010 年前使生物质燃料占运输燃料的份额变为 5.75%。有几个欧洲国家正在考虑施行相关政策，帮助欧盟达成这一目标。2003 年，欧盟委员会的一个指令给每个国家设定了 2005 年(2%)和 2010 年(5.75%)的目标。虽然目标的达成是自愿的，但是每个国家要么递交达成目标的计划，要么解释他们为甚么不能达成目标的原因。有些欧盟成员国最近颁布了促进生物质燃料的法律或将要达成的目标，其中包括匈牙利的 2010 年生物质燃料达到总能量的 2%的目标和荷兰的生物质燃料达到运输燃料的 2%的目标。

绿色电力购买机制及电价形成机制

在 2004 年，欧洲、美国、加拿大、澳洲和日本有超过 450 万绿色电力消费者。在政策支持、私有资金参与、公共计划以及政府购买等方面的联合援助下，绿色电力购买机制及电价形成机制的工程正在稳步前进。带动绿色电力购买机制及电价形成机制前进的三大因素分别是：电力公司绿电销售、在取消电力管制条件下通过第三方制造者开展的竞争性零售（亦称为“绿电营销”）以及可交易可再生能源证书。日本也存在社会组织的绿电项目。随着市场扩展，绿色电力对于常规电力差价在继续下降。在美国，零售绿色电力差价一般为 1~3 美分/kWh。 [注 34]

在欧洲，自 90 年代后期，有些国家就存在绿色电力购买机制及电价形成机制。截至 2004 年，在绿色电力购买的免税支持下，荷兰已有近 300 万绿色电力消费者。其它有绿色电力零售市场的欧洲国家有芬兰、德国、瑞士和英国。自 1998 年以来，德国的绿色电力市场一直在平稳地增长。2004 年就有 60 多万的消费者购买了约 2000GWh 的绿色电力。RECS 是一个在 90 年代后期建立的可再生能源认证体系，旨在规范和认证可再生能源证书和交易市场，其成员中有 18 个欧洲国家。到 2005 年，发放的可再生能源证书累计已达到 33000GWh，其中大约 13000GWh 的证书用于绿电交易[*]。

美国估计每年有 50 万绿色电力消费者，购买电力达到 4500GWh。绿色电力购买正式开展时间约为 1999 年。2004 年，美国可再生能源发电至少扩容了 2GW 以填补这个市场。[†]联邦政府是绿色电力最大的单一买家：美国空军每年购买的绿色电力就有 320GWh。到 2004 年，34 个州中超过 600 家电力公司已开始提供绿电销售服务。其中大部分公司都是自愿提供该服务的，但是在 2001 到 2003 年间，美国的 5 个州颁布法规，要求电力公司为消费者提供绿电产品。2004 年，电力公司绿电销售几乎占据了绿色电力销售的一半。

许多美国的大公司，从航空航天承包商到天然食品公司，都自愿购买绿色电力产品。这些公司买家包括 IBM、Dow、Dupont、Alcoa、Intel、HP、Interface、Johnson&Johnson、Pitney Bowes、Staples、Baxter、FedEx Kinkos、General Motors 和 Toyota。公共的和非政府的举措也给这些买家带来便利。美国环境保护局的“绿色电力伙伴关系”在 2005 年已有 600 个成员，每年购买绿色电力达到 2800GWh。“Green-e”自愿认证项目在建立市场信誉方面也有所助益。

在日本，至 2005 年初，估计有 6 万绿色电力的消费者。他们都是电力公司的顾客，并通过合作制、社区组织和公共项目等形式自愿为绿色电力贡献力量。日本的绿色电力最初是通过社区义务组织发展起来的。北海道生活俱乐部（Seikatsu Club）是一个消费者合作联盟，它启动了日本第一个绿色电力项目。在联盟成员和大众的的义务协助下，联盟和当地电力公司一起收缴电费，并投资可再生能源项目。成员能够购买风电项目的股份，这样产生了第一个“民有”风机。日本别的地方也建立了类似的绿色基金，现在十

[*] 在英国，自愿绿色电力购买和电力公司的可再生能源义务的差别受到质疑。据称，英国的绿色能源自愿购买政策并不总是现有电力义务的补充。现在在德国，超过 50%的绿色电力市场是靠水电支撑的，大部分恰在德国电力市场自由化之前投入使用。

[†] 美国的绿色能源购买政策既独立于任何可再生能源政策，又是这些可再生能源政策的补充，如可再生能源配额制。

个日本电力公司让顾客自己选择是否捐助绿色电力基金，以支持风能和太阳能系统的发展。就在 2005 年初，已经有 57 000 名顾客每月通过缴纳电费自愿捐助绿电基金。

日本可再生能源认证市场也开始形成。日本的天然能源公司(JNEC)对商业和工业客户出售绿色电力证书，这些客户包括 50 多家日本大公司，象索尼、Asahi、Toyota 和日立。JNEC 将在 15 年内向这些公司出售约 60GWh 的绿电证书，价格比传统电力高出 2.4~3.4 美分/kWh(3~4 日元/kWh)。

澳洲有超过 10 万消费者从各种零售商购买绿色电力。绿色电力购买正在传播到其它国家。中国就是一个例子：2005 年十二家上海企业自愿从三个当地风电厂购买绿色电力，这在中国尚属首次。而且其价格差额非常高：比传统电力高出 6 美分/kWh(0.53 元/kWh)。

市级政策

全球范围的许多市政府颁布了他们自己的可再生能源政策。许多城市设定了未来可再生能源发展目标和二氧化碳减排目标，颁布了太阳能热水和/或屋顶光伏的促进政策，修改了城市规划方法或程序以将未来能耗纳入考虑，开展了示范或试点项目，制定了多种多样的促进政策并实施了众多项目。 (参见表 7)[注 35]

表 7：部分有可再生能源目标和/或政策的主要城市

城市	可再生能源目标	降低 CO_2 的目标	太阳能热水器政策	光伏政策	城市试验计划和吉他政策
阿德莱德，澳大利亚	X	X			X
巴塞罗那，西班牙	X	X	X	X	X
开普顿, 南非	X	X			X
芝加哥，美国	X				
大丘，韩国	X	X			X
弗莱堡，德国	X	X		X	X
哥德堡，瑞典					X
光州, 韩国	X	X			X
海牙，荷兰		X			
檀香山，美国					X
林茨，奥地利					X
明尼亚波利斯，美国	X				X
牛津，英国	X	X	X	X	X
波特兰，美国	X	X	X	X	X
青岛，中国					X
旧金山，美国					X
圣·莫尼卡，美国					X
札幌，日本		X			X
多伦多，加拿大		X			
范库弗峰，加拿大		X			

很多城市已决定为市政建筑和活动购买绿色电力。如美国的波特兰、俄勒冈、圣莫尼卡和加利福尼亚，这些市政府 100%使用绿色电力以满足其能源需求。其它美国城市如芝加哥、洛杉矶、明尼亚波利斯和圣地亚哥，其市政电力需求的 10~20%来自绿色电力。

许多城市的未来目标是可再生能源发电占城市总需求的 10~20%，而不仅仅只是政府用电。其中包括澳大利亚阿德莱德、、南非开普顿、德国弗莱堡和美国萨加门多(加利福尼亚)。实现这个目标的时间一般设

定在 2010 年到 2020 年。有些城市的目标是总能耗中可再生能源所占份额，譬如韩国大邱的目标是 2012 年份额达到 5%。有些城市的目标是装机容量。英国牛津以及南非开普顿等城市的目标是到 2010 年 10%的家庭安装太阳能热水器 (牛津的光伏有同样的目标)。西班牙的巴塞罗那目标为 2010 年太阳能集热器面积达到 10 万平方米。有些英国的城市政府要求超过指定规模的新建筑都要配套安装可再生能源设备。

有些城市提出或采用二氧化碳减排目标，一般为相对于基准水平(通常为 1990 年的水平)减少 10~20%，这与京都议定书目标的形式相一致。(然而，在城市层面，工业排放和城市居民没有必然的联系，所以这样的目标设置会因为工业生产而过于复杂化。) 这样的城市有德国的弗莱堡(25%)、韩国的光州(20%)、日本的札幌(10%)、加拿大的多伦多(市政府的二氧化碳排放量减少 20%)和温哥华(6%)。荷兰的海牙计划到 2006 年市政府能耗实现“碳平衡（CO_2 Neutral）”；整个城市能耗实现“碳平衡”为其长期目标。澳洲的阿德莱德计划 2012 年实现建筑“零排放（zero net emissions）”，2020 年实现交通运输“零排放”。

在各相关方的参与支持下，许多城市已在市政规划中将未来清洁能源纳入考虑。典型的例子是瑞典的哥德堡，它通过名为哥德堡 2050 的项目为城市制定长远规划。该项目需要大学、市政府和城市能源公共事业公司的共同努力。内容含有研究、前景规划、战略规划、公众对话和示范项目。日本的可再生能源政策在地方层面非常活跃。在国家政府的一个项目支持下，800 个地方政府在过去 10 年中分别规划了各自的城市发展远景。这些日本城市根据各自特点，结合可再生能源创造了一个超前而独特的前景。

全球城市共同组织并参与了各种支持当地可再生能源发展的全球性组织，譬如 ICLEI 城市气候保护活动、联合国太阳能城市促进会、欧洲绿色城市网和欧洲气候联盟。

5. 农村 (离网)可再生能源

农村（离网）可再生能源最常见的应用形式是炊事、照明和其他小规模用电、产生原动力、提水、供热和制冷。表 8 列出了这些应用形式，其中包括“第一代”或“传统”应用及技术（即原始生物质燃料和小规模水电）和“第二代”应用及技术（即风能、光伏发电、生物质气化和超小规模水电）。尽管发展的重心更多的放在了“第二代”技术上，农村发展问题专家还是不断提醒关注发展问题和可再生能源问题的各界人士：第一代技术依然具有十分重要的作用，特别是在最不发达国家。这一部分讨论了表 8 中的部分农村能源应用，以及农村电气化政策。[注 36]

表 8：农村地区（离网）现存常用可再生能源应用形式

用途	应用的可再生能源	替代的传统能源
炊事 (家庭和商业用)	• 生物质直接燃烧(薪柴，秸秆，森林废物，粪，木炭和其他形式) • 家庭沼气池生产沼气 • 太阳能炊具	液化石油气，煤油
照明和其他小规模用电 (家庭，学校，街道照明，通讯，手工工具，保存疫苗)	• 水电（超小规模，微小规模，小规模） • 家庭沼气池生产沼气 • 带内燃机的小规模生物质气化炉 • 村级电网和风/光互补系统 • 户用太阳能系统	蜡烛，煤油，电池，中央电池，柴油发电机
产生原动力(小规模工业)	• 配有电动机的小型水电 • 生物质发电和电动机 • 带内燃机的生物质燃气发生装置	柴油发电机和发动机
提水(农业和饮用)	• 风力机械提水 • 光伏发电提水机	柴油提水机
供热和制冷 (农作物干燥和其他农业加工,热水)	• 生物质直接燃烧 • 小规模和中等规模的沼气池生产沼气 • 太阳能农作物干燥机 • 太阳能热水器 • 制冰以保存食物	液化石油气，煤油，柴油发电机

“传统”应用主要指燃烧薪柴、农业和森林废物（残渣）、粪便和其他未处理的生物质燃料供家庭炊事、供热和其他加热需要。部分生物质能转换为木炭在市场上出售。在许多发展中国家，生物质能占有能源供应的大部分份额。2001 年，非洲是 49 %，亚洲是 25%，拉丁美洲是 18%。2000 年，撒哈拉以南非洲国家消耗了将近 4 亿 7 千万吨薪柴（人均 0.72 吨），包括木头和木炭。与之相比，印度和中国一共消耗了 3 亿 4 千万吨。撒哈拉以南非洲国家，木头或者秸秆是 94%的农村家庭和 41%城市家庭的主要的家庭能源来源。木炭是 4%的农村家庭和 34%城市家庭的主要的家庭能源来源。煤油是 2%的农村家庭和 13%城市家庭的主要的家庭能源来源。[注 37]

使用传统生物质能的代价和健康影响（以及改进生物质能炉灶和其他技术带来的相应好处）虽然不包括在本报告的内容中，但是仍然十分重要。由于收集时间是一种大量的非货币性支出，尤其是对妇女来说，

大部分生物质燃料的收集被排除在商业经济体系之外。Ezzati 和 Kammen 研究员在一份全面的现状研究报告中指出，全球由于暴露在固体燃料产生的室内空气污染中而导致死亡的人数的保守估计显示，2000 年，这一风险因素导致了 150 万到 200 万的死亡， 占全球死亡人数的 3～4%。[注 37]

炊事: 改进的生物质燃料炉

改进的生物质燃料炉不仅可以节约 10～50%的生物质消耗，而且可以极大的提高室内空气质量。在中国和印度，由于政府的推广，节能炉在大部分地区都有生产和销售。在肯尼亚，已经形成了大规模的商业化市场。目前，由于过去 20 年中多种公共项目的进行和私有市场的成功，全球一共有 2 亿 2 千万节能炉在使用。而全球有将近 5 亿 7 千万家庭把传统生物质作为主要炊事燃料，中国现有的 1 亿 8 千万使用节能炉的家庭占这种家庭的 9 5%，印度的 3 千 4 百万节能炉使用节能炉的家庭占这种家庭的 25%。*[注 38]

在非洲，在过去的几十年间，研究，传播和商业化努力带来了一定范围内节能炭炉——现在是木柴炉——的使用。大多数炉子的设计，以及支持其商业化的项目和政策都非常成功。目前有 5 百万节能炉在使用。在肯尼亚，超过半数的城市家庭和将近 16～20%的农村家庭使用陶瓷的 Jikko 炉（KCJ）。虽然几乎没有适当的政策，但是大约三分之一的非洲国家有改进生物质炊事炉的项目。同时非政府组织和小企业也在继续推广和市场化节能炉。

炊事和照明：沼气池

估计全球有 1 千 6 百万家庭将家庭规模的设备（所谓的厌氧反应容器）产生的沼气用于照明和炊事。其中包括中国的 1 千 2 百万家庭，印度的 3 百 70 万，和尼泊尔的 14 万。除去照明和炊事，沼气直接改善了农村家庭的生活。比如，对尼泊尔沼气效益的分析显示，它使妇女和女孩每天减少了 3 小时的家务劳动时间，一年每户节约 25 升煤油，3 吨薪柴，农业废物和粪便。[注 39]

在中国，照明和炊事用家庭规模沼气推广很快。一个典型的沼气池容积为 6 到 8 立方米，一年可以产生 300 立方米的沼气，根据各省的情况，成本为 1500 到 2000 人民币（200～250 美元）。由于沼气是一种简单的技术，不需要高级的专业人士，因此可由当地小公司负责建造。农民在经过适当的培训后也可自己建造沼气池生产沼气。一个 2002 年启动的政府项目每年提供 10 亿人民币补贴自建沼气池的农民家庭。补贴额度为每个沼气池 800 人民币。有人估计每年有 1 百多万个沼气池建成。除了家庭规模的，中国还有几千个中等和大规模的工业沼气厂。最近的国家沼气行动计划的目的就是增加这种工厂的数量。

在印度，从 20 世纪 80 年代早期开始，非传统能源部一直在推广家庭规模的沼气生产。非传统能源部给沼气池建造和维护，培训，公众意识培养和技术中心建设等活动提供津贴和资金，并支持当地执行机构。著名的印度土布和乡村工业委员会也支持沼气生产。

在尼泊尔，SNV/生物质燃气支持项目为家庭规模沼气厂（4～20 立方米，普遍为 6 立方米）提供新技术，资金，工程和市场开发。通过这个项目，60 个私有沼气公司提高了他们的技术和市场能力，100 个小规模的信贷机构提供了贷款，采用了质量标准，创建了一个长期的市场促进机构，生物质燃气合作伙伴/

* 与其说改进的生物质能炉是一项可再生能源产品技术，不如说它是一种燃效技术。不过，它明显是一种农村可再生能源利用的形式，范围广大，效果明显。促进高效炉的政策和项目，不像本报告中其他可再生能源政策一样是可再生能源“促进”政策，而是一个改善健康、经济和现有可再生能源资源压力的政策。(因此与可持续的森林和土地经营紧密相关。）目前正在使用的节能炉的数量可能比本报告中的数量少很多，例如，印度的一些评估报告说大多数炉子已经过了使用期，不能用了）

尼泊尔。

电能，热能和动能：生物质气化

小规模热生物质气化在一些发展中国家，特别是中国和印度，是一种新兴的商业技术。气化炉产生的气体可以直接燃烧供热，或者用于内燃机或气体发动机产生电能或动能。在少数中国省份，热气化炉产生的生物质燃气还可以通过管道网络供炊事使用。 印度 2002 年气化炉的总装机容量约为 35MW，共有 10 个制造商生产小规模气化炉和最大 200kW 的配套发动机。在菲律宾，从 20 世纪 80 年代开始，气化炉与双燃料柴油机结合起来，用于磨米和灌溉。气化炉还在印度尼西亚、泰国和斯里兰卡被示范应用。[注 40]

在印度，包括丝绸和其他纺织品生产和处理中的生物质气化的项目在商业化的基础上被示范应用，商业化是指本地生产商和短还款期。使用气化炉而不是电的香料（豆蔻）干燥，干燥周期短，产品质量高。在这种应用中，投资人一个季度就收回了投资。多于 85%的受益人是拥有少于 2 公顷作物的小生产者。用气化炉的橡胶干燥也说明了其代替传统能源和一年内收回投资的能力。气化器还可以用于在入窑前干燥砖块，这种应用减少了燃料消耗和产生的烟，在改善工作条件的同时减少了干燥时间（意味着产量增加）。

电力：村级小型混合电网系统

村级小型混合电网系统能为数十乃至数百家庭服务。 传统上，小型混合电网多见于偏远地区和海岛，并由柴油发电器或小水力发电供给动力。在亚洲大部分地区，光伏发电，风，或生物质能发电，通常以组合的形式，包括电池和/或一台备用柴油发电器，正在慢慢地代替传统模型。成千上万个主要依赖于小水力发电的小型混合电网系统存在于中国，印度、 尼泊尔、 越南和斯里南卡有数以万计的同样系统。中国 2000 年前就在使用的风电和光伏发电技术，现在仍在小型混合电网体系中占主要地位。中国的"村镇电气化工程" 从 2002 到 2004 年间，以光伏发电、 风/光互补系统和小水力发电系统，为大约 250 000 个家庭和一千个村镇的一百万农村人口提供了电力。在 2002 到 2004 年间，几乎 700 个小镇建成大约 30～150 KW 的村级太阳能电站 (总数大约 20 MW) ，其中一部分使用风光互补系统(大约共计 800 千瓦风能)。在印度，安装了 550 KW 风光互补系统。其作为另一为村级电网供电的主要途径，为数十个村庄的数千家庭提供电力。[注 41]

提水：风能及光伏发电

光伏发电和风能广泛用于提水动力,包括灌溉和饮用。并且有许多项目和投资正在建设之中。经过几十年的发展，大约一百万机械风力提水机在使用，主要在阿根廷。大量的风力提水机在非洲使用：南非(300 000)、 纳米比亚(30 000)、 佛得角(800)、 津巴布韦(650)及其它国家(2 000)。全世界现在有超过 50 000 台光伏发电提水机，大部分在印度。 印度最近在其乡村地区安装了 4 000 台光伏提水机(范围从 200 W 到 2 000 W)，这也是印度光伏发电提水机计划（Indian Solar PV Water Pumping Programme）的一部分。估计有 1 000 个太阳能提水机在非洲西部使用。为饮用供水提供太阳能动力的援助工程正在阿根廷、巴西、印度尼西亚、乔丹、纳米比亚、尼日尔、菲律宾、突尼斯和津巴布韦等国家开展。[注 42]

近年来，面向商业的光伏发电饮用供水（提水和净化）项目的支持者有所增加。比较著名的是在印度、马尔代夫和菲律宾。在马尔代夫，一个商业示范项目正在实行，目标是家庭用水的价格达到每公升 0.2～0.5 美分，销售量达到 1 000 公升/天。另一个近期的例子是在菲律宾宿务岛：一台 3 千瓦光伏发电提水机为 10 个村庄提供经过过滤和氯化的水。1 200 位居民通过预付转账卡购买饮用水，价格大约是每 20 公升 3 PHP

(5.5 美分), 或每公升 0.3 美分, 是瓶装水价格的十分之一。水的销售收入被用于支付 10 年的无补贴银行贷款。该模式可应用于菲律宾的 10 多 个海岛, 为 40 个城市中的 200 000 人口提供饮用水。

电力:户用太阳能光伏系统

截至 2005 年, 发展中国家共有超过 2 百万家庭安装了户用太阳能光伏系统。 近年来，大部分已安装及新安装的户用系统都在以下几个亚洲国家：印度、斯里南卡、尼泊尔、孟加拉国、泰国和中国。当地民众支付能力问题由小额信用贷款解决或销售符合当地购买能力的小型系统，另外政府和国际捐赠项目也起了支持作用。在这些国家中, 每月有成百上千个家庭安装这种系统(根据报告，2005 年在中国每月就有 10 000 个)；2004 年一年的总安装量就超过 200 000 套。通过几个捐赠项目，印度尼西亚安装了大约 40 000 个户用太阳能光伏系统，但去年的宏观经济困难挫伤了这种持续成长。除了亚洲地区，肯尼亚、 摩洛哥和墨西哥也有较大的市场。一些拉美国家也计划推行户用太阳能光伏系统。如果他们的购买力问题能够得到很好解决（通过政府补贴和/或服务费模式），未来户用系统的增长将主要发生在拉美地区。*[注 43]

在非洲, 因为它的农村电气化程度及国民平均收入都很低，在户用光伏系统的新装数量上没有显著增长，但有若干国家不在此列。肯尼亚现有 150 000 套户用光伏系统, 占整个非洲几乎一半的安装量, 并且有市场还在增长。在农村和郊区，符合购买力的小型系统推动了市场的增长。摩洛哥计划在 2010 年以前安装 150 000 套户用光伏系统。乌干达有一个关于户用光伏系统和其它教育和医疗保健产品的十年计划。南非已经筹划多年，希望由私营企业通过"服务费"的方式为 200 000 个农村家庭提供户用光伏系统。马里、坦桑尼亚和塞内加尔等国家,为农村地区使用诸如太阳能光伏等可再生能源户用系统提供有限补贴。但总的来看，早先的让非洲数百万家庭安装户用光伏系统的愿望并未实现。原因主要在于支付能力问题, 因为一个典型的低端户用光伏系统的费用相对多数非洲国家居民的平均收入仍然偏高。

户用太阳能光伏系统的私营经销模式已经在五个国家成为市场基石：中国、斯里南卡、印度、孟加拉国和肯尼亚。 在中国和肯尼亚, 系统几乎完全以现金支付的方式销售。在印度、斯里南卡和孟加拉国, 赊销方式一定程度上解决了支付能力问题，并推动了市场发展。众多新的购买方式涌现出来，如基于非政府组织的小额融资、经销商信贷和商业银行消费信贷等。 在印度, 伴随着大量的现金购买, 作为商业太阳能贷款计划的一部分，超过 2 000 个农业银行分支机构为户用光伏系统提供信贷。实际上, 过去五年间，印度、斯里南卡和孟加拉国通过信贷销售的 120 000 套户用系统也就是全世界所有基于信贷销售的系统。 肯尼亚也有一个非常活跃的私营市场, 有超过 20 个主要的光伏进口和制造企业、上百个农村销售商以及城市分销商, 他们中的大多数出售一系列品牌的户用系统。

电能及热能的其他生产用途

在农村，现代可再生能源技术日益关注小规模工业、农业、电信、医疗保健和教育等领域的电能及热能需求。工业应用包括丝绸生产、制砖、 橡胶干燥、工艺品生产、缝纫、焊接和木材加工。 农业和食品加工应用包括灌溉、食品干燥、磨房、 火炉和烤箱、 制冰、圈养家畜和牛奶冷藏。医疗保健应用包括疫苗冷藏和照明。沟通应用包括影院、电话、计算机和广播。其它社区应用包括学校、街道照明和饮用水净化。与这些多种多样的应用潜力相比，现有的项目只是很少的一部分。很大程度上，这些应用在长期的或商用方面的大规模发展尚未开始。

* 户用太阳能光伏系统不仅包含固定系统，还包含“太阳灯”。印度及一些国家有超过 500 000 家庭使用太阳灯。户用太阳能系统主要使用节能荧光灯。但低电压 LED 及冷阴极荧光灯的使用也日益增多，它们主要用于低成本太阳灯及某些小功率户用太阳能系统。

用于照明、提水、医疗冷藏和动力等方面的可再生能源供电开始受到广泛关注，但供热方面的新兴可再生能源应用仍然很少被谈及或被付诸实践。传统的生物质燃料被用于供热和热能相关应用，譬如炊事、供暖、农作物烘干、烘烤、农产品加工、窑炉、烤箱和商用食物加工。太阳能发热的应用和先进的生物质技术正开始受到关注。发展中国家政府也在这些领域投入了更多的注意力。 例如，印度政府实施了一个综合计划，用于促进在农村以燃烧，混用和气化等方式使用生物质供热、发电和提供动力。这些农村能源项目的目标是满足数百农村各种形式的的家庭、社区和生产方面的能源需求。

在健康和教育方面的应用的一个成功例子是世界银行和全球环境基金会合作的乌干达农村改革能源项目。该项目为医疗设备、职员住所、照明、冷却系统、消毒和电信提供能量，并且将这些多种多样的应用展示给卫生部。在教育方面，光伏发电系统为职业训练提供能源设备，为夜校和职员提供住房照明。 其它应用包括提水和小企业。墨西哥的"telesecundaria" 节目就是另一个成功例子。这个节目的目的是提高农村学校远程教育节目的水平,而许多遥远的学校依靠光伏发电供给通信设备和其它远程教育设备的动力。在危地马拉，洪都拉斯和玻利维亚，出现了一个为"telecenters" 设计的新形式，把公共服务中心和赢利电话服务结合了起来。

近年来，通过 UNEP/联合国基金组织在非洲，巴西，和中国及其他财政创始国发起的"农村能源企业发展"项目，中小规模的企业参与可更新能源的相关产品生产的资金来源获得了相当大的关注。这些企业提供各种各样的服务和产品，包括太阳家庭系统,提水机，太阳能作物干燥,用于研磨和碾碎的生物质燃料动力机械，太阳能面包店，生物质能冰砖和药丸，和其它有收入的用途。在乡村，随着捐赠计划和商业银行贷款的增加，这样的企业的数量在增长。

农村电气化政策和项目

国家农村电气化政策和项目，与国际援助项目一起，使可再生能源作为附属"获得"战略。即，满足那些需求仍在增长，但却不能纳入中央电网考虑范围的农村人口获得电力的要求。估计全世界 3 亿 6 千万个家庭仍然缺乏这种获得。 主要电气化选择包括力电力网络引伸，连接在微型网络的柴油发电机，连接在微型网络的可再生能源(太阳，风，并且和生物质气化，有时与柴油结合)，以及家庭规模的可再生能源(户用光伏系统和小风机) 。通常传统电网接入的费用是高昂的；在肯尼亚，例如，为一个农村家新连接的平均费用是全国国民平均收入的七倍。[注 44]

许多发展中国家都把兴趣集中在对农村和偏远地区使用可再生源技术供电，作为一个拓展电网的有效途径。 同时，越来越认识到，私人单独投资是不够的,政府补助和政策还应扮演关键角色，这一点由普遍使用电力的发展目标和公共要求证明了。“我们在拉丁美洲的所有国家客户告诉我们，他们意识到他们需要补贴和管理措施使农村最后 20%用不上电人口用上电，包括利用可再生能源,"世界银行项目负责人说。

在几个国家，特别在拉丁美洲,农村电气化工程,明确地大规模集中投资在家庭太阳能系统，为一些家庭提供电能。政府逐渐发现边远地区不适合接入电网，并且正在为在这些区域利用可再生能源代替拓展电网制定明确的政策和补贴。 例如，巴西计划到 2008 年可由"Luz para Todos"项目向 250 万个家庭供电(大约 700 000 已经供电)，并且计划 200000 户或大约这些家庭的 10% 使用可再生能源。如前面所提，中国的"村镇电气化工程,"将在 2004 年大部分完成，为乡村 1 百万居民提供可再生能源作为动力。印度政府的"边远乡村电气化工程" 确认了 18 000 个村庄为电气化目标，部分由可再生能源技术尤其是生物质能气化提供。

几个其它拉丁美洲国家最近建立或修改了的新农村电气化项目，包括玻利维亚，智利，危地马拉，墨西哥，尼加拉瓜，还有秘鲁。 大多这些国家把"主流" 可再生能源作为新农村电化的一个标准选择。 例如，智利最近确定可再生能源为国家农村电气化工程第二个阶段的关键技术。假设这建立了可再生能源用于乡村电气化的规划，管理者意识到，法律和管理框架需要尽快健全。的确，阿根廷，玻利维亚，巴西，智利，危地马拉还有尼加拉瓜都于 2004 年和 2005 年期间出台了新的法律法规。

在亚洲，明确规定用可再生能源实现农村电气化的国家包括孟加拉国，中国，印度，尼泊尔，菲律宾，斯里南卡，泰国和越南。 部分国家是投资多边协助的项目，同时提供其它技术协助和支持方法。1999 年菲律宾制定了一个在 2007 年以前实现全部乡村电气化的战略，在那个战略中明确的包括使用可再生能源。斯里兰卡的目标是 85%人口可获得电力使用，目前已经直接补贴农村户用光伏系统。 2003 年泰国决定在 2005 年底,使还未供电的 300 000 个农村家庭以太阳能为家庭能源系统，到 2004 年这个目标几乎已完成一半。

名词解释

生物质柴油 轿车, 卡车, 公共汽车, 以及其它柴油发动机车的燃料。生物柴油由油籽种子庄稼生产，譬如大豆, 油菜籽, 芥末, 或者其它植物油来源比如废炊事用油。

沼气池 把动物和植物废物转换成气体，用于照明, 炊事, 加热, 以及发电。

生物质动力和供热 固体生物提供的力量和/或热, 包括林产品废物, 农业残渣和废物, 能源用庄稼, 以及城市政固体垃圾和工业垃圾有机组分。其中包括沼气产生的动力和过程热。

资本补贴或消费者津贴 一项投资中由政府或公共事业投资所占的资本成本的百分比, 譬如太阳能热水系统或屋顶太阳能光伏电池系统。

乙醇 由生物质 (典型地有玉米，糖甘蔗, 或麦子) 制成的车用燃料，可能在适当比例的替换普通的汽油(参见汽油-乙醇混合燃料), 或单独用于特殊改造过的机动车。

分类电价 供电商以一个固定的价格把可再生能源电力卖给电网的政策。 或者指定固定的税额，或者给市场或者成本相关的税指定固定的补贴。或者两项都有。

汽油-乙醇混合燃料 汽油和酒精的混合物, 一般是 10～25%的酒精（所谓的 E10、E25 等)。

地热发电和供热 从地球内部散发的热能, 通常以热水或蒸汽的形式, 可用于发电或直接为建筑、工业以及农业供热。

吉瓦(GW)/ 吉瓦时(GWh)/ 吉瓦（热）(GWth) 参见兆瓦, 千瓦时, 兆瓦（热)。

绿电购买 居民、商业界、政府或工业界从电力公司(参见"公共绿色电价")或第三方可再生能源发电者(也叫做"绿色销售")自愿购买绿色电能或者“可再生能源证书”。通过绿电价格或销售等方面的竞争，顾客的电力需求与同等数量的并网可再生能源电力匹配。绿电证书允许在任何地方生产可再生能源。

投资税减免 允许在可再生能源领域的投资在义务税或者所得税方面部分或全部减免。

千瓦时(kWh) 生产或消耗的电的单位。最常用的零售电价的单位为美分/kWh 。

大水电 水从高处流下产生的电能, 一般是从水坝上。没有区分大小的国际通用界限，上限一般在 2.5MW 到 50 MW 之间。10MW 正在成为标准值。

兆瓦(MW) 发电能力的单位。 代表瞬间功率流, 不能与产生的能量混淆(如 MWh, 或兆瓦时) 。

兆瓦（热）(MWth) 热供应能力的单位，用来测量供热厂的潜在产能，比如可能供应建筑或小区。最近经常用于测量太阳能热水/供暖设备。代表瞬间热流, 不能与产生的热量的单位混淆（即 MWh(th), 或兆瓦时（热）) 。

现代生物质 生物质应用技术，但不是传统定义上的生物质。如生物质热电联产，生物质气化, 生物质厌氧沼气池, 以及机动车用液体生物质燃料的生产。

多边代理机构 通常指在全球范围内为发展中国家提供发展、环境或经济援助的公共机构, 比如世界银行；或设定国际协定和条约, 比如联合国。

净流量 允许电流在电网和可以自己发电的用户之间双向流动。当瞬间消耗电量超过自产电量时，电流从电网流向用户（正向)，当瞬间自产电流超过消耗电量时，电流从用户流向电网。用户在一个结账周期内支付净流量的费用，而且可以按月延期。

生产税减免 以该电厂生产的电量为基础，为投资者或者合乎要求的财产的所有者提供年度税收减免。

可再生能源目标 国家为了在远期达到可再造能源发展的某一水平所作的承诺, 计划或目的。某些目标成为了法律，其他的由管理机构或政府部门制定。可以根据强制程度的不同而采取不同的形式。也叫做“规划目标”,“发展规划”和“义务”。

可再生能源配额制(RPS)所售电量或者装机容量中可再生能源发电要求占到的最小比例。要求公共事业用户必须保证达到这个目标，可以是自己发的电，也可以从其他生产者处购电，也可以从第三方直接卖给公共事业用户。

小/微小/超小/极小水电 (参见大水电) 小水电通常被定义为在 10 兆瓦以下的水电, 微小水电在 1 兆瓦以下,

超小在 100 千瓦以下, 极小在 1 千瓦以下。 极小水电一般没有水坝，仅仅靠水流的能量发电。

户用太阳能系统 可为农村家庭提供相当数量的电能而没有联网的屋顶太阳能板、电池、充电控制器等。一般充电一天可以提供一晚上的照明（使用高效灯）和电视用电。

太阳能热水/供热 可以加热水并储存起来提供生活热水或者取暖的屋顶太阳能采集器。

太阳光伏电池板/组件/电池 把太阳能转换成电能。电池是基本组成部分,包括在板和组件中。

可交易可再生能源证书 每个证书代表通过认证的一个单位的可再生能源产生的电量（一般是一个兆瓦时）。证书允许在用户和/或生产者之间交易使用可再生能源的义务。在一些地方的市场上，比如说美国，允许任何人单独购买包含可再生能源电力的“绿点”。

传统生物质 未加工的生物质，包括农业废物、林产品废物、收集的薪材以及动物粪便。通过燃烧为炊事、取暖、农业和工业加工提供热能, 一般在农村地区。

绿电上网电价 电力公司以不同价格为其顾客提供不同比例的可再生能源电力，并且保证自产或购买满足所有顾客所需的绿电。

RENEWABLES 2005 GLOBAL STATUS REPORT

Notes and References Companion Document

October 20, 2005 Version
Companion to the main report: www.ren21.net/globalstatusreport

NOTES

[N1] Coverage of Report and General Notes

Most figures of global capacity, growth, and investment are not exact, but rather approximate to two significant digits at most (i.e., 630 but not 632; 1,300 but not 1,350, etc.). Sometimes only one-and-half significant digits may apply; for example, a number could be given as 15 rather than 10 or 20, but 17 would be too precise based on the data available and assumptions made.

This report generally covers those technologies with high technology maturity and either high or low levels of market maturity. These categories follow an analysis by Navigant Consulting, which groups renewable power generation technologies into three categories: *1.High technology maturity and high market maturity:* small hydro, biomass direct combustion, landfill gas, geothermal, and on-shore wind (just emerging into high market maturity); *2.High technology maturity but low market maturity:* biomass co-firing, crystalline silicon PV, waste-to-energy (combustion), anaerobic digester biogas, parabolic trough solar thermal power (just emerging into high technology maturity), and offshore wind (just emerging into high technology maturity); *3. Low technology maturity and low market maturity (technologies to watch):* tidal barrage, thin-film PV, concentrating PV, biomass integrated gasification combined-cycle (BIG/GT), dish stirling, wave power, solar thermal power tower, biomass pyrolysis, tidal current OTEC, and nano solar cells.

This report does not cover policies and activities related to technology transfer, capacity building, carbon finance, and CDM projects. Hopefully subsequent editions, if published, could cover these topics.

For a general treatment of market, policies, and barriers to renewable energy, see IEA 2004b; EREC 2004; Beck & Martinot 2004; Komar 2004; Fulton et al. 2004; UNDP et al. 2000; Goldemberg & Johansson 2004; Johansson & Turkenburg 2004; Sawin & Flavin 2004; and Sawin 2004.

[N2] Primary Energy from Renewable Energy

Table N2 shows the relative energy contributions from new renewables, large hydro, and traditional rural biomass. The primary energy attributed to electricity supply is adjusted to reflect fossil fuel energy required to produce an equivalent about of electricity. This type of adjustment is made in some but not all published global energy statistics. The best example is BP's annual *Statistical Review of World Energy*. In BP statistics, "the primary energy value of hydroelectricity generation has been derived by calculating the equivalent amount of fossil fuel required to generate the same volume of electricity in a thermal power station, assuming a conversion efficiency of 38% (the average for OECD thermal power generation)" (BP 2005). BP gives hydropower as 634 Mtoe in 2004, or 6.2% of global primary commercial energy. Other statistics not using this methodology will give hydropower as 2.4% of global primary commercial energy, so there will be significant discrepancies between numbers here and some other published numbers. In addition, this correction makes total primary energy higher, with BP's number of 10,224 Mtoe commercial primary energy in 2004 higher than some other published figures.

Traditional biomass was given as 1,035 Mtoe for 1999 from World Resources 2002-2004, Table 8 (UNDP et al. 2002). Assuming 2% growth per year in traditional biomass use gives 1,140 Mtoe for 2004. This reflects population growth minus fuel switching minus more efficient use of resources. There are no definitive sources of information on traditional biomass use, and a fairly wide range of estimates can be found, reflecting the plausible range of assumptions, methodologies, and data quality. Traditional biomass fuels are commonly estimated in the literature at 9-10% of global primary energy (see Goldemberg & Johansson 2004; Kartha et al. 2004). The typical range in the literature for traditional biomass is 28-48 EJ. The WRI estimate of 1,035 Mtoe for 1999 is 43 EJ, which is at the higher end of the range. Goldemberg & Johansson 2004 give 950 Mtoe for 2001 (Figure 5), which is 40 EJ. Applying 2% growth from 2001 to 2004 would give 1,010 Mtoe in 2004, which is the figure assumed for purposes of this report. There is no consensus on how fast traditional biomass use is growing. Traditional biomass users should grow at the rate of growth of rural populations in developing countries, except for those countries where adoption of modern fuels in rural areas is becoming more widespread. Growth of biomass fuel use will be related, but not the same.

So total world primary energy in 2004 was 10,224 Mtoe (commercial) + 1,010 Mtoe (traditional) = 11,234 Mtoe. Renewables share of 1,876 Mtoe is 16.7%. (1 Mtoe = 41.9 PJ).

Electricity production from renewables in Table N2 is calculated from capacity figures in Table N2 by scaling energy production figures provided in Table 4 of Johansson & Turkenburg 2004, which gives 2001 figures of 2600 TWh large hydro from 690 GW, 43 TWh wind from 23 GWe, 170 TWh biomass electricity from 40 GWe, 730 TWh biomass heat from 210 GWth, 53 TWh geothermal from 8 GW, 55 TWh geothermal heat from 16 GWth, 57 TWh solar hot water from 95 million m^2, 450 PJ ethanol from 19 billion liters/year, and 45 PJ from 1.2 billion liters/year. Thus, average capacity factors in 2004 are assumed similar to those implied by Johansson & Turkenburg for 2001.

Energy content of avoided fossil fuels for Table N2 assumes global average power generation efficiency from fossil fuels of 36% (BP's *Statistical Review of World Energy* uses 38% as the average for OECD thermal power generation in their primary energy conversion, but developing countries will be less). Energy content of avoided fossil fuels assumed to be parity for biofuels and hot water/heating.

BP (2005) shows 17,450 TWh of electricity produced worldwide in 2004. Large hydro, at 2,800 TWh, is 16.0%. Renewables, at 540 TWh, are 3.1%. World electricity production in 1994 was 12,850 TWh and large hydro was 2,380 TWh, so the share of large hydro in 1994 was 18.5%.

IAEA (2005) gives electricity production from nuclear power at 2,619 TWh in 2004. The estimated 550 TWh from renewables (excluding large hydro) in 2004 (see Table N2) is 21% of this figure.

Table N2. Relative Energy Contribution of Different Forms of Renewable Energy, 2004

	Primary energy supply based on direct energy output		Adjusted energy supply based on energy content of avoided fossil fuels (Mtoe)	Share of total renewable energy supply
	natural units	Mtoe		
Power generation				
Biomass power	150 TWh	12.9	35.8	
Wind power	95 TWh	8.2	22.7	
Small hydro	240 TWh	20.6	57.3	
Geothermal power	60 TWh	5.2	14.3	
Total			**130**	**6.9%**
Hot water/heating				
Solar hot water	290 PJ	6.9		
Geothermal heat	200 PJ	4.8		
Biomass heat	2,600 PJ	62.1		
Total		73.7	**73.7**	**3.9%**
Biofuels				
Ethanol	700 PJ	16.7		
Biodiesel	80 PJ	1.9		
Total		18.6	**18.6**	**1.0%**
Other renewables				
Traditional biomass		1,010	**1,010**	**53.8%**
Large hydro power	2,700 TWh	232	**644**	**34.3%**
Total				
Total			**1,876**	**100%**

[N3] Added and Existing Capacities and Growth Rates

Table N3 presents installed capacities, added capacities, and growth rates of renewable energy. Growth rates are author's estimates based on compilations of global installed capacity figures for all renewable technologies from 1995 to 2004. According to compiled figures, grid-connected solar PV grew from 190 MW in 1999 to 1,760 MW in 2004, and 630 MW were added in 2004 (adapted from Maycock 2003, 2004, 2005a). Off-grid solar grew from 990 MW to 2,200 MW (same). Wind power grew from 13.5 GW to 48 GW (GWEC 2005 and BTM Consult 2005). Ethanol grew from 18.8 billion liters to 31 billion liters (author's spreadsheet based on Lichts 2005 and other data). Biodiesel grew from 0.7 billion liters/year to 2.3 billion liters/year (same). Geothermal power grew from 8.0 GW in 2000 to 8.9 GW in 2005 (Lund 2005a). Geothermal heat grew from 15.2 GWth in 2000 to 27.8 GWth in 2005 (same). The average growth rate for the five-year period 2000-2004 is calculated as the average compound rate for each of the five years, using end-1999 data and end-2004 data.

The table is compiled from author's database of country-by-country capacities and installations by year, including data from individual country statistics and submissions from report contributors, also AWEA 2005 ; EWEA 2005a; GWEC 2005; EREC 2004; Maycock 2004 and 2005a; Fulton 2004 plus updates; Lichts 2005; Weiss et al. 2005; ESTIF 2005; Johansson & Turkenburg 2004; Martinot et al. 2002 plus updates; Martinot 2004a; Karekezi et al. 2004; IEA 2004a; IEA 2004c; Graham 2001; TERI 2001; D'Sa & Murthy 2004; Goldemberg and Johansson 2004; World Geothermal Council 2005; and Lund 2005a and 2005b.

Table N3. Renewable Energy Capacities and Installations, 2004

		Added during 2004	Existing at end of 2004	Growth rate of existing in 2004	Average growth rate 2000-2004
Power generation					
Large hydro power		---	740 GW	---	2%
Wind turbines		8.1 GW	48 GW	20%	29%
Small hydro power		4.5 GW	61 GW	8%	7%
Biomass power		---	39 GW	---	3%
Solar PV, grid-connected	(GW)	0.63 GW	1.8 GW	54%	61%
	(homes)	150,000	400,000	---	---
Solar PV, off-grid		0.33 GW	2.2 GW	17%	17%
Geothermal power		---	8.9 GW	---	2.4%
Solar thermal power		---	0.4 GW	---	---
Ocean (tidal) power		---	0.3 GW	---	---
Hot water/space heating					
Biomass heating		---	220 GWth	---	2%
Solar collectors for hot water and space heating, glazed	(GWth)	12 GWth	77 GWth	---	---
	(m^2)	17 mil m^2	110mil m^2	17%	17%
	(homes)	6.5 million	39 million	---	---
Geothermal heating		---	28 GWth	---	13%
Transport fuels					
Ethanol production		2.3 billion liters/year	31 billion liters/yr	8%	11%
Biodiesel production		0.4 billion liters/year	2.2 billion liters/yr	26%	25%
Rural household energy					
Biomass cooking stoves in use	(total, all types)	---	570 million	---	---
	("improved" types)	---	220 million	---	---
Household-scale biogas digesters in use		---	16 million	---	---
Household-scale solar PV systems in use		0.3 million	2 million	---	---

Notes:

(a) PV existing capacity is based on cumulative production since 1990, neglecting retirements.

(b) Number of homes for solar hot water collectors estimated based on 2.5 m^2/home average for developing countries and 4 m^2/home for developed countries, neglecting commercial use. Li (2002) suggests closer to 2 m^2 in China, the largest market, so the actual number of homes is probably higher than the figures in the table.

(c) Total number of biomass cooking stoves is estimated based on assuming 4.4 persons per household and 2.4 billion people still using traditional biomass. Improved biomass cooking stoves based on Martinot et al. 2002 with updates from Karekezi et al. 2004, IEA 2002a, Graham 2001, TERI 2001, and D'Sa & Murthy 2004, but still reflect figures that are at least a few years old.

(d) Biomass power-generation capacity figures do not include electricity from municipal solid waste (MSW). Many sources include MSW in biomass figures, although there is no universally accepted definition. If MSW were to be included in the numbers in this table, biomass power generation might increase from 36 GW to 43-45 GW. OECD power generation from MSW was 6.7 GW in 2002 (IEA 2005a). Developing country numbers for MSW are difficult to estimate.

(e) Growth rates for biomass heating and large hydro are taken from Johansson & Turkenburg 2004 and reflect growth rates for the period 1997-2001. More recent worldwide growth rates are not available. The average annual capacity increase for all hydro in OECD countries was 1.2% from 1990-2002 (IEA 2004a).

(f) Geothermal heat figures include shallow geothermal energy and geothermal heat pumps.

(g) "---" means data not available or not reliable enough to state.

(h) Total installation of solar PV in 2004 was reported by Maycock (2005b) as 960 MW compared to total solar PV production of 1,100 MW.

(i) The "hot water/heating" category includes solar hot water, solar space heating, and solar cooling in residential, commercial, and industrial applications. The number of homes shown in the table assumes that a high proportion of installed capacity is for residential solar hot water systems. Active solar space heating is provided by a significant share of installations in some countries, although not in China, which is now two-thirds of the global market. Technically, this category is called "Solar Heating and Cooling" by the International Energy Agency, but this report uses the terminology "solar hot water/heating."

(j) Geothermal power capacity has grown by an average of 2.4% from 2000-2004. Geothermal heating capacity has grown by an average of 12.9% from 2000-2004 (World Geothermal Council 2005 and Lund 2005a.

(k) Solar hot water household estimation: 2.4 m^2/system in China (70% of systems sold are small 2 m^2 size) and 3.8 m^2/system in rest of world. So 13.5 million in China equals 5.6 million homes, and 3.5 millon m^2 elsewhere equals 0.9 million homes. 64 million m^2 in China equals 26.7 million homes, and 46 million m^2 elsewhere equals 12.1 million homes.

(l) SHW growth rate for 2004 is net, based on annual additions minus retirements.

(m) Solar PV for off-grid includes residential, commercial, signal, and communications, and consumer products. In 2004 globally, there were 70 MW used for consumer products, 80 MW used for signal and communications, and 180 MW used for residential and commercial off-grid applications (Maycock 2005a).

(n) Where 2004 data are not available, 2004 numbers are determined based on assumed growth rates from year(s) of last reported data and considering differing or conflicting data from multiple sources.

(o) Solar PV is separated into grid-connected and off-grid to reflect the different market characteristics of each application, such as costs relative to competing alternatives and types of policy support.

(p) Lund (2005) reports 1.7 million geothermal heat pumps with 56% of total geothermal heat capacity (27,600 GWth). But he notes the data are incomplete. Geothermal heat pumps grew by 24% per year from 2000-2005, a tripling of capacity in five years.

[N4] Electric Power Capacities

Table N4 presents installed electric power capacities. The table is based on author's database compiled from individual country statistics and submissions from report contributors, also IEA 2003a, 2004b; IEA 2004c; EREC 2004; AWEA 2005; EWEA 2005; GWEC 2005; Maycock 2004 and 2005a; Johansson & Turkenburg 2004; Martinot et al. 2002 plus updates; Martinot 2004a. Many figures in the table are approximate, valid at best to two significant figures. These sources also provide information for much of the capacity discussion of Section 1.

Small hydro totals reflect reported small hydro, generally according to a definition of 10 MW, but higher in some countries such as China, which officially defines small hydro as less than 50 MW.

Municipal solid waste is commonly reported in biomass power generation statistics for OECD countries. However, municipal solid waste is not included in the biomass power generation capacity figures here because equivalent statistics from developing countries are not available and because municipal solid waste is not considered a form of renewable energy by some. There was 6.7 GW of municipal solid waste in OECD countries in 2002 (IEA 2004a), so including this figure increases world total biomass power capacity to 46 GW.

Table N4. New Renewable Electric Power Capacity, GW existing as of 2004

Technology	World Total	Developing Countries	EU-25	China	Germany	U.S.	Spain	Japan
Small hydropower	61	39	13	34	1.6	3.0	1.6	3.5
Wind power	48	4.3	34.2	0.8	16.6	6.7	8.3	0.9
Biomass power	39	22	8	2.3	0.9	7.2	0.3	> 0.1
Geothermal power	8.9	4.5	0.8	< 0.1	0	2.5	0	0.5
Solar photovoltaic-grid	1.8	0	0.9	0	0.7	0.1	0	0.8
Solar thermal electric	0.4	0	0	0	0	0.4	0	0
Ocean (tidal) power	0.3	0	0.3	0	0	0	0	0
Total renewable power capacity (excluding large hydro)	160	70	57	37	20	20	10	6
For comparison:								
Large hydropower	740	330	90	70	n/a	90	n/a	45
Total electric power capacity	3,800	1,400	580	440	n/a	860	n/a	260

Notes:

(a) There is no international consensus on the definition of small hydropower (SHP). In China, it officially refers to capacities of up to 50 MW, in India up to 15 MW, and in Brazil up to 30 MW. In Europe, capacity of up to 10 MW total is becoming generally accepted by ESHA (European Small Hydropower Association) and the European Commission. Many published figures for small hydropower apply a definition of 10 MW maximum, which tends to exclude capacity from China, Brazil, and some other countries. Thus other published figures can be substantially smaller than the figures presented here, which represent data according to each country's definition.

(b) Grid-connected solar PV exists in small quantities of a few MW in some other countries, primarily as small demonstration projects. Zero is given in the table because these numbers are much smaller than 0.1 GW, thus not significant enough to register.

(c) Comparison of "new" renewable power capacity to total electric power capacity does not provide a good comparison of actual energy produced. Capacity factors for conventional electric power generation are much higher than for most "new" renewable energy sources. So even though global "new" renewable capacity is roughly 4% of the world total capacity, electricity produced from renewables is about 2% of world total electricity production.

(d) These figures should not be compared with previous versions of this table or similar tables to get growth rates. Adjustments from previous versions are a combination of real growth plus adjustment due to improved data.

[N5] Large Hydropower Capacity and Growth Rate

IEA (2004c) shows OECD hydro was 393.8 GW in 1999 and increased to 407.9 GW in 2002, for a 1.2% annual growth rate for the three-year period 2000-2002, or an average of 4.7 GW per year. China's large hydro capacity has been increasing by 6-8 GW per year in recent years. (China installed 7.6 GW of large hydro capacity in 2004, according to Water Conservation Information Network (www.hwcc.gov.cn). China's total hydro capacity went from 53 GW in 1999 to 105 GW in 2004, with 14 GW of the increase being small hydro. So large hydro increased by 38 GW, or 7.5 GW per year average during the five-year period 2000-2004.) Other developing countries probably represent another 3-5 GW per year, for total capacity additions of probably 14-16 GW per year. Thus, given the current installed large hydro capacity of 760 GW, the global average growth rate is on the order of 2%.

US EIA *International Energy Annual 2003* (EIA 2005a) gives world total of 15,852 TWh of electric power generation in 2003, including 2,654 TWh from all hydro. Allowing for 3% annual growth in 2004 (2% for hydro) results in 16,328 TWh total and 2,707 TWh for all hydro in 2004. Subtracting 160 TWh of small hydro from this (assuming a third of small hydro doesn't appear in global statistics), gives 2,540 TWh large hydro in 2004. EIA gives 2,461 TWh hydro in 1995 and 12,634 GWh total generation. Total hydro is thus 16.6% of global total for 2004 and 19.5% in 1995. Subtracting small hydro, large hydro alone is roughly 16% in 2004 and 19% in 1995.

Altinbilek et al. 2004 gives 730 GW and 2,650 GWh of hydro worldwide based on a 2003 source, so this number is presumed to be 2002 data. This is consistent with an IEA (2004b) figure of 2,676 TWh of hydro in 2002. Given the other sources, this number appears correct for large hydro, excluding all (or most) of small hydro. Allowing a 2% growth rate in 2003 and 2004 gives 760 GW in 2004.

Hydropower production statistics for 2004 from BP (2005).

There is a basic conflict between hydro statistics reported by the International Hydropower Association and World Energy Council, and those from the International Energy Agency. IHA and WEC statistics suggest total hydro worldwide was around 750 GW in 2004. The IEA shows hydro in OECD at 425 GW in 2002, which when added to reported small and large hydro in developing countries from several sources yields a total in the range of 800-820 GW allowing for modest growth since 2000 (most other data are for 1999-2000). It is believed that the former set of statistics misses some installed capacity due to reporting channels used. This report places more credibility in the later set of figures, with a total of 800 GW hydro, 740 GW large hydro, and 60 GW small hydro.

[N6] Wind, Geothermal, Biomass Power

Table N6 shows added and existing wind power. There is some variation of statistics depending on source, with data from the Global Wind Energy Council (2005) and BTM Consult (Cameron 2005) differing by about 200 MW world total added in 2004 and also in cumulative existing capacity (EWEA cites GWEC data of 47,317 MW total installed at end of 2004). Other sources include the AWEA (2005) and EWEA (2005a).

Offshore wind power 0.6 GW installed comes from New Energy Finance, www.newenergyfinance.com, as reported in RenewableEnergyAccess.com, "Blustery Conditions for European Wind Power
New Energy Finance White Paper Outlines Difficulties in European Wind Power Market," 22 July 2005. www.newenergyfinance.com/NEF/HTML/Press/Offshore-wind-funding.pdf and www.renewableenergyaccess.com/rea/news/story?id=34645. (Note: China is also beginning to develop off-shore wind, with plans for the first wind farm off-shore of Shanghai in 2006.)

Information on biomass power and heat from IEA (2004b), Kartha et al. (2004), and submissions from report contributors. Also IEA 2005c.

Information on geothermal power and heat from Lund (2005a and 2005b). Information on biomass power generation is the most difficult to develop and generally relies on more informal data collection from in-country sources. In reporting on geothermal heating, Lund notes: "the world direct utilization of geothermal energy is difficult to determine; as, there are many diverse uses of the energy and these are sometimes small and located in remote areas. Finding someone, or even a group of people in a country who are knowledgeable on all the direct uses is difficult. In addition, even if the use can be determined, the flow rates and temperatures are usually not known or reported; thus, the capacity and energy use can only be estimated. This is especially true of geothermal waters used for swimming pools, bathing and balneology."

Some of the biomass used for power generation around the world is urban and industrial residues, what the IEA calls "combustible renewables and waste." Urban residues, landfill gas (LFG), and digester gas from municipal water treatment and concentrated animal feeding operations (CAFOs) are currently very important and are becoming more so—they provide environmental services as well as generate energy. (This report excludes MSW from the biomass power generation statistics given, as comparable statistics for developing countries are not available and some contributors felt MSW belongs in a separate category and should not be mixed with "pure" biomass.)

Table N6. Added and Existing Wind Power, Top 10 Countries, 2004

Country	Added in 2004 (MW)	Existing in 2004 (MW)
Germany	2,050	16,600
Spain	2,070	8,300
United States	390	6,700
Denmark	10	3,100
India	880	3,000
Italy	360	1,300
Netherlands	200	1,100
Japan	230	990
United Kingdom	250	890
China	200	770

[N7] Grid-Connected Solar PV

Table N7 shows grid-connected solar PV from the largest programs worldwide, which make up most of the global grid-connected solar PV. Sources: Maycock 2004 and 2005a; Jones 2005; Dobelmann 2003; California Energy Commission 2004; Navigant Consulting 2005; submissions from report contributors.

EU-15 grid-connected capacity was 316 MWp in 2002, including 258 MWp in Germany (EREC 2004). Thus, about 60 MWp existed in the EU outside of Germany in 2002. Czech Republic has 120 kWp grid-connected, Poland 47 kWp, and Romania 10 kWp (EREC 2004).

Table N7. Grid-Connected Solar Rooftop Programs, 2004

Program and start year	Cumulative homes as of 2004	Cumulative installations as of 2004	Installations added in 2003	Installations added in 2004	Supporting policies
Japan (1994-2005)	200,000	800 MWp	190 MWp	260 MWp	"Sunshine program" capital subsidy started at 50% in 1994, declining to about 10% by 2003.
Germany (1999-2003)	150,000	680 MWp	140 MWp	300 MWp	"100,000 roofs program" provided low-interest loans for households and 50 eurocents per kWh feed-in tariff through 2003. Since 2004, market supported by feed-in tariffs of 45-62 eurocents/kWh.
California programs (1998-)	15,000	95 MWp	27 MWp	36 MWp	State program capital subsidy of $4.50/W(AC) declined to $3.50/W(AC). There are also municipal utility (SMUD, LADWP) and utility RPS programs.

Notes:

(a) California reports total number of installations, which includes both residential and commercial, but the number of residential installations is assumed to be much higher than the number of commercial installations. The number of homes reported is consistent with an average of 4 kW/home and residential being more than half of total installed capacity in 2004.

(b) Assumption of 4 kW/home for new 2004 installations in Japan and Germany. Cumulative homes for 2003 estimated at 170,000 in Japan and 65,000 in Germany based on prior reports of homes and capacity.

(c) On-grid solar PV capacity in Europe was 480 MWp in 2003, of which 375 MW was in Germany. The Netherlands was the major contributor, with 44 MW in 2003. So additional on-grid capacity in Europe in 2004, besides Germany, was probably about 110 MW.

(d) Korea in 2005 announced a 100,000 rooftop program targeting 0.3 GW of solar PV by 2011.

(e) Thailand has had a small rooftop solar PV program. As of July 2004, 67 kWp were installed, subsidized by EPPO.

(f) Japan's program was due to end in 2005. In 2004, Japan had 1,100 MWp of installed PV, 800 MWp for homes and 300 MWp for commercial and public buildings and other uses (not clear what fraction is grid-connected).

[N8] Solar Hot Water/Heating

Table N8a: Solar Hot Water Installed Per-Capita, Top 10 Countries, 2004

Country	**Installations (m^2/1000 inhabitants)**
Israel	740
Cyprus	620
Greece	260
Austria	260
Turkey	140
Japan	100
Australia	70
Germany	70
Denmark	60
China	50

Note: This table excludes Barbados and other small island nations with population less than 500,000. Barbados has 277,000 inhabitants and at least 35,000 SWH systems. The indicator would be around 250 m^2/1,000 inhabitants and this means Barbados would rank 5 of the top 10.

Source: Weiss et al. 2005; Li 2002 and 2005; ESTIF 2004 and 2005; Martinot 2004a; Karekezi & Kithyoma 2005; submissions from report contributors.

Table N8b: Solar Hot Water Installed Capacity, Top 10 Countries/EU and World Total, 2004

Country/EU	**Existing 2003 (million m^2)**	**Additions 2004 (million m^2)**	**Existing 2004 (million m^2)**	**Existing 2004 (GWth)**
China	50.8	13.5	64.3	45.0
EU	13.1	1.6	14.0	9.8
Turkey	9.5	0.8	9.8	6.9
Japan	7.9	0.3	7.7	5.4
Israel	4.7	0.4	4.9	3.4
Brazil	2.2	0.2	2.4	1.6
United States	2.1	0.05	2.0	1.4
Australia	1.4	0.1	1.5	1.1
India	0.9	0.1	1.0	0.7
South Africa	0.5	--	0.5	0.4
(other countries)	< 2	--	< 2	< 1.5
World Total	95	17	110	77

Notes:

(a) Figures exclude passive (swimming pool) heating, which is considered a separate application from domestic hot water and space heating.

(b) Retirements are difficult to estimate for some countries, so all figures are approximate. The totals here reflect 2 million m^2 of retirements in 2004, not including China.
(c) The International Energy Agency's Solar Heating and Cooling Program (IEA-SHC) recommended in December 2004 that SHW be reported in GWth (gigawatt thermies), with a standard conversion factor of 0.7 GWth per million m^2.
(d) Additions for 2004 and existing 2004 for Turkey, Israel, United States, Australia, India, and Egypt are extrapolations based on actual 2003 installations. A 5% retirement rate of existing stock is assumed in the extrapolation. The resulting global total checks against estimates of 2004 by Weiss et al. 2005.
(e) Modeling retirements in Japan is a complicating factor in both Japanese and global totals, as retirements have been high relative to new installations for the past several years. Weiss et al. 2005 have a total about 4.5 million m^2 higher than the figure used here for Japan in 2003, but the lower number used here is based on another model of retirements by Japanese researchers consulted for this report (also see the reference: Solar System Development Association website, www.ssda.or.jp/index.php). The global total of 110 million m^2 (77 GWth) would be 115 million m^2 (80 GWth) using the higher number for Japan.
(f) About 1.5 million is estimated to be installed in Africa, primarily in South Africa, Egypt, and Niger (Karekezi & Kithyoma 2005).
(g) Solar hot water numbers in a given year must account for both additions and retirements. Retirements are modelled and estimated by various organizations in different ways, and so figures are not always compatible, particularly for countries with long-standing markets in which many systems are now reaching the end of their service life. In particular, there is a large discrepancy as to how to account for retirements in Japan, leading to a large divergence between figures published by the IEA (Weiss et al. 2005), which give 12.4 million m^2 in 2004, and those provided by other Japanese sources, which give 7.7 million m^2 in 2004. The lower figure is used in this report.
Sources: Weiss et al. 2005; Li 2002 and 2005; ESTIF 2004 and 2005; Martinot 2004a; EurObserv'ER 2005b; Karekezi & Kithyoma 2005; submissions from report contributors.

The solar thermal industry in Europe will install 1.2 GWth of capacity during 2005 according to the latest statistics from the European Solar Thermal Industry Federation. See story at ReFocus, at www.sparksdata.co.uk/refocus/fp_showdoc.asp?docid=83735293&accnum=1&topics=

[N9] Ethanol and Biodiesel

Table N9. Biofuels Production, Top 12 Countries, 2004 (billion liters)

Country	Ethanol (billion liters)	Biodiesel (billion liters)
Brazil	15	---
United States	13	0.1
China	2	---
Germany	0.02	1.1
France	0.1	0.4
Italy	---	0.35
Canada	0.2	---
Thailand	0.2	---
Spain	0.2	---
Denmark	---	0.08
Czech Republic	---	0.07
Australia	0.07	---
World Total	31	2.2

Notes:
(a) Ethanol figures do not include production of ETBE in Europe, which was about 0.7 billion liters in 2004.
(b) Finland plans to build a biodiesel production plant of 170,000 tons/year capacity by 2007, which would put it in fourth place in Europe behind Germany, France, and Italy.
(c) Fulton et al. 2004 gives Germany 2002 biodiesel capacity as 750,000 liters/year and sales as 550,000 liters/year. Production was 550,000 tons in 2002; 720,000 tons in 2003; and 1 million tons in 2004 from EurObserv'ER 2005a.
(e) Germany added 0.3 billion liters/year biodiesel production capacity in 2004, and 0.1 billion l/yr for ethanol.
(f) Ethanol in the United States, 2005 figures, from presentation by Brian Jennings, Executive Vice President, American Coalition for Ethanol (Jennings 2005). Jennings gives 3.4 billion gallons produced in 2004, or 13 billion liters. Also same from the Renewable Fuels Association (www.ethanolrfa.org/pr050223.html), an increase of 21 percent from 2.8 billion gallons (10.6 billion liters) in 2003.
Sources: Adapted from Fulton et al. 2004; Lichts 2005; EurObserv'ER 2005a; US Renewables Fuels Association (www.ethanolrfa.org); IEA 2004d; and submissions by report contributors.

Australia Ethanol Limited gives 70 million liters/year produced in Australia (presumed current), and Fulton et al. (2004) gives 40 million in 2002.

In Spain, there are currently two ethanol production facilities, one in Cartagena, with capacity of 100 million liters, and the other in Teixeiro, with capacity of 126 million liters (IEA 2005c)

Other countries in Europe have also decided to go into biodiesel production. Spain started up its biggest biodiesel production unit (250,000 tons) last May in the region of Cartagena. The company, called Biodiesel Production, is part of the German group Sauter and has invested 50 million euros in this project. A first 100-ton biodiesel production unit will also be put into service in Portugal next August. The Ibersol company, a subsidiary of the German food group Nutas, is responsible for this 25 million euro investment. Other units are also under construction or in project stage in the United Kingdom and Finland.

In Canada, there are currently more than 1,000 retail locations selling ethanol-blended gasoline in six provinces. Approximately 7 percent of gasoline sold in Canada is currently blended with ethanol. Ethanol production is expected to grow to 1.4 billion liters to meet the Government of Canada's target of 35 percent of Canadian gasoline containing 10 percent ethanol by 2010. This target means that ethanol production will have to increase from production of 200 million liters per year (2004) to 1.4 billion liters per year. To reach that target the federal government, through Natural Resources Canada, has implemented an Ethanol Expansion Program (EEP) that provides funding for construction of new ethanol plants or plant expansions. Under the first round of EEP CDN, $72 million in contributions has been allocated to six projects across Canada, and in the second round an additional CDN$46 million have recently been allocated. In addition to EEP the federal government provides an exemption on its gasoline excise tax of $0.10 per liter of ethanol. At the provincial level, Manitoba provides the greatest exemption of the provinces at $0.25 per liter of ethanol produced and consumed in the province, British Columbia $0.11 /liter (when a plant is built in BC), Alberta $0.09 /liter (no restriction on ethanol source), Saskatchewan $0.15 /liter (ethanol must be produced/consumed in SK), Manitoba $0.25 /liter (ethanol must be produced/consumed in MB), Ontario $0.147 /liter (no restriction on ethanol source), Quebec $0.198 /liter (when plant is built in QC). (www.nrcan-rncan.gc.ca/media/newsreleases/2005/200550a_e.htm and other sources).

This report generally compares ethanol and gasoline based on equivalent energy content rather than volumetric equivalents. It may be that some of the comparisons mistakenly are based on volumetric equivalents, since source material sometimes isn't clear. The energy content of ethanol is only 70% or so of gasoline on a volumetric basis.

Liquid fuels from biomass have major impacts on land use, farm policy (which in turn bears indirectly on the poor agricultural countries in the developing world), and food pricing. Corn farmers in the U.S. appreciate the fact that in 2003 the substitution of 1.5% of gasoline on an energy basis consumed 14% of the corn crop. In 2005, due to demand for ethanol there was a savage spike in sugar prices. In Brazil, ethanol production fluctuates with sugar prices; when sugar prices are low more ethanol is produced, and when high less ethanol is produced. Fulton et al. (2004) covers the food and land issues.

[N10] Ethanol in Brazil

Total ethanol consumption by cars in Brazil was 12.5 billion liters in 2004, 5.22 as hydrated, used in neat ethanol and flex-fuel cars, and 7.22 as anhydrous, blended to gasoline. Total gasoline for road use (essentially cars, since almost no truck uses gasoline) in 2004 was 15.8 billion liters. Thus, on a volume basis, gasoline represents 15.8 billion liters in a total volume of 28.3 billions liters of liquid fuels for cars. Ethanol share is 44.2%. Production of ethanol in 2004 was 16.0 billion liters , which surpasses gasoline production of 15.8 billion liters. From the 16.0 billion, 2.52 billion was exported and 1.02 billion used for other purpose than fuel. For the year 2005 it is expected there will be an increase in ethanol consumption and a decline in gasoline, but even so gasoline will be responsible for more than 50%.

[N11] Renewable Energy Cost Comparisons

Three sources of recent information are the IEA reports *Renewables for Power Generation* (IEA 2003a), *Renewable Energy Market and Policy Trends in IEA Countries* (IEA 2004b), and *Biofuels for Transport* (IEA 2004d).

Sources for Table 2 include: IEA 2003a; IEA 2004b; OECD and IEA 2005; ICCEPT 2002; Fulton et al. 2004; Johansson & Turkenburg 2004; and submissions from report contributors.

Ethanol from cellulose shows great promise for future cost-competitiveness. Canada and Sweden are leading research and demonstration. Canada has helped to fund construction of the first commercial-scale cellulosic ethanol production plant, which converts wheat straw into ethanol using an advanced enzymatic hydrolysis process. Such plants may eventually become common, and will allow ethanol to be produced from almost any type of biomass, including agricultural and forestry wastes and high-yielding dedicated energy crops such as poplar trees and switchgrass. The province of Ontario plans to provide additional recognition for ethanol produced from cellulosic feedstocks (e.g., wood, straw) in its proposed ethanol regulation.

Technology cost estimates and projections for renewable power generation technologies, made by the International Energy Agency and Imperial College of London, are shown in Tables N11a and N11b. Compared to the costs of historical coal and natural gas generation costs (typically 2-4 cents/kWh, although recent natural gas price rises are increasing costs in some countries), hydro, geothermal, and some forms of biomass power generation are already competitive with good resources and sites. Wind power costs are approaching competitive levels, and are expected to achieve those levels sometime by 2010. Solar PV costs are still substantially higher, although compared to retail residential electricity rates in some countries with substantially above-average rates (i.e., 20-30 cents/kWh), the costs of solar PV should likewise become competitive before 2010, particularly in sunny (high insolation) climates.

Geothermal costs for Table 2 are those for new plants at new sites. Costs will vary higher and lower depending on whether they are for currently operating plants, expansion plants on existing fields, or new plants at new sites.

Table 2 states that wind-generated electricity fell from about 46 cents/kWh in 1980 (in the U.S.; 2003$) to 4-5 cents/kWh at good sites today. DOE document DOE/GO-102005-2115, April 2005, p. 4 says "…dramatic reductions in cost – from $.0.80 (current dollars) per kWh to about $0.04/kWh for utility-scale turbines…."

Also, the statement in Table 2, "how to make the machines bigger is still the number one technological issue in the turbine industry," oversimplifies the technical challenges facing the wind industry.

Table N11a. Power Generation Costs, 2002 and Projections for 2010

	Capital costs ($/kW)	Low-side generation costs (cents/kWh)	High-side generation costs (cents/kWh)	Low-side generation costs by 2010
Small hydro power	1,000-5,000	2-3	9-15	2
Solar PV power	4,500-7,000	18-20	25-80	10-15
Concentrating solar power	3,000-6,000	10-15	20-25	6-8
Biopower	500-4,000	2-3	10-15	2
Geothermal power	1,200-5,000	2-5	6-12	2-3
Wind power	850-1,700	3-5	10-12	2-4

Source: IEA 2003a

[N12] Global Investment in Renewable Energy

Investment figure of $30 billion/year developed from database of installed capacity by technology for the period 1995-2004, as used for Martinot 2004a, along with submissions from report contributors, using global average capacity costs (installed costs, including balance of plant for solar PV). Further details of cost estimates taken from the literature and explanations of cost assumptions used for those papers are available at www.martinot.info/markets.htm.

Typical investment costs for 2004 were estimated as follows:

- SHW in China: $150/m^2$
- SHW elsewhere: $800/m^2$
- Wind: $1,200/kW
- Solar PV (installed): $7,000/kW
- Geothermal heat: $500/kWth
- Geothermal power: $1,600/kW
- Biomass heat: $200/kWth
- Biomass power: $2,000/kW
- Small hydro in China: $900/kW
- Small hydro elsewhere: $1,300/kW
- Large hydro in China: $1,400/kW
- Large hydro elsewhere: $2,000/kW

Table N11b. Costs of Renewable Energy Compared with Fossil Fuels and Nuclear Power

Technology	Current cost (U.S. cents/kWh)	Projected future costs beyond 2020 as the technology matures (U.S. cents/kWh)
Biomass Energy:		
• Electricity	5-15	4-10
• Heat	1-5	1-5
Wind Electricity:		
• Onshore	3 - 5	2-3
• Offshore	6 - 10	2-5
Solar Thermal Electricity (insolation of 2500kWh/m^2 per year)	12-18	4-10
Hydro-electricity:		
• Large scale	2-8	2-8
• Small scale	4-10	3-10
Geothermal Energy:		
• Electricity	2-10	1-8
• Heat	0.5-5.0	0.5-5.0
Marine Energy:		
• Tidal Barrage (e.g. the proposed Severn Barrage)	12	12
• Tidal Stream	8-15	8-15
• Wave	8-20	5-7
Grid connected photovoltaics, according to incident solar energy (insolation):		
• 1000 kWh/m^2 per year (e.g. UK)	50-80	~8
• 1500kWh/m^2 per year (e.g. southern Europe)	30-50	~5
• 2500 kWh/m^2 per year (most developing countries)	20-40	~4
Stand alone systems (incl. batteries), 2,500 kWh/m^2 per year.	40-60	~10
Nuclear Power	4-6	3-5
Electricity grid supplies from fossil fuels (incl. T&D)		Capital costs will come down with technical progress, but many technologies largely mature and may be offset by rising fuel costs
• Off-peak	2-3	
• Peak	15-25	
• Average	8-10	
Rural electrification	25-80	
Costs of central grid supplies, excl. transmission and distribution:		Capital costs will come down with technical progress, but many technologies already mature and may be offset by rising fuel costs
• Natural Gas	2-4	
• Coal	3-5	

Source: ICCEPT 2002

Wind power costs from previous years might justify a figure than $1,200/kW, but in 2004 wind power costs rose, some said to more typically $1,300/kW, due to higher steel prices from high global demand for steel. Canada reported $1,500/kW in 2004 (according to a private communication with the Canadian Wind Energy Association). Solar PV prices also increased in 2004. Solar PV prices in 2004 in California were reported at $9,000/kWp installed. Canada solar PV prices in 2004 were reported at $8,000/kWp. However, the assumption of $7,000/kWp was left unchanged from 2003.

Solar hot water costs in China for 2002 were reported by Li (2005). Over 70% of solar hot water heaters were sold in 2002 at prices less than 1,500 RMB ($180) and the lowest-cost heaters typically comprise 2 m^2 of collector area. This would imply a cost of $90/$m^2$. A further 26% of products are sold between RMB 2,200-3,000 ($270-360), probably implying costs of $100-120/$m^2$. High-end systems, still a small market share, sell for $300/$m^2$. The China SHW industry in 2000 had 6 million m^2 production and $750 million revenue, or an average of $125/$m^2$ in revenue. This has probably increased since 2000 as larger and more expensive systems capture more of the market. Another expert source gives 1,000-1,500 RMB/m^2 as typical costs, or $120-180/$m^2$. An average cost of $150/$m^2$ is assumed for solar hot water collectors in China, for purposes of calculating global investment figures. This is still much lower than estimated costs in Europe and other developed countries.

Small hydropower costs in China are reported from one Chinese source as 3,000-6,000 RMB/kW, or $370-740/kW. This is significantly lower than small hydro costs elsewhere. But others have questioned such low figures, so $900/kW is used.

Cost data from a variety of sources, including Johansson & Turkenburg 2004, Turkenburg et al. 2000, EC 2002a, IEA 2004b, IEA 2003a, and ICCEPT 2002. EC CORDIS cost data from Section 1.9 on geothermal energy (12/20/02), Section 1.10 on photovoltaics (12/23/02), Section 1.11 on small hydropower (12/20/02), Section 1.12 on solar heating and cooling (12/20/02), Section 1.15 on wind energy (12/23/02) and Section 1.3 on CHP microturbines (12/18/02).

Investment of $4-5 billion for capital expenditures in 2004 by the solar PV industry is estimated by Michael Rogol, MIT, and CLSA Asia-Pacific (personal communication). See also CLSA Asia-Pacific Markets (2004). Some of this investment will not immediately translate into increased production in 2005 due to time required to get some capacity up-and-running (e.g. silicon production capacity takes 18-24 months or longer to reach full production) and due to constraints on silicon availability (e.g. significant portion of Chinese ingot growth capacity is idle). Rogol also estimates the figure will be $5-7 billion for 2005.

Comparisons with global investment in power generation are rough estimates based on 2.5-3% average growth in power generation worldwide and personal communications with experts. Some experts believe the total may be much higher than $150 billion, perhaps closer to $400 billion for the entire power sector, including transmission and distribution and fossil fuel supply chains. Comparisons of renewables power generation investment with global power generation investment exclude transmission and distribution investment and fossil fuel supply chains, which might mean the comparison is too favorable to renewable energy.

[N13] Private Financing and Venture Capital

Venture capital investment from Makower et al. (2005) and Liebreich & Aydinoglu (2005). CLSA Asia-Pacific Markets projections from CLSA Asia-Pacific Markets (2004). An updated version was available in mid-2005.

New Energy Finance, Ltd. (2005) analyzed 201 venture capital investment rounds from 2001 to 2004, covering total estimated investment of $2.2 billion, including about $1.2 billion in efficiency, fuel cells, and hydrogen. Investment increased from $414 million in 2003 to $958 million in 2004, although it is not clear how much of the increase was for renewable energy.

[N14] Public Financing

EIB total financing for renewables was reported by EIB as € 91 million in 2000, € 180 million in 2001, €682 million in 2002, € 414 million in 2003, and €469 million in 2004. The average for 2002-2004 is € 520 million. Converting to USD at an average exchange rate of $1.20 yields $630 million. EIB is a public sector institution in the sense that it is owned by the EU Member States. However, it raises its resources on capital markets. It only has access to "public money"—funds that come from government budgets—in the case of its financing operations under the Cotonou Agreement's Investment Facility in the African, Carribbean and Pacific (ACP) Countries. The Investment Facility resources in fact come from the European Development Fund financed by the EU Member States. Source: personal communication with EIB, 2005.

For information on EIB renewable energy lending between 1999 and 2003, see: http://www.eib.org/Attachments/thematic/renewable_energy_en.pdf

All exchange rate conversions done using € 1 = $1.20, the rate as of July 2005, and are thus conversions into current 2005 dollars rather than 2002, 2003, or 2004 dollars.

[N15] Multilateral and Bilateral Financing for Developing Countries

From 1990-2004, the World Bank Group committed $1.8 billion to new renewables, which along with co-financing of $450 million from the Global Environment Facility, resulted in $2.3 billion World Bank/GEF combined financing for new renewables. The World Bank also committed $3.9 billion to large hydro (>10 MW) during this period (World Bank 2005, Table 1). Thus, average World Bank Group financing for new renewables has historically been about $120 million per year (excluding GEF financing). This average has remained in recent years. During the three-year period 2002-2004, the World Bank Group committed an average of $113 million per year to new renewables ($338 million committed to new renewables by IBRD, MIGA, IFC, IDA, and carbon finance in 2002-2004 per Table 3, Annex 2). Associated with those commitments was GEF co-financing averaging $43 million per year during the three-year period 2002-2004. The World Bank Group also committed an average of $166 million per year to large hydro during the three-year period 2002-2004 (no

GEF co-financing involved). Thus total World Bank/GEF financing for all renewables during the three-year period 2002-2004 averaged $320 million per year. (Note: "World Bank Group commitment" as used in World Bank 2005 includes allocations by the GEF. This report separates the two agencies and reports on their commitments separately.)

World Bank and GEF projects often include non-renewables components, or are blended with energy efficiency components, making it difficult to analytically separate out the renewable energy finance from other finance. Reported figures by these agencies are subject to such analytical uncertainties, and it is possible that non-renewables finance from a few projects is included in reported renewables totals.

GEF-reported financing figures for renewable energy include fees paid to the GEF implementing agencies. If such fees are excluded, GEF financing would average closer to $90 million per year for the three-year period 2002-2004 rather than $100 million per year. Some discrepancies may exist with other reported figures because this report totals by calendar year, while the GEF totals by fiscal year.

From 1999 to 2002, OECD DAC overseas development assistance averaged about $130 million/year for non-hydro renewables and about $400 million/year for hydro (OECD DAC, cited in Saghir 2005; OECD DAC 2005). Total official development assistance (ODA) for hydro averaged more than $420 million per year during the five-year period 1999-2003. Donor statistics are from OECD DAC (2005) and include all forms of reported donor assistance to developing countries.

Table N15. Overseas Development Assistance for Renewable Energy, 1999-2003

	1999	2000	2001	2002	2003
	(million dollars)				
Hydro	244	368	584	694	239
Geothermal	33	0.3	0	1.7	0.2
Solar	8	13	197	32	50
Wind	33	3	31	53	151
Ocean	0	0.003	0	0	0
Biomass	0.9	8.4	3.8	10.4	1.5
Total non-hydro	75	25	232	97	203

Note: Average for period for non-hydro new renewables is $130 million/year, for hydro $420 million/year.
Source: OECD DAC 2005.

Financing amounts based on e-mail queries and interviews with agency officials and a variety of unpublished sources. The $500 million public financing for developing countries only includes public funds from projects—grants, loans, and other financing from governments, international agencies, or other public sources. These are often called "budgetary funds." Figures do not include private financing tied to projects, often called "private financing" or "market funds."

Source for OECD Agreement on Officially Support Export Credits: OECD 2005. Sources for future multilateral commitments: email inquires and interviews with development agency officials; OECD 2005; submissions by report contributors.

In 2004, KfW approved about € 151 million for renewable energy, of which € 81.6 million were "budget funds" and € 69.3 million were "market funds." The budget funds are considered public-source investment and the market funds are considered private-source investment. Source: KfW, personal communication. Use mid-2005 exchange rate of € 1 = $1.20 for conversions into dollar equivalent.

[N15b] Bonn Action Programme in International Context

Source for the content analysis of the Action Programme is Fritsche & Kristensen 2005.

There are no global estimates for CO_2 emissions reductions from renewables in the literature, so a rough estimation was made for power generation. Analysis of global CO_2 emissions is approximate and does not include rural energy technologies like solar home systems and biogas digesters (which are orders of magnitude lower than the other numbers here).

Power generation avoided CO_2 emissions calculated at 0.6 billion tons CO_2/year for new renewables, excluding biofuels and heating, and 3.6 billion tons/year for large hydro (based on 720 GW). Assumptions for power generation: (a) Large hydro replaces baseload power, i.e. coal. (b) Small shares of gas-CC are offset by similar shares of lignite. (c) Small hydro is same as large hydro. (d) Wind replaces intermediate load, i.e. 50% from coal and 50% from gas-CC in OECD, and 50% from coal and 50% oil-fired GT in developing countries. (e) Biomass replaces 50% baseload and 50% intermediate load. Same assumptions on mix for all countries. (f) Geothermal replaces 100% baseload. (g) Solar PV replaces 100% peak load from 50% gas-CC and 50% oil-fired GT. (h) Solar-thermal replaces 50% intermediate load and 50% peak load. (i) Ocean tidal replaces 100% baseload. Emissions factors (CO_2 eq in g/kWhel): 1,040 for coal in developing countries; 1,050 for coal in OECD; 451 for gas-CC; and 1,141 for oil-GT. Capacity factors: large hydro 68%, small hydro 57%, wind 23%, biomass 51%, geothermal 74%, solar-PV 11%, solar-thermal 23%, and ocean tidal 68%.

Solar hot water was probably around 25-30 million tons avoided CO_2/year in 2004. Weiss et al. (2004) give 15 million tons CO_2/year from all SHW, excluding unglazed, in 2001, with 70 million m^2 installed. Installed increased by 60% by 2004, to 110 million m^2. China reported 13 million tons CO_2 from solar hot water in 2003, with 52 million m^2 installed.

Geothermal heat supply is about two-thirds of solar hot water on a thermal output basis, and thus might be 20 million tons/year. Biomass heating is about 70% more than biomass power generation on an equivalent energy basis, and since much biomass is combined heat and power, the same fossil fuels would be displaced for both. Addition analysis for hot water/heating and gives about 0.2 billion tons CO_2/year total.

Biofuels probably add another 100-120 million tons/year. Rossillo-Calle & Cortez (1998) estimated 46 million tons CO_2/year avoided from Brazil biomass in 1998-1999, when production was 15 billion liters, about the same as today. The global biofuels market is now more than twice as large as Brazil.

[N16] R&D Spending and Subsidies

The IEA RD&D database for all IEA countries (IEA 2005d) gives $352 million, $364 million, and $356 million for solar RD&D for the years 1999-2001 (using data based on exchange rates rather than PPP). Total of all solar, wind, ocean, biomass, small hydro, and geothermal for these three years is $2,165 million, for an average of $720 million per year. Of this number, about $250 million was accounted for by the United States, and another $130 million by Japan, with the remaining $340 million by European countries. RD&D on large hydro for all IEA countries averaged $10 million per year. All numbers are slightly lower if PPP is used rather than exchange rates. There is a large discrepancy in reported RD&D for the U.S. in 1999 by the IEA, which gives $280 million, and the U.S. Energy Information Administration (1999), which gives $327 million.

Estimates of global subsidies for fossil fuels and nuclear power taken from UNEP & IEA (2002). Also, Johansson and Turkenburg2004 say "at present, subsidies to conventional energy are on the order of $250 billion per year" (p.29). Earthtrack (earthtrack.net) has a comprehensive set of references on subsidy policies and estimates.

Goldberg (2000) gives U.S. federal subsidy estimates for the period 1943-1999 (cumulative) of $5.7 billion (1999 dollars) for wind, solar, and solar thermal power. Another $1.6 billion is estimated for subsidies to hydropower during the same period. One source cited (EIA 1999) gives $1.1 billion subsidies for renewables in 1999 alone, including hydropower. This represents federal on-budget, for direct payments, tax expenditures, and research and development. It includes $725 million for ethanol excise tax exemption, $327 million for R&D, $15 million on income tax exemptions, and $4 million on direct expenditures. Ritschel & Smestad (2003) cite $135 million per year in California public benefit fund support for renewables in the late 1990s. They also quote $9 billion for global subsidies to renewable energy and energy efficiency, compared to $150 billion for fossil fuels and $16 billion for nuclear power, citing van Beers & de Moore (2001). In the United States, public benefit funds in more than a dozen states are spending $300 million per year on renewables (Martinot et al. 2005).

The OECD defines subsidies as: "any measure that keeps prices for consumers below market levels, or for producers above market levels or that reduces costs for consumers and producers." EEA (2004) notes that energy subsidy definitions that refer only to a direct cash payment to an energy producer or consumer ignore a range of other indirect support mechanisms, including tax measures, and the effects of trade restrictions and other government interventions (such as purchase obligations and price controls) on prices received by producers and paid by consumers.

EEA (2004): Off-budget subsidies are typically transfers to energy producers and consumers that do not appear on national accounts as government expenditure. They may include tax exemptions, credits, deferrals, rebates and other forms of preferential tax treatment. They also may include market access restrictions, regulatory support mechanisms, border measures, external costs, preferential planning consent and access to natural resources. Quantifying off-budget subsidies is complex, in some cases impossible. It often requires that the benefit be calculated on the basis of differential treatment between competing fuels, or between the energy sector and other areas of the economy.

EEA (2004): Taxation policy is a key mechanism for off-budget support in energy markets. A fuel may be exempted from certain taxes, or enjoy lower rates of value added tax (VAT) and excise duty in relation to other fuels or to the wider economy. Tax exemptions, rebates and incentives for investments in the energy sector and for the installation of energy related materials and equipment may allow industry and consumers to offset their costs. Accelerated tax depreciation may also be permitted, allowing energy-related equipment to be amortised (have the costs written off) more quickly, thereby lowering effective tax rates in the early years of an investment.

EEA (2004): Regulatory support mechanisms make up the other most significant area of off-budget support for the energy sector. These mechanisms most commonly take the form of price guarantees and demand quotas for specific energy sources. They are introduced to support environmental, economic, employment or energy security policy objectives. Some of these mechanisms, such as feed-in tariffs or competitive tenders can be described as ‘supply push’ mechanisms, in that they stimulate production. Others, such as purchase obligations are ‘demand pull’ mechanisms in that they create an artificial demand to which the market responds.

EC (2004) estimated energy subsidies in the EU. It noted that “Various attempts have been made to quantify the type and amount of aid provided to energy industries. There is no comprehensive official record of historical and ongoing energy subsidies in the EU.” With various caveats and analytical notes, that report provides indicative estimates of € 0.6 billion in on-budget subsidies and more than € 4.7 billion in off-budget subsidies for renewable energy in 2001.

A Greenpeace-commissioned report in the late 1990s, titled “Energy Subsidies in Europe,” cited $1.5 billion in direct subsidies for renewable energy (Greenpeace 1997). Jennings (2005) gives $1.7 billion in ethanol fuel subsidies (excise tax exemptions) in 2004 (roughly 3.4 billion gallons times 51 cents/gallon).

One report contributor well versed with energy subsidies thought the subsidy numbers used for this report were too low. Some factors that might cause the numbers to be too low: (1) State and provincial subsidies are quite important with renewables. Sub-national subsidies are most relevant with oil, gas, and certain renewables (through the portfolio standards, but also many direct subsidies to ethanol). (2) As ethanol absorbs a higher percentage of total corn production, it's pro-rated share of corn subsidies rise as well. The ethanol share was 9.7% of corn production in 2003. Between 1995 and 2002, the Environmental Working Group tallied subsidies to corn at $34.6 billion, or $4.33 billion per year. The ethanol share of this in 2003 would have been $420 million, making it the second largest subsidy to the fuel. Pass-through of irrigation subsidies to corn would be additional, but I've not seen it estimated. It's important not to forget about these ancillary subsidies to key feedstocks, be they corn or uranium. (3) Tax-exempt debt used for energy purposes are often ignored in many public accountings of subsidization. Sometimes they pick up tax-exempt private activity bonds, but if the facility is municipally-owned the subsidies are often lumped in with all tax-exempt debt issued by states. Tax-exempt debt is used for WTE plants and landfills (affecting the cost of landfill-gas-to-energy), and perhaps for other projects classed as renewable energy as well. (4) Large scale hydro continues to receive large and varied subsidies associated with the government ownership that they often entail. Low market interest rates tend to reduce the value of some of these subsidies, since historically they had very long term bonds at fixed low interest rates. Such contracts deviate less from market conditions during low interest rate periods. For this reason, dam financing subsidies to hydro may be lower than in the past, though other forms of support still exist. It is not clear if some of the subsidy numbers include large hydro or not.

Global subsidy estimates are highly uncertain. If they are done by aggregating the various existing studies, they generally suffer from large inaccuracies associated with double-counting and non-systematic valuation methods. Often, very large but more complicated value transfers are missing entirely from at least a portion of the studies. This may include incomplete evaluation of tax breaks and loan guarantees; and exclusion of programs of are of large benefit to particular fuels, but not solely targeted to them. Shifting of accident or cleanup liability to the public sector is also commonly missing. If they are generated using price-gap methods for multiple countries (the gap between the domestic price and the world price for a fuel), they will pick up only the portion of subsidies that affect domestic prices, totally missing the support that leaks to other factors of production.

It is possible that many of these problems underlie what seems a low global value for nuclear subsidies of $16 billion per year. That is roughly what some estimated in the U.S. alone during the early 1990s, and accident liability caps outside of the U.S. are even more generous to producers than Price-Anderson is inside. Thus, the real value of nuclear subsidies is most likely much higher. Investment incentives, sovereign guarantees or guaranteed purchase contracts, accident liability caps, public responsibility for waste management, losses on uranium enrichment, and support for uranium mining are all common subsidies to the sector. Most likely many of these are missing from the $16 billion figure. It's also useful to be clear about separating fusion and fission subsidies, as the former is pretty much basic research while the latter is a market-distorting subsidy—even if supporting new reactor designs.

For the fossil fuels, a check to see if estimates include any allowance regarding research on externalities (such as climate change) or energy security (such as securing key infrastructure or shipping; or oil stockpiling) would be warranted. These are big-ticket items generally ignored in most subsidy studies.

[N17] Market Capitalization and Top 60 Publicly-Traded Companies

The following companies represent a preliminary list of companies that meet the following criteria: (1) publicly traded stock, and (2) more then US$40 million in market capitalization attributable to renewable energy. This list is provisional and may inadvertently exclude stocks that meet these criteria. Market capitalization attributable to renewable energy is a rough estimate. For “pure play” renewable energy stocks (stocks that have bulk of earnings from renewables), market capitalization is assumed to be 100% attributable to renewable energy. For companies engaged in renewable energy as a minority of earnings, we have made rough estimate of earnings from renewable energy, divided this by total earnings and multiplied this percentage by total market capitalization to derive a rough estimate of renewable energy market capitalization. In cases where this was not possible due to information being either confidential or not available, we made an outside-in estimate of renewable energy capacity, revenue and operating profit. We then took the ratio of renewable energy operating profit by the company's total operating profit, then multiplied this ratio by the total market capitalization. Categories of renewable energy included in this list include bio fuels/biomass, geothermal, hydro, solar, wave and wind energy. Sources include: Bloomberg, MarketWatch.com, CLSA Asia-Pacific Markets, InvestGreen.com, Investext, Reuters, and company data. List compiled by John Michael Buethe (Georgetown University) and CLSA Asia-Pacific Markets.

Acciona (Spain), Alliant Energy (USA), Automation Tooling Systems (Canada), Bharat Heavy Electricals (India), Boralex (Canada), BP (UK), Brascan (Canada), British Energy (UK), Calpine (USA), Carmanah Technologies (Canada), Conergy (Germany), Corning (USA), Cypress Semiconductor (USA), Daystar (USA), E.On Energie (Germany), Endesa (Spain), ENEL (Italy), Energy Developments (Australia), Enersis (Chile), Eni (Italy), Evergreen Solar (USA), Florida Power & Light Energy (USA), Gamesa Energia (Spain), General Electric/GE Wind (USA), Geodynamics (Australia), Greentech Energy Systems (USA), Ishikawajima-Harima Heavy Industries (Japan), Japan Wind Development (Japan), Kaneka SolarTech (Japan), Kyocera (Japan), Marubeni (Japan), Mitsubishi Electric (Japan), Mitsubishi Heavy Industries (Japan), Nordex Energy (Germany), Novera Energy (Australia), Omron (Japan), Ormat Technologies (USA), Pacific Hydro (Australia), Pfleiderer (Germany), Repower Systems (Germany), RWE (Germany), SAG Solarstrom (Germany), Sanyo (Japan), Scottish Power (UK), Sekisui Chemical (Japan), Sharp (Japan), Shell (UK), Solar Integrated Technologies (UK), Solar-Fabrik (Germany), Solarparc (Germany), SolarWorld (Germany), Solon (Germany), Spire (USA), Sunways AG Photovoltaic Technology (Germany), Talisman Energy (Canada), Tokuyama (Japan), TransCanada (Canada), TXU (USA), Vestas (Denmark), XCEL Energy (USA).

In addition to these companies with publicly-traded stock, there are many other companies involved in renewable energy, such as private unlisted companies and public utilities, that are not traded on stock exchanges. There were no clear criteria or data available to include these companies in an expanded list for this version of the report. Prominent examples of such companies include Iberdrola of Spain, Nuon and Essent of the Netherlands, Electricité de France, Hydro Quebec of Canada, Hydro Tasmania of Australia, Norsk Hydro and SN Power of Norway, and Enercon of Germany. It also excludes project developers that may not have large capital bases but still are major players in the renewables industry. Examples include Zilkha Renewables of the United States (owned by Goldman Sachs), Clipper Windpower and AES of the United States (which just bought Seawest), Eurus of Japan, and many others. There is also the issue of renewable energy value chains and what part of the value chain constitutes a renewable energy business—such as PV silicon wafer manufacturers, manufacturing equipment suppliers, and wind turbine blade manufacturers like LM Glasfibre of Denmark. Future versions of the status report could attempt to create a more comprehensive list.

[N18] Wind Power Industry and Costs

Wind technologies fall into two distinct types: large turbines, designed to supply electricity to the grid, typically 1-3 MW rated capacity with blade diameters of 60-100 meters, and small turbines rated from around 3 kW up to around 100 kW. As wind technology has matured, large wind turbines have become increasingly standardized. All are now broadly similar three bladed designs. However, the potential for innovation has not been exhausted. There is scope for cost reductions through site optimization and innovations in blade and generator design and in grid connection using power electronics. Offshore wind power is still in its infancy and large potential cost reductions exist.

Typical wind turbines produced today are in the 1-3 MW scale, although the 600 kW scale is still common in India and China. European manufacturers have introduced new wind-turbines in the 5 MW range, and achieved an evolution of cost per kW of installed capacity from 1,650 Euro/kW in 1986 to about 850 Euro/kW in 2004. At present little offshore wind capacity is installed anywhere in the world. As with onshore developments during the 1990s, Europe is the lead, with all the world's operating offshore capacity and ambitious plans for future development in the 2006-2007 timeframe. The first large-scale offshore wind farm (160 MW) was completed in 2002 in Denmark.

Wind technology costs have declined 12-18% for each doubling of global capacity, with costs of wind-generated electricity falling from about 46 cents/kWh in 1980 (in the US; 2003$) to 4-5 cents/kWh at good sites today. Technology development and cost reduction have been driven primarily by feed-in policies in just a few countries: Germany, Denmark, and Spain. The German Wind Energy Association (BWE) estimated that the costs of wind power in Germany fell in real terms by 55% between 1991 and 2004.

How to make the machines bigger is still the number-one technological issue in the turbine industry, with the current philosophy being that the larger the turbine, the greater its cost effectiveness. The average size of turbines installed increased by only around 3% to 1.25 MW in 2004, with the three-blade, three-stage gear box design remaining the most popular. Some progress is being made in producing a single-geared generator, with German company Enercon being the only one to commercially produce them at present. 5 MW turbines remained the largest available but so far only three prototype units have been installed worldwide. (Cameron 2005).

During 2003-2004, there were six competitively-bid wind projects in China and Canada , totaling almost 2,000 MW, that show winning-bid prices from 4.1-4.8 eurocents/kWh, considerably lower than most present feed-in tariffs (see Table N31). However, competitive bidding in new markets may not reflect commercially viable prices if aspiring market entrants underbid to gain market entry or mis-bid due to insufficient experience.

Wind power markets remain fragmented by country. That is, the wind market is not yet a global market but really a collection of national markets, each growing fairly independently. Wind power has become a mainstream commercial investment in about 8-10 primary countries (including Denmark, Germany, India, Italy, Netherlands, Spain, the United Kingdom, and the United States) (Figure 6). Several countries are now taking their first steps to develop large-scale commercial markets, including Russia and other transition countries of Europe, China, South Africa, Brazil, and Mexico. In the case of China, most wind power investments historically have been donor or government driven, but a shift to private investors has been underway in recent years. Several other countries are at the stage of demonstrating wind farm installations, looking to develop commercial markets in the future.

The global market for small-scale wind turbines has been growing rapidly in recent years. Small-scale wind turbines (typically 100-1,000 W) provide power for homes and remote locations. The largest installed base of small-scale turbines is an estimated 230,000 in Inner Mongolia in China, for household use. Sales of small wind turbines were estimated to be 13,000 in 2005, totaling 14 MW (an average of 1 kW per turbine), bringing total small wind capacity to 30 MW. Manufacturers are aiming to reduce hardware costs by 20 percent to $1,700 per installed kW by 2010; and the average size of small wind turbines has doubled from 500 W in 1990 to 1 kW in 2004.

[N19] Solar PV Costs, Industry, and Production Capacity Expansion

The three main types of solar PV in commercial production are single-crystal, polycrystalline, and thin film. Japanese single-crystal solar cell technology has seen its module conversion efficiency improve from 6% in 1963 to over 17% today. The average efficiency of polycrystalline silicon cells is approaching 15%, and of thin film 10-12%. Still under development are the super-thin flexible cell, which has attained 38% efficiency, and the condensed type, which has attained 28.5%.

Since 1976, costs have dropped about 20% for each doubling of installed PV capacity, or about 5%/year. (Module prices have fallen from $30/W in 1975 to close to $3/W today. Costs rose slightly in 2004 due to high demand (which outpaced supply) and the rising cost of silicon. Rooftop PV systems currently cost around $6,000-$9,000 per kW installed.

The potential for further cost reductions as markets expand is appreciable. The technologies are small-scale and modular, and the scale economies of batch production and new manufacturing techniques have been barely exploited. In addition, conversion efficiencies of PV modules have seen continuous improvement through the use of new materials and cell designs. One of the issues for the future of PV is whether and how fast crystalline silicon can be replaced by high-volume, low-cost thin-film production.

Global solar PV module prices reached a low of $2.60/Wp in 2002/2003 (Sharp), but have since rebounded to average of about $3.25/Wp in 2004. But grid-connected installed prices remained flat (about $5.50/AC-watt in Japan and $6.50-8.00/AC-watt in the U.S.). One reason for module price increases is the rising cost of silicon due to high demand (coupled with the industry's traditional reliance on computer-industry scrap silicon). Another reason is simply high demand relative to existing production. In China, solar PV module prices declined from an average of $5/Wp in 2000 to $3.50/Wp in 2003, but rose again to $4/Wp in 2004 due to raw material shortages and increased demand relative to supply. The high prices in 2004 were spurring many new manufacturers to get into the solar PV business, as profits were also high.

The PV industry celebrated its first gigawatt of global installed capacity in 1999. Five years later, by the end of 2004, this capacity had quadrupled to more than 4 GW. Solar PV market growth has very much been influenced by the grid-connected rooftop programs in Japan, Germany, and the U.S. state of California since the mid-1990s. Indeed, without these programs, the solar PV industry would likely be several years behind where it is today.

Investment in solar PV production capacity is growing in both capacity and plant scale. World solar PV production grew from 740 MW in 2003 to 1,150 MW in 2004. In 2004, U.S. solar PV production increased 39% even as its share of global production fell to 11%. Japanese production topped 600 MW. German production was up 66%, representing 60% of total European production. Production expansion continued aggressively around the world in 2004 (Table N19).

China and other developing countries have emerged as major solar PV manufacturers. As of 2004, China had 70 MW of cell production capacity and 100 MW of module production capacity, compared to the world total module production capacity of 1,150 MW. Chinese module production capacity doubled during 2004, from 50 MW in 2003. (China's domestic PV market was 20 MW in 2004, so most production is exported.) Production capacity could double again in 2005, as the Nanjing PV-Tech Co. launched construction of China's largest PV cell production facility, with 100 MW capacity, in early 2005. The Nanjing plant is scheduled to be finished by the end of 2005. Also, Chinese Electrical Equipment Group Ltd. plans to invest in new solar cell production capacity of 600 MW by 2008.

Other developing countries are also emerging as solar PV manufacturers. India's primary solar PV producer is Tata BP solar, which expanded production capacity from 8 MW in 2001 to 38 MW in 2004. Central Electronics, Bharat Heavy Electrical, and WEBEL Solar are other leading solar cell/module manufacturers in India. In the Philippines, Sun Power doubled its production capacity to 50 MW in 2004. In Thailand in 2004, Solartron PLC, a solar-cell module assembler, announced plans to develop the country's first commercial solar cell manufacturing facility, with annual capacity of 20 MW, to start production in 2007.

Future plans for production expansion by the major solar PV manufacturers, as well as major new entrants, are also impressive. Announced plans by major manufacturers for 2005 included at least 400 MW increase in production capacity and several hundred megawatts further capacity in the 2006-08 period (Table N19).

Table N19. Solar PV Production Capacity Expansion

Company (in order of *PV News* 2004 rank)	**Expansion in 2004/early 2005**	**Future Plans**
1. Sharp (Japan)	Increased capacity at Katsuragi Plant, bringing annual capacity from	

	315 MW to 400 MW. New line represents investment of 5 billion Yen (US$50 million).	
2. Kyocera (Japan)	Capacity increased to 120 MW, from 72 MW in 2003. Opened new assembly plant in Mexico; increased production at facilities in Japan and Czech Republic to 24 MW.	Plans to double PV module manufacturing capacity to 240 MW/year during 2005. Mexico plant expected to reach annual production of 36 MW in 2005.
3. BP Solar (United States, Spain, Australia, Malaysia, Hong Kong, India)	15 MW increase in 2004. BP total global manufacturing capacity has increased from 34 MW in 1999 to 90 MW in 2004.	Plans to increase global production capacity from 90 MW to 200 MW by end-2006. Global expansion will include increase from 40 to 50 MW in Sydney, Australia; investment of Aus$8 million (about US$6.33 million). And more than $25 million to expand Frederick, MD, USA facility from 20 MW to 40MW.
4. Mitsubishi (Japan)	Total annual production capacity grew from 35 MW in Jan. 2003, to 50 MW in Sept. 2003, and to 90 MW in June 2004.	Will expand annual production capacity of PV cells and modules at Nakatsugawa and Kyoto Works from 90 MW to 135 MW by mid-2005 and planning to reach 230 MW by 2006. Will invest 3.3 billion Yen ($30 million) in new equipment.
5. Q Cell (Germany)	European production increased from 28 to 75 MW, making Q Cell the number-one producer in Europe.	
6. Shell Solar (U.S., Germany, Netherlands)	72 MW produced.	
7. Sanyo (Japan)	Expanded to 150 MW in Osaka, with 7.5 billion Yen (US$70 million) investment in 2004.	New plant in Hungary will be 50 MW by mid-2005 and 100 MW by 2006.
8. Isofoton (Spain)	Number two in Europe; increased production from 35 MW in 2003 to 53 MW in 2004.	
9. RWE Schott Solar (Germany)	Produced more than 50 MW in 2004.	Committed to 40 MW increase at facility in Bavaria, bringing total production to 100 MW.
10. Deutsche Shell (Germany)	Production up from 17 MW in 2003 to 24 MW in 2004.	
SolarWorld AG (Germany)		Increasing production capacity by 40 MW for total of 120 MW. Plan to double solar silicon PV manufacturing from 120 MW to 220 MW by end of 2006; have secured financing package of

		some € 80 million (US$100 million). Expect to reach at least 150 MW in 2005.
Photovoltech	13 MW produced.	Will increase cell production at Belgium facility from 13 MW to almost 80 MW in 2006.
Sun Power (Philippines, China)	Doubled Philippine cell production to 50 MW.	
Suntech (China)	Increased production, with 50 MW planned by 2004.	
Nanjing PV-Tech Co., Ltd (China) (also Chinese Electrical Equipment Group Co.)	(not yet operating)	In March 2005, launched construction of China's largest and most advanced solar production facility, in Nanjing. Expect 100 MW of production capacity in place by end of 2005. Plans to produce 600 MW solar cells by 2008.
Motech (Taiwan)	Production up by 106% to 35 MW in 2004.	
Evergreen Solar (United States)	Increased solar string production capacity in Massachusetts to 15 MW.	Announced 30-MW plant in Germany with Q-Cells as partner
First Solar - AZ (USA)	6 MW produced.	Plans to triple the output of its Ohio facility, to bring thin-film solar PV production to 40 MW/year by 2006, and 75 MW by 2007.

[N20] Biomass

Cost reductions have been achieved in the area of small- to medium-scale steam turbines for biomass-based co-generation (mainly from woody residues) in Germany and Finland, and for "new" smaller-scale co-generation technologies like ORC and stirling engines (mainly Austria and Germany). Currently, plants of this type are estimated to deliver energy at a cost between $0.07/kWh (a CHP scheme) and $0.12/kWh (electricity only). Engineering assessment suggests that capital costs could be reduced by half through replication and economies of scale once the plants enter early commercial application. Much lower costs could be achieved in co-firing applications, where suitable quantities of biomass can be supplied to existing coal plants for example.

The largest potential for cost reduction lies with gasification technologies. Costs of advanced biomass gasifiers are dropping to 10-12 cents/kWh for megawatt-scale gasifiers. Small-scale gasification of biomass still lacks development, but from RT&D in the area of biofuels (BtL schemes), positive impacts are expected to medium- to large-sized gasification and, hence, for efficient biomass-based electricity generation using gas turbines and combined cycles. China and Europe are both leaders in small-scale gasification technology.

Rural biomass pelleting for heat and power. The most prominent development in Europe is the rapid introduction of pellet heating systems, mainly in Finland and Sweden, and to a smaller extent in Austria, Germany, and the UK. Cost reductions per unit of installed kWth could be achieved by some 10%, and logistics to deliver pelletized fuels to customers improved significantly. In developing countries, rural use of biomass for power generation and heating could be on the verge of wide-scale commercial use because of deployment of pelleting and briqueting technologies. These technologies improve portability, reliability, and range of feedstocks. (E.g. Project in Bangalore to palletize agricultural waste and gasify it and a mobile pelletizing process technologies being developed in China.)

[N21] Geothermal

Geothermal energy has been used for electricity generation and heat for about 100 years. Electricity generation from geothermal sources can take place at various temperatures, starting from below 100 °C ("Binary" power plants, ORC or Kalina-cycle) to high-temperature steam plants with more than 300 °C steam temperature. The distribution of power plant types in terms of installed power is the following: Natural steam 29%, single flash 37%, double flash 25%, binary 8%, and back-pressure 1%. For heat production, hydro-thermal resources are commonly used for district heating, and CHP plants.

Natural steam or hydrothermal resources are easiest to exploit, typically located at depths of 1-4 km and containing steam or liquid hot water. Molten rocks (magma systems) may also be accessed in the future at greater depths (up to 7 km) as can hot dry/wet rocks at 4-8 km, depending on the temperature gradient. The hot dry/wet rocks concept, more generally called "enhanced geothermal systems," has been proven successfully in a European test facility. Hot dry/wet rock resources are much more abundant, and are in principle available everywhere just by drilling sufficiently deep to produce rock temperature useful for heat extraction.

Geothermal heat pumps, also called ground source heat pumps (GSHP), are increasingly being used for building heating and cooling. Ground couplings include borehole heat exchangers (vertical loops), groundwater wells, horizontal loops in the soil, and similar techniques.

The main technical challenges being addressed for reducing costs and opening up new resources include cheaper driller techniques (drilling typically accounts for half of the capital costs), remote detection of producing zones during exploration, well-stimulation measures or 'heat mining' to extract the heat more extensively and efficiently, and better power conversion technology.

[N22] Biofuels

Ethanol is the most common biofuel, accounting for more than 90% of the total usage. Ethanol is most frequently used in low-concentration blends with petroleum gasoline. In North America and parts of Europe, blends of 5-10% (E5 and E10) are common, and selected filling stations in a few major metropolitan areas sell

E85 for "flexible fuel" vehicles that can run on either gasoline or ethanol. The warm climate of Brazil also makes feasible the use of E95, and an increasing number of vehicles capable of using that fuel are being sold. ETBE, a mixture of ethanol and isobutylene (petrochemical), is used in low-concentration gasoline blends up to about 8-10% in fuels in parts of Europe, particularly France and Spain. (ETBE is "25% renewable" on a carbon atom basis and some question whether it should be considered a renewable fuel.)

In the U.S., construction of 12 new ethanol plants was completed in 2004, bringing the total to more than 80 plants. Also in 2004, construction of 16 new plants was started. More and more states are requiring that use of MTBE as a gasoline oxygenator be discontinued, due to its toxicity and contamination of drinking water, and ethanol is being used as a substitute. Consequently, by 2004, over 30% of all gasoline sold in the U.S. was being blended with ethanol as a substitute oxygenator (Renewable Fuels Association 2005).

There were more than 300 sugar mills/distilleries producing ethanol, served by a plantation area of 5.4 million hectares. In early 2005, 39 new distillers were licensed. As production increases, some even expect that ethanol exports could reach 6 billion liters/year by 2010. Several larger bioethanol plants will begin production in 2005 in Germany and the United States. Projections for the global market are for 60-75 billion liters/year by 2010.

Ethanol prices in Brazil have steadily fallen. Prices (in 2002 US$) fell from $11/GJ in 1980 to $5/GJ in 2002, and since 1999 have been equal to or below the equivalent Rotterdam gasoline price (Goldemberg et al. 2004).

Ethanol is now very competitive with gasoline. Cost reductions have been driven by Brazil and U.S. policies and also improvements in production efficiencies with additional investments and technology advances.

Ethanol from cellulose shows great promise for the future. Canada has led research in this field, and has helped to fund construction of the first commercial-scale cellulosic ethanol production plant, which converts wheat straw into ethanol using an advanced enzymatic hydrolysis process. Such plants may eventually become common, and will allow ethanol to be produced from almost any type of biomass, including agricultural and forestry wastes and high-yielding dedicated energy crops such as poplar trees and switchgrass.

International biofuels trade has expanded rapidly during the past few years. World ethanol trade volume hit a record level in 2004, reaching nearly 4.9 billion liters, compared with 3.7 billion liters in 2003. Brazil is by far the biggest exporter, accounting for about half of international shipments of ethanol during 2004. Japan and the U.S. were the largest importers, with India close behind. However, Brazilian ethanol prices during 2004 were near historic lows, fuelling trade, and higher ethanol prices likely during 2005 could slow or even reverse this trend, at least in the short term. There was also considerable biofuels trade (of both ethanol and biodiesel) within the EU (between various member countries), and growth in intra-EU trade appears likely to continue with the 10 new members beginning to play an active role.

Biodiesel was not produced in significant quantities anywhere in the world prior to 1996. By 2004, biodiesel markets had developed in seven primary countries (Austria, Belgium, France, Germany, Italy, Indonesia, and Malaysia). Germany has been the biggest biodiesel producer, with about 2 billion liters capacity on line or under construction. France, Italy, and the UK are the next largest producers.

A biodiesel market is emerging in the U.S., with currently between 20 and 25 biodiesel production sites, with an estimated production capacity over 150 million gallons per year. An additional 100 million gallons of annual capacity is under construction or has been announced. Sales of biodiesel exceeded 30 million gallons in 2004, and are expected to more than double in 2005 due to tax incentives. A recent example of expansion is a 15-million-gallon-per-year biodiesel production plant planned for Missouri by Mid-America Biofuels. The plant will use the soybean oil from nearly 10 million bushels of soybeans grown in the state, representing approximately 7 percent of Missouri's average annual harvest.

India has been examining for quite some time the supply of ethanol-blended petrol in the country. In order to ascertain financial and operational aspects of blending 5% ethanol with petrol, the government had launched three pilot projects in different states during 2001 and these pilot projects were supplying 5% ethanol-doped-petrol only to the retail outlets under their respective supply areas. The Society for Indian Automobile Manufacturers (SIAM) has confirmed the acceptance for use of 5% ethanol-blended petrol in vehicles. State governments of major sugar producing states and representatives of sugar/distillery industries have confirmed availability/capacity to produce ethanol. An expert group established by the government recommended blending of ethanol with petrol at supply locations (terminals/depots) of oil companies. In 2003, the government resolved that 5% ethanol-blended petrol would be supplied in the nine states and four union territories. For biodiesel, a national program aims to produce enough oil seeds for the production of biodiesel in sufficient quantities to enable its blending with diesel to the extent of 20%. Pilot projects and analyses of feed-stock collection and plantations were ongoing.

[N23] Concentrating Solar Thermal Power

In Europe, research and development for concentrating SEGS was significantly increased in 2003 and 2004. New designs using Fresnel reflectors are being proposed, promising 20% cost reductions as compared to the standard parabolic trough and tower concepts. Performance of trough receiver tubes continues to increase, thermal storage continues to be developed for trough systems, and advanced stirling dishes are under test at some laboratories.

[N24] Jobs from Renewable Energy

We conducted a literature review of analytical factors for jobs-per-existing-capacity and jobs-per-unit of produced capacity (Table N24c). We then totalled the jobs based on existing installed capacity in 2004 and new manufactured/installed capacity in 2004 (Table N24a). In general, employment impacts of renewable energy development are difficult to measure in a precise way, especially if total employment figures—including both direct and indirect jobs—are to be estimated. A proper approach would be to build input-output analysis models, an analytic tool that macroeconomists use to derive employment multipliers with which to predict the number of jobs (direct and indirect) created by sales increases from a given sector or industry. The simplified alternative adopted here is to use analytical approaches to define employment coefficients, generally based on (a) information on labor time needed for a unit of power (i.e. person-years per MW), or (b) data on expenditure necessary to support a full-time job annually (person-years/USD invested).

Table N24a. Estimation of Jobs from Renewable Energy, 2004

Technology	**Global capacity (MW as of 2004)**	**Additional capacity in 2004 (MW)**	**Current employment in manufacturing (person-years in 2004)**	**Current employment in O&M (jobs)**
Small hydropower	62,000	5,000	56,500	13,640
Wind power	48,000	8,200	31,160 – 60,680	4,800 – 9,600
Biomass power	38,000	800	1,600 – 6,800	12,160 – 79,040
Geothermal power	9,000	200	800 – 3,500	15,300
Solar PV	4,000	900	22,590* - 29,097	4,000 – 10,000
Solar thermal (hot water)**	116 million m^2	18 million m^2	13,6056	381,150
Solar thermal electric power	400	--	--	280
Ocean (tidal) power	300	--	--	30
Total			**249,000 – 293,000**	**431,000 – 509,000**
Ethanol production	--	32 billion liters	**902,000 direct jobs*** **	
Biodiesel production		2.2 billion liters	**31,000 direct jobs******	

(*) = This low estimate is obtained with the parameter from Pembina Institute (2004), as the lower figure from Greenpeace does not account for installation labor.

(**) = These estimates are obtained by using coefficients derived from 2000 Chinese industry data (see Table N24c) for Chinese production and de-rated (30% lower) coefficients for the production capacity of the other countries assuming higher labor productivity.

(***) = Estimated global direct jobs obtained by applying the Brazilian employment coefficient of Table N24c to production in Brazil (14 billion liters), China (2 bill. ltrs.) and others (1 bill. ltrs.), and a 30% discounted coefficient to take into account the less labor-intensive U.S. production (14 bill. ltrs.).

(****) = Estimated assuming jobs in biodiesel production are half of the jobs in ethanol production, per liter produced.

Table N24b. Some Additional Parameters, Country Data, and Relevant Employment Impact Estimates

Technology	Manufacturing & Installation	O&M	Source & Notes
Wind	2.6 Jobs/MW	0.3 Jobs/MW	EPRI, 2001
Geothermal	4.0 Jobs/MW	1.7 Jobs/MW	
Solar PV	7.1 Jobs/MW	0.1 Jobs/MW	
Biomass	3.7 Jobs/MW	2.3 Jobs/MW	
Wind	7.75 person-years/MW		Heavner & Del Chiaro 2003–2005 estimates Using EPRI factors (time adjusted), authors calculate total employment impacts for 2004-2017 (in person-years) in California, with an assumption that only 30% of manufacturing is locally provided. Here, the person-year/MW parameters are derived from their 2005 estimated scenario of added capacity.
Geothermal	41.57 person-years/MW		
Solar PV	5.2 person-years/MW		
Biomass	56 person-years/MW		
Wind	17 person-years/MW	5 person-years/MW	EWEA 2003. Figures derived from an Input-Output model.
Solar PV	20 Jobs/MW	30 Jobs/MW	EPIA 2004. Information on existing direct employment in Europe (the 30 jobs/MW figure includes installation, consulting, retail, and other services)
Small hydro	2,200 (1,200 manufacturing + 1,000 consulting and research) people employed in Europe in 2002		ESHA, www.esha.be/
Solar thermal power	356 person-years employed in U.S. in 2002		Data from US DOE, EIA
Solar thermal power	16.33 person-years/MWe	1.58 person-years/MWe	Schwer & Riddel 2004. Estimated employment impacts of 3 x 100 MWe concentrating solar plants in Nevada.

Additional Explanatory Notes:

Methodological premise. Employment impacts of renewable energy development are difficult to measure in a precise way, especially if total employment figures—including both direct and indirect jobs—are to be estimated. A proper approach would be to build *Input-Output analysis* models (see note-f below), an analytic tool that macroeconomists use to derive employment multipliers with which to predict the number of jobs (direct and indirect) created by sales increases from a given sector or industry. A simplified alternative is to use *analytical approaches* to define employment coefficients, generally based on (a) information on labor time needed for a unit of power (i.e. person-years per MW), or (b) data on expenditure necessary to support a full-time job annually (person-years/USD invested).

Table N24c summarizes some of the most relevant employment coefficients developed by analysts. The following points summarize additional explanatory elements on the employment impact parameters and estimates presented:

(a) Most of the studies in the literature focus on *direct jobs* that is, employment generated within the renewable energy industry chain, usually disaggregated in the following categories: manufacturing, construction and installation, operation and maintenance, and fuel collection. They therefore do not count the *indirect jobs*, that is, those jobs created in the economy by multiplier effects in the renewable energy sectors.
(b) There are different ways to build employment impact indicators. Many studies report on employment in the manufacturing and installation segment in terms of *person-years per MW*, that is the amount of labor time required to manufacture equipment (or build a power plant) equivalent to MW of power. In Tables N24b and N24c, this indicator has been selected to offer the picture of how many full-time employees were working in renewable energy manufacturing and installation in 2004. For this reason, whenever possible, other employment coefficients from the literature were adapted to person-years values. The indicator *Jobs per MW* is used in Table N24c with regards to the O&M and fuel collection segments of labor, it refers to permanent employment, that is the number of laborers needed continuously to support the ongoing operation of a power plant with a maximum output of one MW.
(c) Generally the employment created is measured against the power capacity installed (MWp), as it is in this report, but an alternative may be to consider as common denominator the average power capacity (MWa), the power capacity de-rated for taking into account the capacity factor of each energy technology. This way an indicator that standardizes the actual energy outputs is obtained and values referring to employment impacts of different RE technologies can be compared.
(d) Table N24a reports the range of values of estimated employment obtained by using the lowest and the highest employment coefficients of Table N24c for each technology. While for solar hot water heaters there are not many employment studies and parameters available, it should be noted that the Chinese industry is representative of the largest production (72% of global production in 2004). Therefore the choice was to use Chinese industry data to derive employment coefficients and adjust them to account for lower labor intensity for the non Chinese production figures. As for biofuels, the employment parameter (Table N24c) and the estimate figure (Table N24a) refer to total direct employment in the relevant agriculture and industrial sectors, thus it is presented separately from the other employment estimates.
(e) All figures estimating the labor requirement of renewable energy presented in Table N24c have been developed in the OECD countries, except for solar heating and biofuels. It can be recognized that in a developing country context the same processes and markets can be more labor intensive per MW, thus leading in a probable underestimation of global employment when applied to global renewable energy capacity figures in Table N24a.
(f) For further reference, see MITRE Project (EC 2002b**)** for a good example of this method applied to the growth scenarios of renewables across technologies and within EU 15 member states: starting from SAFIRE model of market penetration for the different RE technologies, an input-output model named RIOT (Renewables Enhanced Input Output Tables) was used to calculate production functions representing the value

of inputs (including employment) needed from the different sectors of the economy to obtain a unit of energy from different energy sources (both conventional and renewables). These parameters were then used to model net employment impacts (including the substitution of conventional energy sector jobs) in the scenarios at 2010 and 2020.

Table N24c. Summary of Relevant Employment Coefficients

	Estimates of Employment Coefficients			
Technology	**Manufacturing & Installation (person-yrs/MWp)**	**O&M and Service (Jobs/MWp)**	**Source**	**Type of study, type of impact, and basic assumptions**
Small hydro	11.30	0.22	Pembina Institute 2004	Data from industry interviews and literature review; direct impacts only.
Wind	3.80	0.10	Singh et al. 2001 (REPP)	Analytical study from industry survey of labor requirements for a 37.5 MW wind farm with 30% capacity factor; direct employment impacts.
	7.40	0.20	Heavner & Churchill 2002	Direct employment impacts projected from planned projects by California Energy Commission.
	6.0	(100-450 per TWh)	ECOTEC 2002	Based on information from EWEA, citing 20,000 direct jobs in wind industry in Europe in 2001.
	3.92	0.10	Pembina Institute 2004	Data from industry interviews and literature review; direct impacts only.
Biomass	8.5	0.32 – 2.08*	Singh et al. 2001 (REPP)	Analytical study from industry survey of labor requirements for a set of co-firing plants (100 MW-750 MW) and several biofuels; direct employment impacts.
	2.0	0.95*	Pembina Institute 2004	Data from industry interviews and literature review; direct impacts only.
Geothermal	4.0	1.70	Pembina Institute 2004	Data from industry interviews and literature review; direct impacts only.
	17.50	1.70	Heavner & Churchill 2002	Direct employment impacts projected from planned projects by California Energy Commission.
Solar PV	32.33	2.25	Singh et al. 2001 (REPP)	Analytical study from industry survey of labor requirements for a 2 kWp

				solar roof market; direct employment impacts.
	25.10	2.5	Pembina Institute 2004	Data from industry interviews and literature review; direct impacts only.
	17.0**	1.0 (O&M) + 30.0 (installation, retailing, other)	Greenpeace & EPIA 2005	These parameters have been developed with EPIA for a scenario analysis of direct employment in Europe.
Solar thermal power	6.25	0.70	US DOE 1997	Derived from information on the 9 plants (350 MW) of solar thermal electricity generation in California.
	20.0 per GWh	1.0 per GWh	GAC 2005	Gross direct and indirect employment estimates from I-O model developed in Germany.
Solar hot water (***)	8,330 per mill. m^2	3,850 per mill. m^2	Author estimates	Derived from 2000 Chinese industry figures, assuming 1/3 of employment absorbed by manufacturing and 2/3 by O&M.
Ocean (tidal) power	4.22	0.10	Pembina Institute 2004	Data from industry interviews and literature review; direct impacts only.
Biofuel (ethanol)	33 direct jobs per million liters of production		Goldemberg 2004	Estimated starting from data and parameters developed by UNICA, Brazilian sugar cane producers association.

Notes:
(*) = Includes fuel collection and processing activities.
(**) = Does not include installation of PV systems, accounted for together with the O&M figure.
(***) = Parameters estimated by the authors based on data collected from the Chinese solar water heaters industry (6 mill. m^2 of annual production and 26 mill. m^2 of installed systems in 2000), which by 2004 had grown to account for about 70% of world annual production (13 mill. m^2 annual production and 65 mill. m^2 of installed systems).
Sources: Adapted from all sources indicated in 3rd column and from Kammen et al. 2004.

Individual jobs estimates:

The China solar hot water industry employed 200,000 people in 2002, with a market size of 40 million installed and 12 million produced annually (Li 2005). The top eight manufacturers are Himin, Tsinghua Yang AGuang, Linuo Paradigma, Tianpu, Hua Yang, Mei Da, Sunpu, and Five Star. Considering growth in the market and installed base, by 2004 there may have been at least 250,000 employed.

Europe wind power jobs from Global Wind Energy Council. Nepal biogas industry from Nepal Biogas Support Programme. Other jobs estimates from report contributors. Europe small hydro and solar PV jobs from EREC 2004.

Sources for job estimation parameters and methods: EC 2002b; ECOTEC 2002; GAC 2005; Goldemberg 2004; Heavner & Churchill 2002; Kammen et al. 2004; Pembina Institute 2004; Schwer & Riddel 2004; and US DOE 1997.

[N25] Policy Targets

Sources for Table 3 and Figure 11 are: IEA, OECD, and JREC policy databases (IEA 2005a and 2005b); DSIRE database (DSIRE 2005); Li 2002 and 2005; Sawin and Flavin 2004; Thailand DEDE 2004; South Africa Department of Minerals and Energy 2003; and many other submissions from report contributors.

Some of these targets are not legally binding within the countries concerned, but are rather indicative or planning targets. Some targets may include capacity or energy from large hydropower.

China's targets are from the draft renewable energy development plan being prepared by NDRC. The plan has not yet been approved by the government. The Chinese renewable energy law from February 2005 requires NDRC to publish the renewable energy development plan, including targets, by January 2006. Targets also include 140 million m^2 of solar hot water by 2010, 270 million m^2 of solar hot water by 2020, 20 GW of wind by 2020, and 20 GW of biomass by 2020, and 12.5% of total electric power capacity by 2020 (which would be an anticipated 125 GW out of 1,000 GW). China's target of 10% of total installed electricity from renewable energy, excluding large hydro, would mean 60 GW of renewables out of 600 GW total power capacity. In relation to the target of 5% total primary energy by 2010, China today stands at approximately 3.3-3.5% of total primary energy from renewables (excluding large hydropower).

In 2004, Korea established a goal of 1.3 GW of grid-connected solar PV by 2011. This follows a previously announced target of 100,000 solar PV homes by 2011, an expected 300 MW.

Korea's target of 7% electricity by 2011 includes large hydropower. Excluding large hydropower, the target becomes 5.6%.

Japan also has targets of 4.8 GW from solar PV and 3 GW from wind. Although these targets remain "on the books," they have been eclipsed by the RPS policy of 1.35% and are no longer regarded as primary.

EU data also from EC 2004a and 2004b, which provide the best overview of EU policy targets..

Note: The percentage contributions of RES-E are based on the national production of RES-E divided by the gross national electricity consumption. For the EU15, the reference year is 1997. For the EU10 (Czech

Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia and Slovakia), the reference year is based on 1999-2000 data.

Philippines: The Renewable Energy Policy Framework (REPF) aims to double the capacity of renewable energy resources by instituting favorable policies and incentive packages for industry participants with the following objectives in mind: (1) Increase renewable energy-based capacity by 100 percent by 2013, with 425 MW expected to be supplied by wind power. The Philippines has over 70,000 MW of potential wind energy, with estimates of realizable wind power ranging from 20-30,000 MW. (2) Become the top geothermal energy producer in the world. Currently, the Philippines is the second largest geothermal power in terms of generating capacity, having generated 9,822 GWh from geothermal energy in 2003, displacing around 16.9 MMBFOE. It is projected that geothermal installed capacity will increase from the current 2,146 MW to 2,206 MW by 2014, equal to 14,403 GWh generation and 23.41 MMBFOE. The country is estimated to have 4,790 MW of potential geothermal reserves. (3) Become the largest wind-power producer in Southeast Asia with a wind energy investment kit focusing on the development of 16 wind power areas, beginning with a 25 MW wind farm—which went online this year—and another 40 MW wind farm in Ilocos Norte. (4) Become the solar-manufacturing hub of Southeast Asia through the establishment of a local industry in the manufacture of affordable solar energy systems. A US$300 million solar wafer fabrication plant was inaugurated in April 2004 to manufacture high-efficiency PV cells with an anticipated initial production equivalent of 25 MW, increasing to 150 MW within the next five years. At full capacity, the plant can supply 6% of the world's total market for the PV industry. The manufacturing plant aims to distribute 30% of its production to the local market, thereby significantly decreasing the cost of local solar panels. (5) Push for the development of all viable mini- and micro-hydropower plants through various cost-efficient foreign loans. (6) Install 130-250 MW of biomass, solar, and ocean capacity; and (7) Partner with Congress for the passage of the Renewable Energy Bill that seeks to institutionalize the guidelines, procedures, and incentives for renewable energy development.

Table N25. EU Renewable Energy Targets

Country	**Target(s)**	**Actual 1997 level**
EU-25	21% of electricity and 12% of total energy by 2010	12.9%
Austria	78% of electricity by 2010	70%
Sweden	60% of electricity by 2010	49.1%
Latvia	49.3% of electricity by 2010; 6% of energy (excluding large hydro) by 2010	42.4%
Portugal	45.6% of electricity by 2010	38.5%
Finland	35% of electricity by 2010	24.7%
Slovenia	33.6% of electricity by 2010	29.9%
Slovak Republic	31% of electricity by 2010	17.9%
Spain	29.4% of electricity by 2010	19.9%
Denmark	29% of electricity by 2010	8.7%
Italy	25% of electricity by 2010	16%
France	21% of electricity by 2010	15%

Greece	20.1% of electricity by 2010	8.6%
Ireland	13.2% of electricity by 2010	3.6%
Germany	12.5% of electricity and 4% of energy by 2010; 20% of electricity by 2020	4.5%
Netherlands	12% of electricity by 2010	3.5%
United Kingdom	10% of electricity by 2010	1.7%
Czech Republic	8% of electricity by 2010; 5-6 % of energy by 2010; 8-10% of energy by 2020	3.8%
Poland	7.5% of electricity by 2010; 7.5% of energy by 2010; 14 % of energy by 2020	1.6%
Lithuania	7% of electricity by 2010; 12% of energy by 2010	3.3%
Belgium	6% of electricity by 2010	1.1%
Cyprus	6% of electricity by 2010	0.05%
Luxembourg	5.7% of electricity by 2010	2.1%
Estonia	5.1% of electricity by 2010	0.2%
Malta	5% of electricity by 2010	0%
Hungary	3.6% of electricity by 2010	0.7%

Note: Portugal's 35.6% target, Finland's 35% target, and the Netherlands' 12% target from IEA JREC database. Portugal's original target was 39%, Finland's was 31.5% and the Netherlands' was 9%.

[N26] Power Generation Promotion Policies

Sources for Table 4: IEA, OECD, and JREC databases (IEA 2005a and 2005b); IEA 2004b; Sawin & Flavin 2004; Wahnschafft & Soltau 2004; Johansson & Turkenburg 2004; Martinot et al. 2005; Beck & Martinot 2004; Osafo & Martinot 2003; Thailand DEDE 2004; Tumiwa 2005; Rousseff 2005; Austrian Energy Agency 2005; Stenzil et al. 2003; EWEA 2005c; EAEF 2005; EEA 2004; ECN Renewable Energy Policy Info website (and Vries et al. 2003) (www.renewable-energy-policy.info); country references noted in country data section; submissions from report contributors. IEA 2004b in particular contains a wealth of historical and current information on IEA country policies. EU data also from EC 2004a and 2004b.

Notes for Table 4:
(a) Entries with an asterisk (*) mean that some states/provinces within these countries have state/province-level policies but there is no national-level policy. See separate table for RPS policies by state/province. In the case of Inida, however, the Electricity Act of 2003 mandates state-level policies, and states are developing different combinations of policies, including feed-in tariffs and RPS. Even though this could not be considered a "national feed-in law," the mandate is having a similar effect.
(b) Japan's net metering is voluntary by utilities and features separate buy/sell transactions, although the selling price is typically the same as the purchase price. Japan's feed-in tariffs are also voluntary by utilities, and some utilities have switching to annual caps with bidding.
(c) Spain's feed-in tariff system incorporates both fixed total prices and price premiums added to variable-cost components of electricity tariffs.
(d) Some policies listed may not be active or may not have associated implementing regulations developed. It is very difficult to separate active, inactive, and "not yet implemented" policies without extremely detailed data

gathering. So the table reflects enacted policies, and the information it portrays should be considered as "notional" rather than "definitive."
(e) Mexico has an atypical form of net metering that allows intermittent self-generators access to the grid for surplus self-generation, to be used at other times of the day, subject to certain limits based on local utility marginal costs. Mexico also allows wheeling costs to be based on average plant capacity factor.
(f) Norway had a type of feed-in policy (added premium) for wind power, but this was discontinued in 2003.

[N27] Feed-in Laws

Sources for Table 7: IEA OECD Policies database (IEA 2005a); IEA 2004b; Sawin & Flavin 2004; other sources from Table 10; REAccess 5/10/05 for United States, Washington State; REAccess 5/16/05 for Turkey; Austrian Energy Agency 2005; ECN Renewable Energy Policy Info website (www.renewable-energy-policy.info); country references noted in country data section; submissions from report contributors.

Italy adopted CIP6/92 from 1992 to 1995. Denmark, Spain, and Portugal all had forms of feed-in policies earlier than those shown in Figure 12, but the dates in Figure 12 reflect the modern versions of the laws that are credited with the major market impacts which have taken place. Other countries also had earlier pre-cursor feed-in policies that might be considered the original legislative enactment.

Notes for Table 7
(a) Tariffs can vary depending on size of plant, region of plant, whether onshore or offshore in the case of wind, year of commissioning of plant, season of operation in which the tariff is paid (summer vs. winter), and/or year of plant's operational life in which the tariff is paid. Some tariffs decline substantially or become invalid after a certain year of plant operation, and this varies widely by country. Ranges given reflect typical prices considering these factors, for Germany in 2004 and for other countries in 2002-2004.
(b) Germany's feed-in law has undergone continuous updating, reflecting changing conditions, objectives, and technology characteristics and costs, first in 1994, and then in 1998, 2000, and 2004.
(c) Denmark's price figures are from the old pricing system before feed-in tariff was suspended in 2003.
(d) "---" means law does not cover that technology.
(e) Some tariffs have upper limits to plant size. Czech Republic and Slovenia limit small hydro to 10 MW. Latvia limits small hydro to 2MW. Indonesia limits all plants to 1 MW.
(f) Spain's feed-in tariff system incorporates both fixed total prices and price premiums added to variable-cost components of electricity tariffs.
(g) In India, national feed-in tariffs (common guidelines to all states for a minimum buy-back rate of Rs. 2.25/kWh in order to bring uniformity) were declared by MNES in 1993. However, two states, Gujarat and Tamil Nadu, were offering attractive buy-back rates even earlier in order to attract private sector investment in wind (MNES annual reports for 1991-1994). Similarly, Maharastra and Tamil Nadu had promotional policies for bagasse-based cogeneration. Tamil Nadu had evolved a scheme in 1988 (TNEB-Tamil Nadu Electricity Board Notification dated 12 December 1988) called "Power feed scheme" permitting co-generators and

private-sector power producers of 2 MW capacity and greater to sell surplus power to the grid. It covered co-generation units, mini- and micro-hydro, wind farms, and diesel/gas turbines. The power purchase rate for this scheme in 1990-91 was Rs. 1.00 per unit subject to yearly review. MSEB (Maharashtra State Electricity Board), on the other hand, offered Rs. 1.20 per unit with periodic revisions. (Source for both the above is Winrock International & IDEA 1993.)

(h) India's Electricity Act of 2003 mandates national targets by 2012 and provides guidelines for fixing RPS and feed-in tariffs for each state.

(i) PURPA was first enacted in the U.S. in 1978 and actively implemented by many states during the 1980s. By the 1990s, fewer states still had active PURPA implementation, although currently several states still implement PURPA as a feed-in tariff for small projects; examples of this exist in Idaho, Minnesota, and Oregon.

(j) Some countries have feed-in tariffs that apply only to solar PV.

(k) Turkey Adopts National Feed-in Law for Renewables, news item at REAccess.com, 16 May 2005, at www.renewableenergyaccess.com/rea/news/story?id=29822

(l) Slovakia: Feed-in-Tariffs for Green Electricity 2006 issued. In June 2005, the Slovak Regulator has issued the

feed-in-tariffs for Electricity from Renewable Energy Sources and CHP for the year 2006. This latest decree brings about considerably higher tariffs, as compared to the current regulation. For example, the tariff for electricity from newly installed wind power plants put into operation after January 1st, 2005, is fixed with 2,800 Slovak Crowns per MWh (about 72 Euro). These tariffs are set by the Regulatory Office for one year. A complete table with the tariffs is now online on enerCEE:
www.energyagency.at/enercee/sk/supplybycarrier.htm#res

[N28] Renewables Portfolio Standards

RPS information comes from DSIRE database; Martinot et al. 2005; IEA 2004b; Pollution Probe 2004; Linden et al. 2005; ECN Renewable Energy Policy Info website (www.renewable-energy-policy.info); submissions from report contributors.

Some RPS targets include large hydro, for example in Wisconsin, Maine, New Jersey, Texas, Hawaii, Maryland, New York, Pennsylvania, District of Columbia, and British Columbia, while other targets restrict renewables to a certain maximum size, with the maximum usually falling between 1-30 MW.

A 2005 study by Global Energy Decisions estimated that state RPS laws currently existing in the United States would require an additional 52 GW of renewable energy by 2020, which would more than double existing U.S. renewables capacity.

Table N28a. States, Provinces, and Countries Adopting Renewables Portfolio Standards

Year Enacted	State/Province/Country	Final Target
1997	Massachusetts, USA	4% by 2009 then +1%/yr
1998	Connecticut, USA	10% by 2010
	Wisconsin, USA	2.2% by 2011
1999	Maine, USA	30% ongoing
	New Jersey, USA	6.5% by 2008
	Texas, USA	2,880 MW by 2009
	Italy	2% from 2002
2001	Arizona, USA	1.1% by 2007-2012
	Hawaii, USA	20% by 2020
	Nevada, USA	15% by 2013
	Australia	1.25% in 2004, increasing through 2010 to meet national target of 9,500 GWh/year
	Flanders, Belgium	6% by 2010
2002	California, USA	20% by 2017
	New Mexico, USA	10% by 2011
	United Kingdom	10% by 2010 and 15% by 2015
	Wallonia, Belgium	12% by 2010
2003	Minnesota, USA	10% by 2015
	Japan	1.35% by 2010
	Sweden	16.9% by 2010
	Maharashtra, India	compulsory but no percentage
2004	Colorado, USA	15% by 2015
	Maryland, USA	7.5% by 2019
	New York, USA	24% by 2013
	Pennsylvania, USA	8% by 2020
	Rhode Island, USA	16% by 2019
	Madhya Pradesh, India	0.5%
	Karnataka, India	5-10%
	Andhra Pradesh, India	to be set
	Orissa, India	2 million kWh by 2006-2007
	Poland	7.5% by 2010
	Nova Scotia (Canada)	5% by 2010
	Ontario (Canada)	10% by 2010
	Prince Edward Is. (Canada)	15% by 2010, 100% by 2015
	Thailand	5% of future new generation added
2005	District of Columbia, USA	11% by 2022
	Gujarat, India	5% by 2010

Canada: According to Pollution Probe (2004), there are 10 Canadian provinces with RPS or planning targets for renewable energy. Pollution Probe identifies the Nova Scotia and Ontario policies as RPS policies, while the others are planning targets. Other sources from early 2004 state that no RPS policies yet existed in Canada. News reports confirm Nova Scotia passed energy legislation in November 2004 with the RPS. Ontario enacted its RPS in its 2004 Electricity Restructuring Act. British Columbia has introduced a voluntary RPS targeting 10% of new generation from renewable sources (www.energyroundtable.org/energy_opp.php). Alberta's target is similarly voluntary. "Prince Edward Island introduced an RPS of 15% by 2010, 100% by 2015." PEI's Renewable Energy Act was enacted in December 2004. Hydro Quebec has issued an RFP to procure 1,000 MW of new wind power over 10 years.

Table N28b: RPS and Planning Targets in Canadian Provinces

Province	**Target**
Nova Scotia	5% by 2010 (legislated RPS)
Prince Edward Island	15% by 2010 (legislated RPS)
New Brunswick	1% by 2010 (target)
Quebec	3% by 2010 (target)
Ontario	10% by 2010 (voluntary RPS)
Manitoba	5% by 2010 (target)
Saskatchewan	all new generation through 2010 (target)
Alberta	3.5% by 2008 (target)
British Columbia	10% by 2010 (target)
Northwest Territories	10% of total energy by 2010 and 25% by 2025

Note: British Columbia's target applies to "clean energy," including co-generation.

[N29] Rooftop Solar PV Policies

Table N29. Grid-Connected Solar Rooftop Programs, Selected Countries, 2004

Location and Start Year(s)	Cumulative Homes as of 2004	Cumulative Installations as of 2004	Installations Added, 2003	Installations Added, 2004	Supporting Policies
Japan (1994-2004)	200,000	800 MWp	190 MWp	260 MWp	"Sunshine program" capital subsidy started at 50% in 1994, declining to 10% by 2003.
Germany (1999-2003)	150,000	680 MWp	140 MWp	300 MWp	"100,000 roofs program" provided low-interest loans for households and 50 eurocents per kWh feed-in tariff through 2003. Since 2004, market supported by feed-in tariffs of 45-62 eurocents/kWh.
California programs (1998-)	15,000	95 MWp	27 MWp	36 MWp	State program capital subsidy of $4.50/W(AC) declined to $3.50/W(AC). There are also municipal utility (SMUD, LADWP) and utility RPS programs.

Notes:

(a) California reports total number of installations, which includes both residential and commercial, but the number of residential installations is assumed to be much higher than the number of commercial installations. The number of homes reported is consistent with an average of 4kW/home and residential being more than half of total installed capacity in 2004.

(b) Assumption of 4kW/home for new 2004 installations in Japan and Germany. Cumulative homes for 2003 estimated at 170,000 in Japan and 65,000 in Germany based on prior reports of homes and capacity.

(c) On-grid solar PV capacity in Europe was 480 MWp in 2003, of which 375 MW was in Germany. The Netherlands was the major contributor, with 44 MW in 2003. So additional on-grid capacity in Europe in 2004, besides Germany, was probably about 110 MW.

(d) Korea has a 100,000-rooftop program, with an expected 0.3 GW by 2011. Korea provides 70% capital subsidy for systems less than 200 kW. The subsidy is expected to decline to 30-50% in the future.

(e) Thailand has had a small rooftop solar PV programme. As of July 2004, 67 kWp were installed, subsidized by EPPO.

Sources: Maycock 2004 and 2005a; Jones 2005; Dobelmann 2003; California Energy Commission 2004; Navigant Consulting 2005; submissions from report contributors.

[N30] Other Power Generation Promotion Policies

See Martinot et al. (2005) for further details and full references on U.S. public benefit funds (available at www.resource-solutions.org).

Net metering policies from Martinot et al. (2005), plus IEA and JREC policy databases (IEA 2005a and 2005b) and submissions from report contributors.

[N31] Public Competitive Bidding and Other Regulatory Measures

Many broad policies for power sector reform/restructuring also affect renewable energy in significant ways, beyond the administrative measures specifically targeting renewable energy. Such policies are beyond the scope of this report, but good discussion can be found in Beck & Martinot (2004).

Table N31. Recent Public Competitive Bidding of Wind Power, China and Canada

Country (Year)	Bidding	Award Prices (local currency)	Award Prices (U.S. cents)
Canada (2004)	1,000 MW in Quebec	CAN 6.5 cents/kWh	5.2 cents/kWh
China (2004)	100 MW in Inner Mongolia 100-200 MW in Jilin 100-200 MW in Jilin 100-150 MW in Jiangsu	CNY 0.382/kWh CNY 0.509/kWh CNY 0.509/kWh CNY 0.519/kWh	4.6 cents/kWh 6.1 cents/kWh 6.1 cents/kWh 6.2 cents/kWh
China (2003)	100 MW in Jiangsu 100 MW in Guangdong	CNY 0.437/kWh CNY 0.501/kWh	5.3 cents/kWh 6.1 cents/kWh

Notes:
(a) Project size ranges in China reflect optional additional capacity expansions that can take place after the initial development of 100 MW in each project.
(b) An additional three concessions for 450 MW of bidding in 2005 was mentioned in Ku et al. 2005.
(c) Details of Ontario's programs can be found on the Ontario Power Authority Web site, www.ontarioelectricityrfp.ca.
(d) Exchange rates used are 1.24 CAN and 8.28 CNY.
Sources: Ku et al. 2005; submissions from report contributors.

[N32] Solar Hot Water Policies

More information on China can be found in Li (2005).

For more information about solar hot water policies in Spain, see: Instituto para la Diversificación y Ahorro de la Energía (Institute for Energy Diversification and Saving), at www.idae.es and Comision Nacional de la Energia (National Energy Commission), www.cne.es and www.energias-renovables.com

For specialized news group on renewables in Spain, see: www.energias-renovables.com/paginas/Contenidosecciones.asp?Id=5993 and www.energias-renovables.com/paginas/Contenidosecciones.asp?ID=5202&Tipo=&Nombre=Solar%20t%C3%83%C2%A9rmica

Agència d'Energia de Barcelona (Barcelona Energy Agency), at www.barcelonaenergia.com

For Barcelona Solar Ordinance, see www.barcelonaenergia.com/cas/observatorio/ost/ost.htm

[N33] Biofuels Policies

Table N33. Ethanol and Biodiesel Blending Mandates, Selected Countries

Year Enacted	**Country/State/Province**	**Ethanol Blend (percentage)**	**Biodiesel Blend (percentage)**
1975	Brazil (national)	22-25%	2% by 2005
1997	United States (state of Minnesota)	10% 20% by 2013	2% (future)
---	Dominican Republic (national)	15% by 2015	5% by 2015
---	China (provinces of Heilongjiang, Jilin, Liaoning, and Henan)	10%	---
2003	India (9 states and 7 federal territories)	5%	---
2004	United States (state of Hawaii)	10% by 2006	---
	Columbia (national)	10%	
2005	Canada (province of Ontario)	5% by 2007	
	United States (state of Montana)	10%	

Note: As part of Thailand's national 8% of energy target by 2011, biomass transport fuels are targeted at 1570 ktoe/year, which could be achieved by 3 million liters/day of ethanol and 2.4 million liters/day of biodiesel. But it is still unclear what the actual blending mandates will be.
Sources: Submissions from report contributors. Some of the information is inadequately verified.

In Canada, the province of Ontario announced in 2004 that it intends to require that all gasoline sold there must contain an average of 5% ethanol by 2007. The province of Saskatchewan enacted an ethanol fuel act in 2002 that creates the legal framework to mandate ethanol blending with gasoline and is planning to move in that direction in 2005; the province of Manitoba is also considering enacting a policy to support ethanol blending.

[N34] Green Power Purchasing and Utility Green Pricing

Recent data on green power customers are not readily available.　Most recent data show 600,000 green power customers in Germany (almost double from 2002) and almost 3 million in the Netherlands. According to some sources, Netherlands as of the end of 2003 was 2.2 million. UK and the Switzerland are almost the same number in 2004 as of the end of 2002, they were 45,000 and 46,000 for each.
http://www.greenprices.com gives roughly 4 million green power customers total in Europe. Individual county numbers for Europe totaled together give a slightly smaller number, perhaps 3.7 or 3.8 million.

Bird et al. (2002) gives these totals of green power consumers for 2002: Australia: 60,000; Canada: 6,000; Finland: 8,000 in 2001; Germany: 325,000 (including 250,000 large hydro); Japan: 38,000; Netherlands: 775,000; Sweden: 9,000 GWh; Switzerland: 46,000; and United Kingdom: 50,000. Australia government (2004) gives 70,000 green power consumers.

Sources for green power include: Bird et al. 2002, Bird & Swezey 2004, Martinot et al. 2005, and submissions from report contributors.

An important distinction to make in considering numbers of green power customers is what percentage of these purchases are for new renewables and thus are serving to expand the deployment of renewable power generation. Many of the European purchases are for existing large hydro at prices on par with conventional energy, while the U.S. EPA Green Power Partnership has strict eligibility criteria for new renewables content (minimum 50% new).

See FOE (2004), which says that only "retired" ROCs in the UK are really comparable to U.S. voluntary products; most Green Power buyers in the UK are merely subsidizing the utility's need to buy some renewables.

The Shanghai electricity comes from a 3.4 MW wind farm in Fengxian District, with another 20 MW of wind power capacity coming on line in mid-2005 in two other wind farms. The first round of green electricity purchases by these 12 enterprises is equal to 50% of the power output from these 3 wind farms. (News release from the Shanghai Energy Conservation Supervision Center, 12 June 2005.)
The consumer’s cooperative union in Japan that initiated green power in 1999 was the Seikatsu Club Hokkaido (SCH). Together with a regional utility, SCH established a fund to support the development of new wind projects in the region. Under the program, SCH collects electricity bills instead of the utility, and the members who joined the program can make contributions by adding 5% to their electricity bills. SCH also established the Hokkaido Green Fund (HGF) for contributions from non-members. In turn, the Hokkaido Green Fund established Hokkaido Civic Wind Co. to allow members to purchase shares of wind projects in return for dividends from the sale of electricity from the wind turbines. Thus was built the first “citizen-owned” wind turbine in 2001. By early 2005, the Hokkaido Civic Wind Co. had invested in 7 MW of wind capacity. After this program, HGF and the Institute for Sustainable Energy Policies established the Japan Green Fund Co. to allow further citizen investments in renewable energy. By 2005, the Japan Green Fund had constructed five wind turbines. And by early 2005, there were 1,300 members of HGF’s green pricing program.

[N35] Municipal Policies

Table N35a. Cities with Local/Municipal-Scale Renewable Energy Policies, 2004

City	RE Goals	CO_2 Goals	SHW	Solar PV	Planning	Demos	Other
Adelaide, Australia	X	X			X	X	
Barcelona, Spain	X	X	X	X	X	X	X
Cape Town, South Africa	X	X			X		
Chicago, United States	X						
Daegu, Korea	X	X			X	X	
Freiburg, Germany	X	X		X	X	X	
Gelsenkirchen, Germany					X	X	
Goteborg, Sweden					X	X	
Gwangju, Korea	X	X			X		
The Hague, Netherlands		X					
Honolulu, United States							X
Linz, Austria						X	
Madison (WI), United States				X			
Minneapolis, United States	X					X	
Oxford, United Kingdom	X	X	X	X	X		
Portland, United States	X	X	X	X	X	X	
Qingdao, China					X	X	
San Diego, United States							X
San Francisco, United States							X
Santa Monica, United States					X	X	
Sapporo, Japan		X			X	X	
Toronto, Canada		X					
Vancouver, Canada		X					

Notes:
(a) "X' indicates significant activity in the given category.
(b) Categories are defined as follows: "RE goals" means targets or goals set for the future share of energy from renewable energy; "CO_2 goals" means future CO_2 emissions targets set, usually on a city-wide or per-capita basis; "SHW" means policies and/or incentives for solar hot water enacted; "Solar PV" means policies and/or incentives for solar power enacted; "Planning" means overall urban planning approaches considering future energy consumption and sources; "Demos" means specific projects or one-time demonstrations subsidized by public funds; and "Other" means other policies or programs.
Sources: International Solar Cities Initiative, www.solarcities.or.kr, and www.martinot.info/solarcities.htm, December 2004, with updates from DSIRE database and submissions from report contributors. Barcelona energy improvement plan at www.barcelonaenergia.com.

Table N35b. Cities with Future Targets for Renewable Energy Shares, 2004

City	RE share of municipal electricity consumption	RE share of total city electricity consumption	Other targets
Adelaide, Australia		15% by 2014	
Aspen (CO), United States		50% currently	
Austin (TX), United States		20% by 2020	
Cape Town, South Africa		10% by 2020	10% of homes by 2010 have SHW
Chicago (IL), United States	20% by 2006 10% currently		
Daegu, Korea			5% of total energy by 2012
Ft. Collins (CO), United States		15% by 2017	
Freiburg, Germany		10% by 2010 4% currently	
Gwangju, Korea			2% of total energy by 2020
Los Angeles (CA), United States	20% currently		
Minneapolis (MN), United States	10% currently		
Oxford, United Kingdom			10% of homes by 2010 have SHW and/or solar PV
Portland (OR), United States	100% by 2010		
Sacramento (CA), United States		20% by 2011	
San Diego (CA), United States	23% currently		
San Francisco (CA), United States			1 MW/year added
Santa Monica (CA), United States	100% currently		

Note: Austin's target includes energy efficiency improvements.

Sources: International Solar Cities Initiative, www.solarcities.or.kr; www.martinot.info/solarcities.htm, December 2004; DSIRE database.

Table N35c. Cities with CO_2 Emissions Reductions Targets, 2004

City	Target
Adelaide, Australia	Zero net emissions by 2012 in buildings Zero net emissions by 2020 in transport
Calgary, Canada	6% reduction from 1990 levels for corporate and community emissions
Freiburg, Germany	25% below 1992 levels by 2010
Gwangju, Korea	20% below baseline levels by 2020
The Hague, Netherlands	City government "CO_2 neutral" by 2006; whole city "CO_2 neutral" in long term
Portland (OR), United States	10% below 1990 levels by 2010
Sapporo, Japan	10% below 1990 levels by 2012
Sudbury, Canada	>30% reduction below 1990 levels
Toronto, Canada	Municipal energy 20% below 1990 levels by 2005
Vancouver (BC), Canada	6% below 1990 levels by 2012 and municipal energy 20% below by 2010

Notes:

(a) Calgary: GHG reduction goal is 6% reduction from 1990 levels for corporate emissions, and 6% reduction from 1990 levels for community emissions.

(b) Sudbury: GHG reduction goal is 574,800 tons of GHGs per year (77% through energy, 10% through transportation, 13% through solid waste). This translates into a target of more than a 30% reduction below 1990 levels.

(c) Toronto: GHG reduction goal is 20% from 1990 levels for corporate emissions, 6% for community emissions.

Sources: International Solar Cities Initiative, www.solarcities.or.kr; www.martinot.info/solarcities.htm, December 2004; DSIRE database; submissions by report contributors. Vancouver CO_2 reduction goal from http://vancouver.ca/sustainability/coolvancouver/backgrounder.htm; Toronto CO_2 reduction goal from www.city.toronto.on.ca/taf

(San Francisco, CA, Refocus Weekly, 15 June 2005) Politicians from 50 of the largest cities in the world have signed a treaty to source 10% of their city's peak electric load from renewable energies. The non-binding 'Urban Environmental Accord' was signed at the United Nations World Environment Day conference in San Francisco. The accord lists 21 specific actions, topped by an action item to "adopt and implement a policy to increase the use of renewable energy to meet 10% of the city's peak electric load within seven years." The mayors agreed to adopt municipal plans to reduce GHG emissions by 25% by 2030, including a system for accounting and auditing greenhouse gas emissions. Signatories include Jakarta, Delhi, Istanbul, London, Seattle, Melbourne, Kampala, Zurich, Dhaka, Moscow, Rio de Janeiro, Copenhagen and Islamabad. Available at www.wed2005.org/pdfs/Accords_v5.25.pdf?PHPSESSID=d3f44c0bb102b22541fbf9f35b268650
"Green Cities Declaration" (see PDF file)

[N36] Rural Energy and Development Assistance

For basic references and sources on rural energy, see World Bank 1996, UNDP et al. 2000, and Goldemberg & Johansson 2004.

For information on the World Bank's renewable energy strategies, see:

- World Bank Renewable Energy Action Plan, described in World Bank's RE/EE Annual Report, at http://siteresources.worldbank.org/INTENERGY/Resources/335544-1111615897422/Annual_Report_Final.pdf;
- World Bank, "Fuel for Thought: Environmental Strategy for the Energy Sector." (2000 strategy paper), at http://www-wds.worldbank.org/servlet/WDSServlet?pcont=details&eid=000094946_0008040539585
- "The Strategy of the World Bank in Financing Renewable Energy Projects in South Asia," at www.worldenergy.org/wec-geis/publications/reports/renewable/annexes/annex_2.asp#strategy

For information about ASTAE, see www.worldbank.org/astae.

For Global Environment Facility-related information, see:

- GEF project briefs and documents, at www.gefweb.org.
- Other GEF monitoring and evaluation reports, at: http://thegef.org/MonitoringandEvaluation/METhemesTopics/METClimateChange/metclimatechange.html
- GEF, Office of Monitoring and Evaluation. 2004. Climate Change Program Study. Washington, DC, at http://thegef.org/MonitoringandEvaluation/METhemesTopics/METClimateChange/2004_ClimateChange.pdf

For information about UNEP, see:

- Rural Energy Enterprise Development Programme, at www.uneptie.org/energy/projects/REED/REED_index.htm, www.b-reed.org, and www.c-reed.org
- UNEP Sustainable Energy Finance Initiative, at www.sefi.unep.org
- UNEP Activities on Renewable Energy, at www.uneptie.org/energy/act/re

For information on UNIDO see: UNIDO initiative on rural energy for productive use, at www.unido.org/doc/24839 (lists UNIDO projects by technology type)

For information on African Development Bank, see "Renewable Energy Summary," at www.afdb.org/en/what_s_new/events/s_minaire_sur_l_nergie_olienne_octobre_2004/adb_intervention_in_renewable_energy

The Asian Development Bank (ADB) is currently developing a renewable energy operational and strategic action plan to promote renewable energy by building a pipeline of feasible renewable energy projects. The ADB established a Renewable Energy, Energy Efficiency and Climate Change (REACH) Program (www.adb.org/reach), which supports capacity building, institutional development, and project development activities in the area of energy efficiency and renewables, in 15 DMCs of Asia. It is expected that these technical assistance interventions will lead to increased lending in the area of renewable energy and energy efficiency.

[N37] Rural Biomass Use

Further references on rural biomass use include Kartha and Larson 2000; Kartha et al. 2004; Bailis et al. 2005; Karekezi & Kithyoma 2005; and Elauria et al. 2002.

All data on biomass consumption and rural household energy is from Bailis et al. 2005. Information on the health impact of traditional biomass use is from Ezzati & Kammen 2002.

Biomass energy is used extensively as fuel in the Philippines, particularly in the residential and industrial sectors. The types of fuel used in the country are: wood fuel, wood wastes, and other agricultural residues such as sugar cane bagasse, coconut husk and shell, rice-hull, and industrial and animal wastes. The residential sector accounted for about 70% of biomass use, with cooking as the major end-use. The shares of various biomass fuels consumed in the residential sector are 77 % wood fuel, about 19% agricultural residues, 4% charcoal, and 0.4 % animal manure in the form of biogas. Biomass consumption in the industrial sector is mainly for steam and power generation, which consumed about 84% of the total consumption of the sector while baking and commercial cooking used about 1%. The remaining 15% is used in commercial applications such as fish- and crop-drying, ceramic processing, food manufacturing, metal works, and brick-making. Applications of biomass energy systems are dominated by ovens/kilns/furnaces and biomass dryers, roughly 15,000 of each in 1997, along with about 5,000 cook stoves and on the order of hundreds of biomass-fired boilers and biogas systems, and a few dozen gasifiers (Elauria et al. 2002).

[N38] Traditional Biomass and Improved Cook Stoves

Cook stove data from Li & Shi 2005, AFRENPREN 2004, and Kammen 2005. Kammen (2005) notes that in Kenya, the Ceramic Jikko stove (KCJ) is found in over 50% of all urban homes, and roughly 16-20% of rural homes.

China's National Improved Stove Program operated during the 1980s and 1990s. For a description, see http://ehs.sph.berkeley.edu/hem/page.asp?id=29.

India's National Program on Improved Cookstoves lasted from 1985-2002, provided over 100 different models, and provided a 50-75% direct cash subsidy. The cost of each cook stove was $2-6. Reported lab efficiencies were 20-45% (compared with traditional stove efficiencies of 5-10%). Source: Maithel 2005.

Table N38a: Rural Household Cooking in Developing Countries

Country/Region	Households using traditional biomass for cooking/heating (million)	Improved (more efficient) biomass stoves in use (million)
Africa	130	5
China	190	180
Indonesia	35	n/a
Rest of Asia	30	1
India	130	34
Rest of S. Asia	30	n/a
Latin America	20	n/a
Total	570	220

Notes:

(a) Figures are approximate, based on assumption of 4.4 persons per household for all regions (Worldwatch Institute 2004). Most data are for 2000.

(b) The biggest improved cook stove (ICS) programs of the world are being undertaken in China where 177 million stoves have been installed so far, covering 76% of rural households and in India where about 30.9 million improved stoves were installed by 1999, covering 23% of rural households (Bhattacharya 2002).

(c) Biomass, mostly traditional use, accounts for a large share of total primary energy supply in many developing countries. In 2001, this share was 49% in Africa, 25% in Asia, and 18% in Latin America. "Traditional use" means burning wood, agricultural waste, and dung for home cooking and heating fuel plus for process heat. Often the biomass fuel itself is "free," insofar as there is no direct monetary cost, although large amounts of time, particularly for women, may be used to collect it. A share of biomass is converted to charcoal, which is then sold commercially for the same uses. (IEA 2003a; Karekezi et al. 2004)

(d) Developing countries at large depend on traditional biomass fuels (charcoal, fuel wood, agricultural residues, and animal dung) for just over 26% of their total fuel mix (Johansson & Goldemberg 2004; Figures 1.2 and 1.4, pp. 26-27). Sub-Saharan Africa relies on these same fuels for over 61% of total energy supply (UNDP et al. 2000**,** Fig. 7, p. 29; McDade 2004).

(e) In China, by the early 1990s, 130 million improved stoves had been installed under the National Improved Stoves Program (Sinton et al. 2004). This figure increased to 177 million by 2000 (Bhattacharya 2002).

(f) In India, an estimated 130 million rural households use biomass as the primary fuel for cooking. This compares with about 7 million rural households that use LPG for cooking and about 2 million that rely on kerosene. In India, 700 million people live in homes where biomass is the primary fuel for cooking. However, only about 33.6 million, or 17.5% of all Indian homes, use LPG as their primary cooking fuel, with 90% of rural homes still dependent on some form of biomass. (D'Sa & Murthy 2004).

(g) Roughly two-thirds of African households, more than 580 million people, depend on wood fuels for their daily cooking and heating needs (Utria 2004).

(h) Currently, about one-fourth of Mexican households (27.2 million people) cook with fuel wood, either

exclusively (18.7 million people) or in combination with LPG (8.5 million). Fuel wood use is concentrated within rural and peri-urban households. Fuel wood is still the main residential fuel in Mexico, accounting for approximately 50% of total energy use and 80% within rural households. Despite the rapid urbanization process that has taken place in Mexico in the last 30 years the use of fuel wood has remained virtually constant with an increasing share of mixed fuel wood-LPG users in total consumption (Masera et al. 2005).
Sources: Karekezi et al. 2004, IEA 2002a, Graham 2001, TERI 2001, and D'Sa & Murthy 2004.

Table N38b. Estimated Number of Improved Biomass Cook Stoves in Selected African Countries, 2001

Country	Number of Improved Stoves
Kenya	3,136,739
South Africa	1,250,000
Niger	200,000
Burkina Faso	200,000
Tanzania	54,000
Uganda	52,000
Eritrea	50,000
Ethiopia	45,000
Sudan	28,000
Zimbabwe	20,880
Malawi	3,700
Botswana	1,500

Sources: AFREPREN 2004; African Ministerial Meeting on Energy Proceedings 2004; Kammen 2005.

In Africa, regional organizations like the Southern African Development Community (SADC) have put in place a number of key interventions aimed at ensuring the sustainable use of energy resources. Since 1997, SADC started the Programme for Biomass Energy Conservation in Southern Africa (ProBEC) which is implemented by GTZ. In addition to the German Government, other donors committed to co-funding the program include the Dutch Ministry for Foreign Affairs (DGIS), UNDP-GEF, and the EU Energy Initiative. The purpose of the program is the adaptation and development of efficient technologies and management strategies for biomass energy consumption in households and small businesses in order to use the available resources sustainably. An expansion of ProBEC to the rest of the continent is requested by the NEPAD Action Plan (iii energy, para 110), endorsed by the African Union Summit in Mozambique in July 2003.

[N39] Biogas Digesters

Information on biogas digesters is from: the Biogas Support Programme Nepal 2005; Martinot et al. 2002; Bhattacharya 2002; Karekezi et al. 2004; Graham 2001; TERI 2001; D'Sa and Murthy 2004; China national biogas action plan; and submissions from report contributors.

[N40] Biomass Gasifiers

Information primarily from Bhattacharya 2002.

Note: This report does not cover the lessons and operational experience of different renewable energy technologies, although that is an important subject. For example, dual-fuel gasifiers in the Philippines suffered from low acceptability due to technical problems such as gas-cleaning, lack of consumer acceptance, and lower petroleum prices (Elauria et al. 2002).

[N41] Village-Scale Mini-Grids

Historical data from Martinot et al. 2002. Updates for China and India's installations and programs from submissions by report contributors and from Ma 2004 and Li & Shi 2005. See also NREL 2004 for China program information.

[N42] Water Pumping

Estimates are from the Indian Renewable Energy Development Agency (IREDA) (TERI, personal communication May 2005); Karekezi & Kithyoma 2005; and Martinot et al. 2002. Results reported are from GTZ projects. Original sources from Martinot et al. 2002.

Donor programs have demonstrated that PV-powered pumps can be economically competitive with conventional diesel pumps, in smaller villages up to 2,000 inhabitants. Pumping costs range from \$0.30-1.00/m^3 (0.03-0.1 cents/liter), according to GTZ.

Commercial project examples are being conducted by a subsidiary of Australia's SOLCO in the case of the Maldives and by U.S.-based Worldwater Corporation in the case of the Philippines.

[N43] Solar Home Systems

Table N43a. Solar Home Systems Worldwide, 2004

Country/Region	**Added in 2004**	**Existing in 2004 (at least)**	**Sources**
China	>130,000	450,000-500,000	CREDP 2004; task managers; Martinot et al. 2002
Sub-Saharan Africa		460,000	AFRENPREN 2004; Kammen 2005
India	20,000	310,000 SHS (+ 510,000 solar lanterns)	TERI, as of March 2004
Sri Lanka	15,000-20,000	75,000	World Bank/GEF project; www.energyservices.lk
Thailand	100,000	100,000	New program for 2004-2005
Bangladesh	15,000-20,000	40,000	World Bank/GEF project and Grameen Shakti
Mexico		>80,000	Huacuz 2000
Other Latin America		50,000	
Morocco		>80,000	Martinot et al. 2002; data are for 1995
Indonesia		40,000	Tumiwa 2005
Nepal	16,000	80,000	Rai 2004; World Bank **[which year?]]**
Vietnam		5,000	
Others		50,000	
Total	>320,000	~ 2 million	

Notes:

(a) China: The China REDP project had installed 234,000 systems as of December 2004, 130,000 of these in 2004 and most of the remaining 100,000 in 2003. China had 150,000 SHS as of 2000 (Martinot et al. 2002). Li et al. (2005) say there is 30 MW of PV in off-grid applications. The Township Electrification program added 20 MW of hybrid systems. 10 MW of SHS, assuming 25W systems, is 400,000. 2002 = 83,000 SHS installed, 2003 = 75,000 installed, 2004 = 130,000 systems installed (+ non-REDP). Assuming 50,000 in 2001, then 2004 existing = 478,000. By end-2003, 410,000 cumulative in six Western provinces, per REDP report. This comes to a total of 540,000 by end-2004.

(b) Sri Lanka and Bangladesh: As of March 2005, World Bank projects in Bangladesh had installed 30,000-40,000 systems, and Sri Lanka RERD had installed 42,000 systems (see www.energyservices.lk). Sri Lanka had 3,000 systems as of 2000, and the first RERD project added 30,000 systems.

(c) Thailand: A new government program to electrify the remaining rural households of the country installed at least 100,000 in 2004 and planned to complete a 300,000-system program in 2005. Prior to 2004, there were no SHS in Thailand.

(d) Large numbers of installed solar home systems, estimated at 10-20% by some and even higher percentages by others, may not actually be operational due to lack of service and spare parts, among other reasons (Martinot

et al. 2002).
(e) China installed about 40,000 systems from 2000-03 through pilot projects of the “Brightness” program. This was in addition to 230,000 systems installed through the World Bank/GEF Renewable Energy Development Project in 2002-04.
Sources: As given in table, plus submissions from report contributors. See also Martinot et al. 2002 and Niewenhaut et al. 2000.

In Kenya, government and donor projects remain a steady source of income for some PV businesses. There are more than 20 major PV import and manufacturing companies, and hundreds of rural vendors, many of which sell a range of brands. Rural vendors sell about half of the household-size modules; the other half are purchased directly from distributors in major cities. After an initial market fueled by donor aid and government programs in the early 1990s, by the mid-1990s commercial sales of solar PV for household use had surpassed other uses, and those sales continued to dominate the Kenyan PV market.

India commercial bank program: In 2003, UNEP initiated a credit facility in Southern India to help rural households finance the purchase of solar home systems. Two of India’s largest banks, Canara Bank and Syndicate Bank, along with their eight associate Regional Rural Banks (or Grameen Banks), established a Solar Loan Programme through their branch offices across Karnataka State and part of neighboring Kerala State. Previous to this program, only about 1,400 SHS had been financed in Karnataka. In addition to providing financial support in the form of interest rate subsidies for borrowers, the program provides assistance with technical issues, vendor qualification, and other activities to develop the institutional capacity for this type of finance. As of January 2005, the programme had financed nearly 12,000 loans (homes), through more than 2,000 participating bank branches. Sales volume had reached 1,000 systems per month. The fastest growth in loans is currently in rural areas, thanks in part to the increasing participation of the nine Grameen banks. The three-year program is on target to finance 20,000-25,000 solar home systems, making it one of the largest SHS loan programs globally. In response, other Indian banks have recently launched competing SHS loan programs.
(*) Program supported by the United Nations Foundation and the Shell Foundation.

Table N43b. Estimated Number of Solar Photovoltaic Systems Disseminated in Africa

Country	Number of Systems	Estimated Installed Capacity (kWp)
Kenya	150,000	3,600
Zimbabwe	84,500	1,689
Botswana	5,700	1,500
Ethiopia	5,000	1,200
Zambia	5,000	400
Eritrea	2,000	400
Tanzania	2,000	300
Uganda	3,000	152
Mozambique	(1000)	100

Swaziland	1,000	50
Malawi	900	40
Angola	(200)	10
South Africa	150,000	8
Total	**410,000**	

Source: AFREPREN 2004

[N44] Rural Access to Electricity

Table N44. Rural Access to Electricity, Selected Countries, 2004

Country	**Share of rural households electrified (percent)**	**Number of rural households remaining unelectrified**
China	98	7 million (30 million people, 29,000 villages)
Thailand	97	0.3 million
Costa Rica	90	
Mexico	84	1 million
Cuba	80	
Viet Nam	80	3.5 million
Brazil	70	2.5 million (12 million people)
Philippines	60	3 million
South Africa	50	2 million
India	44	78 million
Sri Lanka	30	2 million
Bangladesh	19	18 million
Zimbabwe	19	
Ghana	17	
Nepal	15	
Tanzania	2	> 3 million
Kenya	2	> 4 million
Ethiopia	1	< 7 million
Mali	1	
Uganda	1	>3.5 million
World Total		**350 million (1.6 billion people)**

Notes:
(a) By 2004, the most common number cited for number of people without access to electricity was 1.6 billion (see Goldemberg et al. 2004). This number used to be cited as 2 billion, but was revised downward in recent years due to analytical refinements. Assuming 4.4 people per household in developing countries (Worldwatch Institute 2004), this comes to 360 million households. It appears from the data above, in comparison with previously published statistics, that progress in several countries with rural electrification, including China and India, has reduced this number significantly. The 14 countries listed in this table represent a majority of the population in developing countries, yet show only 135 million households unelectrified.
(b) Only 1% of the rural households in Kenya and Uganda has access to electricity. This percentage has been relatively constant over the past decade (Karekezi & Kimani 2004).
(c) Rural household access to electricity in India was 33% in 2001-02 (Sihag et al. 2004).
(d) Annual rural connection rates vary, and a global estimate does not exist. In Kenya, roughly 3,000-4,000 rural households were receiving new electricity connections each year in the early 2000s.
(e) Rural access to electricity, rather than both rural and urban combined, is more appropriate to compare with renewable energy, since renewables will not be a competitive option for access in urban (peri-urban) areas close to existing electric grids. Rural-access percentages are harder to find in the literature than just the overall electrification rate for a country.
Sources: Karekezi & Kimani 2004 and 2005; D'Sa & Murthy 2004; AFREPREN 2004; Sihag et al. 2004; Goldemberg, et al. 2004; Krause & Nordstrom 2004; ESMAP 2002; World Bank 2004; India 2001 census; contributions and updates from report researchers and contributors.

[N45] Market Facilitation Organizations

Note: This listing is a work in progress and further updates are expected.

Industry Associations

American Biomass Association	www.biomass.org
American Council for Renewable Energy (ACORE)	www.american-renewables.org
American Wind Energy Association (AWEA)	www.awea.org
Australian Wind Energy Association	www.auswea.com.au
Brazilian Renewable Energy Companies Association	www.brsolar.com.br
British Association for Biofuels and Oils	www.biodiesel.co.uk
British Biogen	www.britishbiogen.co.uk
British Photovoltaic Association	www.pv-uk.org.uk
British Wind Energy Association (BWEA)	www.bwea.com
Business Council for Sustainable Energy (BCSE)	www.bcse.org
Canadian Solar Industries Association (CANSIA)	www.cansia.org
Canadian Wind Energy Association (CANWEA)	www.canwea.ca
China Renewable Energy Industries Association (CREIA)	www.creia.net
Danish Wind Industry Association	www.windpower.org
European Biomass Association	www.ecop.ucl.ac.be/aebiom
European Biomass Industry Association (EUBIA)	www.eubia.org
European Geothermal Energy Council (EGEC)	www.geothermie.de
European Photovoltaic Industry Association	www.epia.org
European Renewable Energy Council (EREC)	www.erec-renewables.org
European Renewable Energy Federation (EREF)	www.eref-europe.org
European Small Hydro Association (ESHA)	www.esha.be
European Solar Thermal Industry Federation (ESTIF)	www.estif.org
European Wind Energy Association (EWEA)	www.ewea.org
Finnish Wind Power Association (FWPA)	www.tuulivoimayhdistys.fi
German Energy Agency (DENA)	www.deutsche-energie-agentur.de
German Renewable Energy Association	www.bee-ev.de/
German Industry Assoc. for the Promotion of Rural Electrification.	www.cle-export.de/
German Solar Industry Association	www.bsi-solar.de
German Wind Energy Association	www.wind-energie.de
Global Wind Energy Council (GWEC)	www.gwec.net
Indian Wind Energy Association	www.inwea.org
Indian Wind Turbine Manufacturers Association	www.indianwindpower.com
(India) Wind Power Developers Association	[n/a]
International Geothermal Association (IGA)	http://iga.igg.cnr.it/index.php
Irish Wind Energy Association (IWEA)	www.iwea.org

Japanese Wind Power Association	www.jwpa.jp
Japanese Wind Energy Association	http://ppd.jsf.or.jp/jwea
Sustainable Energy Industries Association (Australia)	www.seia.com.au
Sustainable Energy Ireland (SEI)	www.irish-energy.ir
Solar Energy Industries Association (SEIA)	www.seia.org
Swiss Wind Energy Association	www.suisse-eole.ch
World Wind Energy Association (WWEA)	www.wwindea.org

NGOs

African Energy Policy Research Network (AFREPREN)	www.afrepren.org
ASEAN Centre for Energy	www.aseanenergy.org
Association for the Promotion of Renewable Energy	www.apere.org
Austrian Biofuels Institute	www.biodiesel.at
Australian and New Zealand Solar Energy Society (ANZSES)	www.anzses.org
Basel Agency for Sustainable Energy (BASE)	www.energy-base.org
Bioenergy Austria	www.bioenergy.at
Biomass Users Network Brazil (BUN)	www.cenbio.org.br
Biomass Users Network Central America	www.bun-ca.org
Canadian Association for Renewable Energy	www.renewables.ca
Center for Resource Solutions	www.resource-solutions.org
Cogen Europe	www.cogen.org
Energieverwertungsagentur-Eva	www.eva.wsr.ac.at
European Renewable Energy Exchange	www.eurorex.com
Eurosolar	www.eurosolar.org
Greenpeace International	www.greenpeace.org
India (Kerala) Renewable Energy Center	www.mithradham.org
Intermediate Technology Development Group	www.itdg.org
International Institute for Energy Conservation (IIEC)	www.iiec.org
International Solar Energy Society (ISES)	www.ises.org
Mali Folkecenter	www.malifolkecenter.org
MicroEnergy International	http://microenergy-international.com
Mosaico Network	www.mosaiconetwork.org
Organizations for the Promotion of Energy Technologies (OPET)	www.cordis.lu/opet
Photovoltaics Global Approval Program (PV GAP)	www.pvgap.org
Renewable Energy Policy Project (REPP)	www.crest.org
Solar Electric Light Fund (SELF)	www.self.org
Winrock International	www.winrock.org
World Alliance for Decentralized Energy (WADE)	www.localpower.org
World Business Council for Sustainable Development (WBCSD)	www.wbcsd.org
World Resources Institute (WRI)	www.wri.org

World Wildlife Fund (WWF)	www.wwf.org
Worldwatch Institute (WWI)	www.worldwatch.org
Brahmakumaris (India)	www.brahmakumaris.com.au
Ramakrishna Mission (India)	www.rkmcnarendrapur.org
Planters Energy Network (India)	[n/a]
Social Works and Research Centre (India)	www.barefootcollege.org
Ladhakh Ecological Development Group (India)	[n/a]
Solar Energy Society of India	[n/a]

International Partnerships and Networks

African Energy Policy Research Network (AFREPREN)	www.afrepren.org
European Green Cities Network	www.greencity.dk
European Renewable Energy Research Centers Agency (EUREC)	www.eurec.be
European Solar Cities Initiative	www.eu-solarcities.org
e7 Network of Expertise for the Global Environment	www.e7.org
Global Network on Energy for Sustainable Development (GNESD)	www.gnesd.org
Global Village Energy Partnership (GVEP)	www.gvep.org
International Network for Sustainable Energy (INFORSE)	www.inforse.org
International Solar Cities Initiative (ISCI)	www.solarcities.or.kr
Mosaico Sustainable Agriculture and Infrastructure Network	www.mosaiconetwork.org
Renewable Energy and Energy Efficiency Partnership (REEEP)	www.reeep.org
Renewable Energy Policy Network for the 21st Century (REN21)	www.ren21.net
UNEP Sustainable Energy Finance Initiative (SEFI)	www.sefi.unep.org
World Council for Renewable Energy (WCRE)	www.wcre.org
World Energy Council (WEC)	www.worldenergy.org
World Renewable Energy Network (WREN)	www.wren.org

International Agencies

Asian Development Bank	www.adb.org
African Development Bank	www.afdb.org
European Bank for Reconstruction and Development	www.ebrd.org
European Investment Bank	www.eib.org
Food and Agricultural Organization of the UN	www.fao.org
Global Environment Facility	www.gefweb.org
Inter-American Development Bank	www.iadb.org
International Energy Agency	www.iea.org
UN Asian and Pacific Centre for Transfer of Technology (APCTT)	www.apctt.org
UN Department of Economic and Social Affairs (UNDESA)	www.un.org/esa/desa.htm
UN Development Programme	www.undp.org

UN Economic and Social Commission for Asia-Pacific (ESCAP)	www.unescap.org
UN Environment Programme	www.unep.org
UN Industrial Development Organization	www.unido.org
World Bank Group	www.worldbank.org

Bilateral Aid Agencies

Australia AusAID	www.ausaid.gov.au
Canada International Development Agency (CIDA)	www.acdi-cida.gc.ca/home
Danish International Development Assistance (DANIDA)	www.um.dk
French Fund for the Global Environment (FFEM)	www.ffem.net
French Agency for Environment and Energy Management (Ademe)	www.ademe.fr
German Agency for Technical Cooperation (GTZ)	www.gtz.de
German Development Finance Group (KfW)	www.kfw.de
Netherlands Agency for Energy and the Environment (Novem)	www.novem.org
Swedish Energy Agency (STEM)	www.stem.se/english
UK Carbon Trust	www.thecarbontrust.co.uk
UK Department for International Development (DFID)	www.dfid.gov.uk
US Agency for International Development	www.usaid.gov
US Environmental Protection Agency	www.epa.gov

National Government Agencies

Brazil Ministry of Mines and Energy	www.mme.gov.br
Brazilian Electricity Regulatory Agency	www.aneel.gov.br
Canada Sustainable Development Technology Canada (SDTC)	www.sdtc.ca
China National Development and Reform Commission (NDRC)	www.ndrc.gov.cn
German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)	www.erneuerbare-energien.de
India Ministry for Non-Conventional Energy Sources (MNES)	www.mnes.gov.in
India Renewable Energy Development Agency (IREDA)	www.ireda.in
Japan New Energy and Industrial Tech. Develop. Org. (NEDO)	www.nedo.go.jp
Netherlands Senter Novem	www.senternovem.nl
New Zealand Energy Effic. and Conservation Authority (EECA)	www.eeca.govt.nz
Thailand Department of Alternative Energy and Efficiency	www.dede.go.th
US Department of Energy (USDOE)	www.eere.doe.gov

State/Provincial Government Agencies [for future development; one example below]

California Energy Commission	www.energy.ca.gov/renewables

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● Energy Policy	www.elsevier.com/locate/enpol
● GVEP electronic newsletter	www.rsvp.nrel.gov/asp/newsletter_search.asp
● Photon magazine	www.photon-magazine.com
● Renewable Energy World	www.jxj.com/magsandj/rew
● RenewableEnergyAccess.com	www.renewableenergyaccess.com
● REFocus	www.re-focus.net
● Renewable Energy Portal	www.odysen.com
● Solar Buzz	www.solarbuzz.com

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