МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ
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ОСОБЕННОСТИ ПЕРЕВОДА НАУЧНЫХ ТЕКСТОВ

Учебное пособие

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Рецензенты:

канд. филолог. наук, доц. каф. «Иностранные языки» ИЭУП
Д.Б. Исмаилова;

д-р филолог. наук, проф. каф. «Иностранные языки» КГЭУ
Г.Ф. Лутфуллина

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В учебном пособии представлены научные тексты, предназначенные для чтения, перевода и последующего их обсуждения, а также лексический материал и упражнения на его закрепление по курсу английского языка в объеме, предусмотренном учебными рабочими программами.

Пособие предназначено для студентов, обучающихся по программе профессиональной переподготовки «Переводчик в сфере профессиональной коммуникации».

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ВВЕДЕНИЕ

В настоящее время существует необходимость в выделении научного перевода как особого вида переводческой деятельности и специальной теории, исследующей этот вид деятельности. Повышение значимости перевода научной литературы как способа обмена и распространения информации в мировом сообществе и недостаточность исследований приемов и способов перевода в данной области обусловили актуальность данного учебного пособия.

Цель пособия – приобретение студентами и развитие у них навыков перевода и обсуждения научных текстов.

В пособии представлены тексты для перевода, а также лексический материал по соответствующей теме и ряд упражнений на его усвоение и закрепление. Кроме того, упражнения на перевод с русского языка на английский позволяют студентам тренировать навыки построения предложений на иностранном языке.

Пособие дает возможность закрепить и углубить знания, полученные в процессе изучения основной программы вуза.

В процессе освоения данной дисциплины студент формирует и демонстрирует следующие компетенции или их составляющие:

– способность к критическому анализу и оценке современных научных достижений, генерированию новых идей при решении исследовательских и практических задач, в том числе в междисциплинарных областях;

– готовность участвовать в работе российских и международных исследовательских коллективов по решению научных и научно-образовательных задач;

– готовность использовать современные методы и технологии научной коммуникации на государственном и иностранном языках.

В результате освоения дисциплины обучающийся должен:

– знать особенности английского научного текста и научной терминологии, особенности перевода научного текста, отличительные черты перевода научных монографий, приемы перевода фразеологических единиц;

– уметь распознавать импликации, характерные для английского языка, при техническом переводе, уметь точно и четко логически излагать материал;

– владеть навыками, способами и приемами перевода научного текста и научной терминологии.

ГЛАВА 1. ОСОБЕННОСТИ АНГЛИЙСКОГО НАУЧНОГО ТЕКСТА

Основной стилистической чертой научного текста является точное и четкое изложение материала при почти полном отсутствии тех выразительных элементов, которые придают речи эмоциональную насыщенность, главный упор делается на логической, а не на эмоционально-чувственной стороне излагаемого. Автор научно-технической статьи стремится к тому, чтобы исключить возможность произвольного толкования существа трактуемого предмета, вследствие чего в научной литературе почти не встречаются такие выразительные средства, как метафоры, метонимии и другие стилистические фигуры, которые широко используются в художественных произведениях для придания речи живого, образного характера. Авторы научных произведений избегают применения этих выразительных средств, чтобы не нарушить основного принципа научно-технического языка – точности и ясности изложения мысли.

Правда, нужно отметить, что при всей своей стилистической отдаленности от живого разговорного языка, богатого разнообразными выразительными средствами, научно-технический текст все же может включать в себя некоторое количество нейтральных фразеологических сочетаний технического характера. (The wire is alive – провод под током; the wire is dead – провод отключен).

С точки зрения словарного состава основная особенность научного текста заключается в предельной насыщенности специальной терминологией, характерной для данной отрасли знания, которая дает возможность наиболее точно, четко и экономно излагать содержание данного предмета и обеспечивает правильное понимание существа трактуемого вопроса. В специальной литературе термины несут основную семантическую нагрузку, занимая главное место среди прочих общелитературных и служебных слов.

В отношении синтаксической структуры английские тексты научно-технического содержания отличаются своей конструктивной сложностью. Они богаты причастными, инфинитивными и герундиальными оборотами, а также некоторыми другими чисто книжными конструкциями, которые подчас затрудняют понимание текста и ставят перед переводчиком дополнительные задачи.

1.1. Научная терминология

В обычной речи слова, как правило, полисемантичны, т. е. они передают целый ряд значений, которые могут расходиться порой довольно широко. Возьмем для примера сумму значений слова table, которые концентрируются вокруг стержневого понятия «плоскость»: стол, скрижаль, доска, таблица, плита, табель, дощечка, плоскогорье. Наряду с этим слово table обладает и рядом переносных значений, сохраняющих известную, хотя и более отдаленную, связь со стержневым понятием: общество за столом, еда (то, что подается на стол), надпись на плите. Такая многозначность слов в общелитературном языке является фактором, свидетельствующим о богатстве языковых изобразительных средств. Лексическая многозначность придает речи гибкость и живость и позволяет выражать тончайшие оттенки мысли.

Иначе обстоит дело в научном языке; в нем главным требованием оказывается предельная точность выражения мысли, не допускающая возможности различных толкований. Поэтому основным требованием, предъявляемым к термину, становится однозначность, т. е. наличие только одного раз и навсегда установленного значения. Фактически далеко не все термины удовлетворяют этому требованию даже в пределах одной специальности, например: engine – машина, двигатель, паровоз; oil – масло, смазочный материал, нефть. Это представляет затруднение для точного понимания текста и осложняет работу переводчика.

Каковы источники возникновения английской научно-технической терминологии? Наибольшую группу составляют термины, заимствованные из иностранных языков, или искусственно созданные учеными на базе, главным образом, латинского и греческого языков, по мере развития науки и техники и появления новых понятий. Так, например, в 1830 году появилось название нового инертного вещества paraffin от латинского parum affinis, т. е. мало соприкасающийся (с другими веществами). Иногда возникали и гибридные образования вроде haemoglobin от греческого haima кровь и латинского globus шар. Особенно много терминов появилось в Англии в XVIII и XIX веках в период бурного развития наук, при этом часть терминов из языка ученых стала проникать в общелитературный язык и сделалась всеобщим достоянием. К таким словам относятся: dynamo, ozone, centigrade, gyroscope, sodium и др. В XX веке возникли такие новообразования, как: penicillin, hormone, isotope, photon, positron, radar, biochemistry, cyclotron и т. д. Эти термины быстро стали общепонятными благодаря тесной связи новейших научных открытий с повседневной жизнью. Все же нужно отметить, что основная масса научно-технической терминологии продолжает оставаться за пределами общелитературного языка и понятна лишь специалисту данной отрасли знания.

Вторая по величине группа терминов представляет собой общелитературные английские слова, употребляемые в специальном значении. К таким словам относятся, например: jacket – куртка и, вместе с тем – кожух; jar – кувшин и конденсатор; to load – нагружать и заряжать. При этом встречается употребление одного слова в разных специальных значениях, в зависимости от отрасли знания; слово pocket – карман, например, имеет следующие специальные значения: воздушная яма (в авиации), окружение (в военном деле), мертвая зона (в радио), гнездо месторождения (в геологии), кабельный канал (в электротехнике).

В структурном отношении все термины можно классифицировать следующим образом: простые термины (oxygen, resistance, velocity) и сложные термины, образованные путем словосложения. Составные части сложного термина часто соединяются с помощью соединительного гласного:

gas + meter = gasometer. При этом иногда происходит усечение компонентов: turbine + generator = turbogenerator. Словосочетания, компоненты которых находятся в атрибутивной связи, т. е. один из компонентов определяет другой: direct current – постоянный ток. Нередко атрибутивный элемент сам выражен словосочетанием, представляющим собой семантическое единство. Это единство орфографически часто выражается написанием через дефис:

low-noise penthode – малошумный пентод, doubling-over test – испытание на сгиб. Аббревиатура, т. е. буквенные сокращения словосочетаний:

e.m.f. = electromotive force – электродвижущая сила. Сокращению может подвергнуться часть словосочетания: D.C. amplifier = direct current amplifier – усилитель постоянного тока. Слоговые сокращения, превратившиеся в самостоятельные слова:

loran (long range navigation) – система дальней радионавигации «Лоран», radar (radio detection and ranging) – радиолокация. Литерные термины, в которых атрибутивная роль поручается определенной букве вследствие ее графической формы:

T – antenna – Т-образная антенна; V – belt – клиновидный ремень. Иногда эта буква является лишь условным, немотивированным символом:

X-rays – рентгеновские лучи.

При переводе терминов мы можем встретиться со следующими моментами:

а) часть терминов, имеющих международный характер, передается путем транслитерации и не нуждается в переводе: antenna – антенна, feeder – фидер, blooming – блюминг;

б) некоторые термины имеют прямые соответствия в русском языке и передаются соответствующими эквивалентами: hydrogen – водород; voltage – напряжение;

в) известная часть терминов при переводе калькируется, т. е. передается с помощью русских слов и выражений, дословно воспроизводящих слова и выражения английского языка: single-needle instrument – однострелочный аппарат, superpower system – сверхмощная система;

г) нередко случается, что словарь не дает прямого соответствия английскому термину. В этом случае переводчик должен прибегнуть к описательному переводу, точно передающему смысл иноязычного слова в данном контексте: video-gain – регулировка яркости отметок от отраженных сигналов. При переводе терминов следует по возможности избегать употребления иноязычных слов, отдавая предпочтение словам русского происхождения: «промышленность» вместо «индустрия», «сельское хозяйство» вместо «агрикультура», «полное сопротивление» вместо «импеданс» и т. д. Поскольку характерной чертой термина является четкость семантических границ, он обладает значительно большей самостоятельностью по отношению к контексту, чем обычные слова. Зависимость значения термина от контекста возникает лишь при наличии в нем полисемии, т. е. если в данной области знания за термином закреплено более одного значения.

1.2. Импликации в английских научных текстах

В различных языках тенденция к импликации, или неявному словесному выражению, реализуется по-разному. В частности, русскому языку чужды некоторые импликации, характерные для английского языка. Это обстоятельство необходимо учитывать переводчикам с английского и на английский: первые должны устранять импликации, неприемлемые в русском языке, а вторым нужно использовать английские импликации как прием компрессии текста, и иногда как стилистическое средство.

Техническому переводчику полезно иметь представление обо всех основных формах импликаций, типичных для монографий и особенно журнальных статей. Чтобы облегчить обнаружение импликаций в тексте оригинала, целесообразно указать идентифицирующие признаки каждой формы, т. е. по существу классифицировать импликации.

Ниже сделана попытка такой классификации и на конкретных примерах показаны приемы устранения импликаций при техническом переводе.

Тип I. В атрибутивной цепочке опускается одно из нескольких существительных, в результате чего определение опущенного существительного можно ошибочно принять за определение другого существительного (В стилистике рассматривается случай, когда опускаемое существительное представляет собой действующее лицо. Прилагательное, служащее определением опущенного существительного, называют «перенесенным эпитетом»). Этот тип импликации обнаруживается при переводе из-за лексической несочетаемости на русском языке. The annealed hardness of the material does not provide as good a correlation with the measured erosion wear. «Отожженная твердость» не имеет смысла, так как отжечь можно материал, но не параметр или характеристику материала. Поскольку из контекста статьи следовало, что отжигу подвергался материал поверхностного слоя детали, переводчик легко восстановил (упущенное существительное (the annealed hardness > he annealed surface hardness = the hardness of the annealed surface) и дал адекватный перевод. Твердость отожженной поверхности материала не дает такой же хорошей корреляции с измеренным значением эрозионного износа.

Распознавание импликаций I типа значительно затрудняется, если определением опущенного существительного служит одно из таких легкосочетаемых прилагательных, как conventional, full, ideal, normal, simple, single, total, uniform, usual. Further studies with the normal computer model revealed that if the assumptions regarding the rate of insulin secretion were correct the duration of infusion of glucose in an intravenous glucose tolerance test would be an important determinant of the amount of insulin released during the infusion. Термин normal computer model вполне можно принять за «обычную машинную модель», и только анализ всей статьи о динамике гомеостаза глюкозы позволяет установить, что под normal имеется в виду normal state, т. е. нормальное состояние человека, или состояние здорового человека. Дальнейшие исследования машинной модели нормального состояния показали, что если бы допущения о скорости секреции инсулина были верными, продолжительность вливания глюкозы при внутривенном анализе на толерантность к глюкозе была бы важнейшим показателем количества инсулина, выделяемого за время вливания. В параллельных синтаксических конструкциях возможно опускание последнего существительного в цепочке. Поскольку такая импликация имеет аналогию в русском языке, переводчику нужно просто быть внимательнее, чтобы избежать буквализма. The possibility of replacing the two stage turbine with a single stage was considered, but rejected because the aerodynamic loading would have been higher than was desirable. Была рассмотрена возможность замены двухступенчатой турбины одноступенчатой, но от нее отказались, поскольку аэродинамическая нагрузка превысила бы требуемую. Задача переводчика осложняется, если параллельность конструкции отсутствует. Fuel nitrogen is minimized by operating the reaction zone as rich as possible without the presence of hydrocarbons. Только контекст всей статьи, из которой взят этот пример, позволяет убедиться, что под fuel nitrogen имеется в виду fuel nitrogen conversion, или превращение азота топлива в NOx.

Тип II. В сравнительном обороте опускается сравниваемое существительное, но сохраняется его определение в общем падеже. The James [2] and Smith [3] correlations show essentially the same predictive reliability, and are somewhat poorer than Murdock. Мы видим, что после сравнительной степени прилагательного вместо таких привычных вариантов, как “than Murdock correlation”, “than that of Murdock”, “than Murdock's one” следует “than Murdock”. В переводе, конечно, импликацию нужно устранить. Корреляционные выражения Джеймса [2] и Смита [3] обнаруживают практически одинаковую точность и несколько менее точны, чем выражение Мардока.

Тип III. По аналогии с импликациями II типа в импликациях этого типа опускается слово-заменитель, но сохраняется его определение. Fig. 5 shows the results of these tests, the upper curve being the large protrusion. Совершенно ясно, что the large protrusion = the one for the large protrusion, что и отражается в переводе. Результаты этих опытов показаны на фиг. 5, причем верхняя кривая относится к случаю большого выступания бруса.

Тип IV. Этот тип импликации напоминает тип I, но определением здесь всегда служит существительное, а цепочка, если ее восстановить, насчитывает только два звена – поэтому перенесение свойств одного существительного на другое (как в импликациях I типа) отсутствует. Мы фактически встречаемся с проявлением метонимии, или с заменой названия одного предмета названием другого, связанного с первым «по смежности». Так, в нижеследующем примере вместо термина «течение на площадке» используется термин «площадка». These small areas are expected to be separated, and oil flow boundary layer visualization studies confirm this.

Тип V. К этому типу импликаций относятся имплицитные термины вроде incidence (угол атаки). В газодинамических статьях термин incidence употребляется так часто, что стал двойником более понятного термина incidence angle, или angle of incidence. (В англо-русском словаре по аэродинамике приводятся оба термина.) Нетрудно увидеть, что в основе мплицитных терминов лежит импликация IV типа. В самом деле – сочетание имплицитного термина с существительным воспринимается как эксплицитное переводчиком, знакомым с термином, и как импликация I типа переводчиком, не знакомым с термином. Покажем это на примере того же incidence. Magliozzi, et al. (35) measured the wake behavior downstream of a rotor and found that over the 15 percent of the span near the tip the incidence variations into the stator are significantly greater than elsewhere. Мальоцци с сотрудниками (35) измерили характеристики следа за ротором и обнаружили, что на 15 % высоты лопатки вблизи ее конца изменения угла атаки в статоре существенно больше, чем где-либо в другом месте. Еще один пример: теплотехнический термин incipience, который встречается сейчас наряду с породившим его термином incipient boiling (начальное кипение, закипание). Как и в предыдущем случае, здесь опущено определяемое существительное (boiling) и оставлено определяющее слово, но т. к. последнее является прилагательным (incipient), происходит одновременная трансформация прилагательного incipient в существительное incipience. Large superheates for incipience appear to be characteristic of organic liquids of low surface tension compared with water. Для органических жидкостей с малым по сравнению с водой поверхностным натяжением характерны, по-видимому, большие перегревы при закипании.

Тип VI. Если исходить из использованного А.Д. Швейцером определения импликации как «неявного словесного выражения», то в семью импликаций можно, пожалуй, включить имплицитные многокомпонентные термины и терминологические сочетания. Встречаясь с импликациями такого типа, переводчик с английского должен устранять чрезмерный лаконизм термина. (Следует отметить, что в современном русском языке научно-технической литературы также наблюдается тенденция компрессии терминов. Многие термины, когда-то резавшие слух, стали привычными, например: «текущая глубина» вместо «текущее значение глубины», «упругое решение» вместо «решение по теории упругости» и т. п.) И наоборот, переводчик на английский должен увидеть в многократно повторяемом русском терминологическом сочетании (или описательном термине) устойчивый английский термин, построенный путем импликации. Приведем несколько примеров таких терминов: bore Reynolds number – число Рейнольдса, вычисленное по диаметру отверстия; measured endurance ratio – относительная выносливость, вычисленная по результатам измерений, stress-life exponent – показатель степенной зависимости между напряжением и долговечностью; plastic design – расчет с учетом пластических деформаций; plastic resistance – сопротивление пластической деформации; unstable conditions – условия неустойчивой работы; rotational blowdown – продувка при вращении ротора.

Тип VII. Известно, что стилистические нормы английского языка допускают тавтологию, или употребление слов одного корня в пределах одного предложения. В то же время в английском языке научно-технической литературы существует противоположная по характеру тенденция ограниченного использования одного и того же слова в предложении и даже в соседних предложениях. Проявляется она в том, что англоязычные авторы не только чаще русских авторов прибегают к местоимениям и словам-заменителям вроде one, that, these, the former, the latter, (the) same, the whole, the foregoing, counterpart, но и тяготеют к словам-заменителям, которые можно назвать имплицитными и которые, что весьма интересно, нередко употребляются самостоятельно, т. е. без предшествующих им заменяемых слов. Имплицитное слово-заменитель (ИСЗ) обладает широким значением, что позволяет ему заменять и семантически родственные слова и слова, связанные лишь метонимически – некоторая аналогия с импликациями IV типа, причем связь не всегда легко обнаружить (Не имея возможности подробнее остановиться на анализе ИСЗ, укажем только, что их следует отличать от многозначных слов и слов широкой семантики. Отметим также, что в русском языке научно-технической литературы встречаются подобные слова-заменители (прибор, устройство, машина, механизм, формулировка, условие, средство), однако их гораздо меньше и, главное, – они не употребляются самостоятельно, а логическая связь заменяемого и заменяющего слов совершенно очевидна). Так, ИСЗ consideration, имеющее словарные значения «рассмотрение», «соображение», «учет», может заменить любое слово, обозначающее некий объект рассмотрения (метонимическое отношение «процесс – объект»).

А. Consequently, it is likely that none of the above considerations would have led to ball-retainer forces sufficiently large to cause failure. Следовательно, вполне вероятно, что ни один из вышерассмотренных факторов не приводил к появлению усилий между шариками и сепаратором, способных вызвать разрушение.

Б. Special considerations insure the reliable operation of these thyristor drive systems. Надежная работа тиристорных систем электропривода обеспечивается специальными мерами.

ИСЗ feature, имеющее основные словарные значения «особенность», «характерная черта», «признак» и «свойство», может заменить любое слово, называющее элемент некоего целого (метонимическое отношение «принадлежность – элемент»).

А. Salient features of the agreement. Основные постановления соглашения.

Б. Fig. 2 is a schematic diagram illustrating the salient features of the analitical and experimental program. На фиг. 2 представлена схема, иллюстрирующая основные этапы программы экспериментально-теоретических работ.

B. The equipment developed for the study of the mechanical pulping process consists of three major components: the grinder machinery, the grinder control instrumentation, and data collection features. Оборудование, разработанное для исследования процесса получения древесной массы, состоит из трех основных частей: дефибрера, приборов и регуляторов системы управления и устройств для сбора данных. Механизм перевода ИСЗ напоминает детскую игру “Changing WARM to COLD in four moves”: warm – ward – word – cord – cold. Чтобы при переводе на русский конкретизировать значение ИСЗ, как это было сделано в вышеприведенных примерах, нужно понять общую идею, заложенную в ИСЗ. Для этого обычно достаточно проанализировать значение ИСЗ, приводимое в двуязычных словарях. Так, в случае ИСЗ consideration конкретизация не представляет большого труда: рассмотрение – рассмотрение факторов – рассмотренные факторы – факторы. Однако из словарных значений ИСЗ feature трудно сделать вывод об общей идее, и определить ее можно только после анализа самых разных контекстов. Переводчикам с английского и на английский полезно знать наиболее распространенные ИСЗ. С целью экономии места мы приводим эти слова без контекста и перевода. Однако для каждого ИСЗ указывается общая идея (в кавычках) и одно или несколько конкретных значений (в скобках). 1. Application – «объект, в котором можно применить» (locomotive, plant). 2. Approach – «связанное с некоторым методом» (results). 3. Arrangement – «определяемое схемным решением» (version, plant). 4. Aspect – «связанное с некоторой особенностью» (equation). 5. Behavior – «характеризуемое особенностями поведения» (flow). 6. Category – «поддающееся группировке, классификации» (parameter). 7. Condition – «описывающее состояние» (temperature, stress, pressure). 8. Configuration – «отличающееся формой» (version, hole). 9. Contribution – «влияющая величина» (strength). 10. Consideration – «объект рассмотрения» (factor, measure). 11. Criterion – «определяемое критерием» (failure). 12. Effect – «испытывающее или оказывающее влияние» (parameter). 13. Environment – «связанное с условиями работы» (oxygen, bearing, vehicle). 14. Feature – «элемент целого» (item, device, stage). 15. Format – «характеризуемое внешними признаками» (design, coordinates). 16. Formulation – «результат формулирования» (composition, theory, equation). 17. Geometry – «характеризуемое геометрическими признаками» (partition). 18. Information – «извлекаемое из информации» (value, figure). 19. Problem – «вызывающее какие-либо затруднения» (fouling, contamination). 20. Requirement – «требуемое или искомое» (amount, loss, value). 21. Result – «являющееся результатом» (characteristics). 22. Situation – «относящееся к рассматриваемому случаю» (process, film). 23. System – «рассматриваемое как система» (material, burner, fuel / air mixture). 24. Theory – «связанное с теоретическим описанием» (equation).

25. Type – «подразделяемое на типы» (tower). Практика показывает, что переводчики с английского, стараясь избежать буквализма, так или иначе раскрывают значения ИСЗ. С другой стороны, даже опытные переводчики на английский (не являющиеся носителями английского языка) не пользуются ИСЗ либо по незнанию этого стилисти-ческого приема, либо из опасения, что редактор (также не принадлежащий к носителям английского языка) сочтет ИСЗ ошибкой. Отметим еще одно обстоятельство, связанное с ИСЗ. Эти слова выступают иногда в роли так называемых «громких слов» (Big Words). Американский математик Джон Кемени в предисловии к одной из своих книг полушутя, полусерьезно пишет: «Многие читатели судят о глубине книги по количеству встречающихся в ней громких слов и обилию труднопонимаемых мест». Так или иначе, но некоторые американские и английские авторы предпочитают concept более обыденным plan и design. Излюбленными «громкими словами», помимо многих ИСЗ, являются также basis, capacity, mode, pattern, technology. В некоторых случаях громкие слова используются рядом со словами, которые они могли бы заменить, в результате чего в текст вносится неоправданная избыточность. При переводе избыточные ИСЗ опускаются без ущерба для понимания текста, например:

А. A schematic drawing of the boiler configuration is shown in Fig. 1. Схематический чертеж котла показан на фиг. 1.

Б. Low temperature tests were performed with the specimen completely submerged in liquid nitrogen (76 K) or liquid helium (4 K) environment. Низкотемпературные испытания проводили с образцом, полностью погруженным в жидкий азот (76 К) или жидкий гелий (4К).

Контрольные вопросы

1. Объясните, в чем проявляется отличительная особенность научно-технического языка.
2. Поясните, какую роль играют термины в специальной литературе.
3. Проанализируйте, почему заимствования занимают особое место в научно-технической терминологии.
4. Перечислите виды терминов.
5. Обьясните, на что нужно обратить особое внимание при переводе терминов.
6. Поясните, что необходимо учитывать переводчику с английского языка и на английский.
7. Объясните, каким образом технический переводчик может обнаружить импликации в тексте оригинала.

ГЛАВА 2. ОСОБЕННОСТИ ПЕРЕВОДА НАУЧНОГО ТЕКСТА

2.1. Общие положения

В то время как основная трудность перевода художественной прозы заключается в необходимости интерпретации намерений автора, т. е. в передаче не только внешних фактов, но и в сохранении психологических и эмоциональных элементов, заложенных в тексте, задача, стоящая перед переводчиком научно-технического текста, лишенного эмоциональной окраски, оказывается более простой – точно передать мысль автора, лишь по возможности сохранив особенности его стиля. Для того чтобы правильно понять научно-технический текст, надо, как уже указывалось ранее, хорошо знать данный предмет и связанную с ним английскую терминологию. Кроме того, для правильной передачи содержания текста на русском языке нужно знать соответствующую русскую терминологию и хорошо владеть русским литературным языком. Перевод с помощью словаря незнакомых однозначных терминов типа – oxygen, ionosphere, не представляет затруднений. Иначе обстоит дело, когда одному английскому термину соответствует несколько русских, например switch – выключатель, переключатель, коммутатор. В этом случае сознательный выбор аналога может диктоваться лишь хорошим знанием данного предмета. Возьмем предложение: Most of the modern radio-transmitters can communicate both telegraph and telephone signals. Переводчик, основательно не знакомый с радиоделом и соответствующей русской терминологией, перевел бы это предложение так: «Большинство современных радиопередатчиков может посылать как телеграфные, так и телефонные сигналы». Однако технически грамотный перевод должен быть следующим: «Большинство современных радиопередатчиков может работать как в телеграфном, так и в телефонном режиме». Основными чертами русского научно-технического стиля являются строгая ясность изложения, четкость определений, лаконичность формы. При переводе английского текста переводчик должен полно и точно передать мысль автора, облекая ее в форму, присущую русскому научно-техническому стилю и отнюдь не перенося в русский текст специфических черт английского подлинника. Для иллюстрации остановимся на некоторых стилистико-грамматических особенностях английского текста, чуждых стилю русской научно-технической литературы.

1. В английском тексте преобладают личные формы глагола, тогда как русскому научному стилю более свойственны безличные или неопределенно-личные обороты, например: You might ask why engineers have generally chosen to supply us with a.c. rather than d.c. for our household needs. Можно спросить, почему для домашних надобностей обычно используется переменный, а не постоянный ток. We know the primary coil in the ordinary transformer to have more turns than the secondary one. Известно, что первичная обмотка обычного трансформатора имеет больше витков, чем вторичная.

2. В английских текстах описательного характера нередко употребляется будущее время для выражения обычного действия. Руководствуясь контекстом, следует переводить такие предложения не будущим, а настоящим временем, иногда с модальным оттенком: The zinc in the dry cell accumulates a great many excess electrons which will move to the carbon electrode. Цинк в сухом элементе аккумулирует большое число избыточных электронов, которые движутся к угольному электроду. Fig. 10 gives a drawing of a bulb; the filament will be seen in the centre. На рис. 10 приводится чертеж электрической лампы; нить накала видна в центре.

3. В английских научно-технических текстах особенно часто встречаются пассивные обороты, тогда как в русском языке страдательный залог употребляется значительно реже. При переводе, следовательно, мы нередко должны прибегать к замене пассивных конструкций иными средствами выражения, более свойственными русскому языку. Предложение – This question was discussed at the conference можно перевести следующими способами: Этот вопрос был обсужден на конференции. Этот вопрос обсуждался на конференции. Этот вопрос обсуждали на конференции. Конференция обсудила этот вопрос.

4. Авторы английской научно-технической литературы широко используют различные сокращения, которые совершенно неупотребительны в русском языке, например: d.c. (direct current) постоянный ток a.c. (alternating current) переменный ток s.a. (sectional area) площадь поперечного сечения b.p. (boiling point) точка кипения и др. Такие сокращения в переводе должны расшифровываться и даваться полным обозначением.

5. Некоторые слова или выражения в английском тексте содержат чуждый нашему языку образ. При переводе они должны заменяться аналогами, т. е. выражениями, соответствующими по смыслу, но более обычными для русского текста, например: We have learned to manufacture dozens of construction materials to substitute iron. Вместо dozen дюжина в русском языке обычно в таких случаях употребляется слово десяток, поэтому это предложение мы переводим: Мы научились производить десятки строительных материалов, заменяющих железо.

2.2. Некоторые отличительные черты перевода научных монографий

Перевод монографии, содержащей крупное открытие в определенной области науки, налагает на переводчика определенные обязательства. Известно, что любое открытие, заявленное в письменном тексте, будет неизбежно подвергнуто критике еще на стадии редактирования. Переводчик, таким образом, несет полную ответственность не только за правильное изложение мыслей автора, но и за то, как будет принят редактором переведенный им текст. Поэтому, на первый план выступает необходимость некатегоричного изложения текста. Новые факты, с одной стороны, должны подаваться в окружении уже известного материала, с другой стороны, необходимо некатегорично, но четко выделять те идеи и факты, которые авторы считают приоритетными. В подлиннике это выделение нередко редуцировано. Переводчику также приходится смягчать слишком эмоциональную критику, которой автор подвергает зарубежных ученых, работающих в той же области. Другая особенность приоритетной монографии – это наличие в ней новых терминов, не имеющих соответствий в англоязычной литературе. Один из способов их передачи – транслитерация, другой – создание нового слова. В обоих случаях такой термин будет нуждаться в четком определении. После работы с редактором и выхода книги из печати переводчик, если он работает в тесном контакте с автором, должен заниматься ответами на письма зарубежных ученых, в которых содержатся критические замечания и вопросы. От стиля этих ответов зависит репутация книги в научном мире, где царит жесткая конкуренция.

2.3. Перевод фразеологизмов в научном тексте

Чтобы в теоретическом плане говорить о приемах перевода фразеологических единиц (ФЕ), нужно всю фразеологию языка расклассифицировать по какому-то обоснованному критерию на группы, в границах которых наблюдался бы как преобладающий тот или иной прием, тот или иной подход к передаче ФЕ. Многие авторы в качестве исходной точки берут лингвистические классификации, построенные в основном на критерии неразложимости фразеологизма, слитности его компонентов, в зависимости от которой и от ряда дополнительных признаков – мотивировки значения, метафоричности и т. п., – определяется место ФЕ в одном из следующих трех (четырех) разделов: фразеологические сращения (идиомы), фразеологические единства (метафорические единицы), фразеолологические сочетания и фразеологические выражения (Ш. Балли, В.В. Виноградов, Б.А. Ларин, Н.М. Шанский). Показательной в отношении творческого использования такой классификации в теории и практике перевода можно считать работу Л.В. Федорова. Разобрав основные для того времени (1968) лингвистические схемы, он останавливается на предложенной В.В. Виноградовым и осмысливает ее с точки зрения переводоведения. Например, он отмечает отсутствие четких границ между отдельными рубриками, «разную степень мотивированности, прозрачности внутренней формы и национальной специфичности» единств, которая может потребовать от переводчика «приблизительно такого же подхода, как идиомы». Та же классификация «весьма удобна для теории и практики перевода» и по мнению Я.И. Рецкера, который, однако, берет из нее только единства и сращения, считая, что по отношению к этим двум группам ФЕ следует применять неодинаковые приемы перевода: «перевод фразеологического единства должен, по возможности, быть образным», а перевод фразеологического сращения «осуществляется преимущественно приемом целостного преобразования». Такой подход к классификации приемов перевода ФЕ нельзя считать неправильным, так как от степени слитности компонентов несомненно зависит в некоторой мере и возможность полноценного перевода, выбор наиболее удачных приемов. Однако, как было отмечено, ведущие теоретики перевода, опираясь на лингвистические схемы, насыщают их своим содержанием, делают ряд модификаций и оговорок, вводят дополнительно деление на образные и необразные единицы, на фразеологизмы пословичного и непословичного типа и т. д. Возможности достижения полноценного словарного перевода ФЕ зависят в основном от соотношений между единицами иностранным языком (ИЯ) и переводимым языком (ПЯ):

1) ФЕ имеет в ПЯ точное, не зависящее от контекста полноценное соответствие (смысловое значение + коннотации);

2) ФЕ можно передать на ПЯ тем или иным соответствием, обычно с некоторыми отступлениями от полноценного перевода, переводится вариантом (аналогом);

3) ФЕ не имеет в ПЯ ни эквивалентов, ни аналогов, непереводима в словарном порядке. Несколько упрощая схему, можно сказать, что ФЕ переводят либо фразеологизмом (первые два пункта) – фразеологический перевод, либо иными средствами (за отсутствием фразеологических эквивалентов и аналогов) – нефразеологический перевод. Это, разумеется, полярные положения. Между ними имеется множество промежуточных, средних решений, с которыми связано дальнейшее развитие нашей схемы: приемы перевода в других разрезах – в зависимости от некоторых

характерных признаков и видов ФЕ (образная – необразная фразеология, ФЕ пословичного – непословичного типа), перевод с учетом стиля, колорита, языка, авторства отдельных единиц и т. д. Эти дополнительные аспекты полнее представят проблему перевода ФЕ, расширят и облегчат выбор наиболее подходящего приема. Фразеологический перевод предполагает использование в тексте перевода устойчивых единиц различной степени близости между единицей ИЯ и соответствующей единицей ПЯ – от полного и абсолютного эквивалента до приблизительного фразеологического соответствия. Фразеологический эквивалент – это фразеологизм на ПЯ, по всем показателям равноценный переводимой единице. Как правило, вне зависимости от контекста он должен обладать теми же денотативным и коннотативным значениями, т. е. между соотносительными ФЕ не должно быть различий в отношении смыслового содержания, стилистической отнесенности, метафоричности и эмоционально-экспрессивной окраски, они должны иметь приблизительно одинаковый компонентный состав, обладать рядом одинаковых лексико-грамматических показателей: сочетаемостью (например, в отношении требования одушевленности/неодушевленности), принадлежностью к одной грамматической категории, употребительностью, связью с контекстными словами-спутниками и т. д.; и еще одним – отсутствием национального колорита. Речь идет по существу о полной и абсолютной эквивалентности, указывающей на чрезвычайно высокие требования, которые предъявляются к фразеологическим эквивалентам. Все это – уже существующие в общем сравнительно немногочисленные единицы, работа с которыми сводится к их обнаружению в ПЯ; решающая роль в этой работе большей частью принадлежит отличному владению ПЯ и словарям. Неполным (частичным) фразеологическим эквивалентом называют такую единицу ПЯ, которая является эквивалентом, полным и абсолютным, соотносительной многозначной единицы в ИЯ, но не во всех ее значениях. Например, the massacre of the innocents, известный библеизм, полностью соответствует рус. избиение младенцев, но эта русская единица является лишь частичным эквивалентом, так как англ. ФЕ имеет еще одно значение – жарг. «нерассмотрение законопроектов ввиду недостатка времени (в конце парламентской сессии)». Частичных эквивалентов сравнительно немного, так как вообще явление многозначности менее характерно для фразеологии. Гораздо чаще случаи относительной фразеологической эквивалентности. Относительный фразеологический эквивалент уступает абсолютному лишь в том, что отличается от исходной ФЕ по какому-либо из показателей: другие, часто синонимические компоненты, небольшие изменения формы, изменение синтаксического построения, иные морфологическая отнесенность, сочетаемость и т. п. В остальном он является полноценным соответствием переводимой ФЕ, «относительность» которого скрадывается контекстом. Частым отличием можно считать неодинаковое лексико-семантическое содержание отдельных компонентов. В приведенном выше примере показать спину в ФЕ некоторых языков появляется с компонентом не «показать», а «повернуть», англ. turn one's back. В других случаях эквивалент может отличаться от исходной ФЕ по компонентному составу; например, один и тот же образ может быть выражен экономнее или пространнее. Но образы двух аналогов (на ИЯ и ПЯ) могут не иметь между собой ничего общего как образы, что не мешает эквивалентам исполнять исправно свою функцию в переводе. В принципе, возможность передавать ФЕ аналогами с образностью, совершенно не имеющей точек соприкосновения в ИЯ и ПЯ, объясняется главным образом тем, что по большей части это стертые пли полустертые метафоры, не воспринимаемые или, скорее, воспринимаемые подсознательно носителем языка: ведь в значении «остаться с носом» никакого носа русский не видит. Степень яркости образа – очень низкая – до нулевой у фразеологических сращений, а в единствах более высокая, но редко достигающая интенсивности в свободном сочетании, – является одной из главных предпосылок для выбора приема перевода между аналогом и калькой. Об этом речь пойдет ниже, но уже здесь ясна опасность слишком поспешного, не увязанного с особенностями контекста решения в отношении этого выбора. Наконец, чрезвычайно часты различия, возникающие в случаях использования таких приемов перевода, как различного рода трансформации типа антонимического перевода, конкретизации и генерализации, которым, подобно лексическим, поддаются и фразеологические единицы. К фразеологическим можно условно отнести и «индивидуальные» эквиваленты. Не находя в ПЯ полного соответствия, переводчик иногда вынужден прибегать к словотворчеству, оформляя в духе переводимой единицы новый, свой фразеологизм, максимально напоминающий «естественный». Если такую «подделку» читатель примет, значит удалось передать содержание и стиль переводимой единицы в достаточно «фразеологической» форме. Индивидуальные фразеологизмы, если они мастерски «сделаны», обладают показателями обычной ФЕ, отличаясь от нее лишь но одному, самому важному показателю – они не воспроизводимы. Переводчик создает их в ходе своей работы, и очень маловероятно, чтобы такой перевод закрепился за данной единицей настолько, чтобы вошел в язык. Поэтому здесь скорее идет речь о контекстуальном переводе. При создании своего фразеологизма-аналога переводчик может воспользоваться уже существующими в ПЯ фразеологическими средствами и моделями.

Близким к этому является приспособление к контексту уже существующего фразеологизма путем изменения структуры, добавления новых компонентов, придания при помощи фонетических средств вида пословицы, комбинирования из двух единиц одной и т. д. – пути, которые можно было бы назвать лексико-фразеологическим переводом. Нефразеологический перевод, как показывает само название, передает данную ФВ при помощи лексических, а не фразеологических средств ПЯ. К нему прибегают обычно, лишь убедившись, что ни одним из фразеологических эквивалентов или аналогов воспользоваться нельзя. Такой перевод, учитывая даже компенсационные возможности контекста, трудно назвать полноценным: всегда есть некоторые потери (образность, экспрессивность, коннотации, афористичность, оттенки значений), что и заставляет переводчиков обращаться к нему только в случае крайней необходимости. Строго лексический перевод применим, как правило, в тех случаях, когда данное понятие обозначено в одном языке фразеологизмом, а в другом – словом. Так, многие английские глаголы, выраженные словосочетаниями, можно передать совершенно безболезненно их лексическим эквивалентом: set или put on fire – «зажечь», catch fire – «зажечься», «загореться», Такому переводу поддаются, хотя и не совсем безболезненно, и ФЕ, у которых в ИЯ есть синонимы-слова. Это большей частью идиомы, т. е. сочетания, обозначающие предметы или понятия. Французский арготизм prendre les manettes значит просто «растеряться», но это словарный перевод, который в живом тексте мы используем лишь в крайнем случае; можно найти фразеологические соответствия, которыми его можно передать, например, «потерять присутствие духа, самообладание», «потерять голову», а может быть, и что-либо более близкое к буквальному значению – «потерять управление»? В отличие от «однословного» и ближе к тому, что называют свободным переводом, смысловое содержание ФЕ может быть передано переменным словосочетанием. Такие переводы вполне удовлетворительно выполняют свою роль и в словаре, указывая точное семантическое значение единицы. Однако в контексте любое соответствие должно приобрести «фразеологический вид» или но меньшей мере стилистическую окраску и экспрессивность, близкие к оригинальным. Одним словом, и при лексическом переводе ФЕ нужно всегда стремиться приблизиться к фразеологическому, передать хотя бы отдельные его элементы или стороны. Калькирование, или дословный перевод, предпочитают обычно в тех случаях, когда другими приемами, в частности фразеологическими, нельзя передать ФЕ в целости ее семантико-стилистического и экспрессивно-эмоционального значения, а по тем или иным причинам желательно «довести до зрения» читателя образную основу.

Предпосылкой для калькирования является достаточная мотивированность значения ФЕ значениями ее компонентов. То есть калькирование возможно только тогда, когда дословный перевод может довести до читателя истинное содержание всего фразеологизма (а не значения составляющих его частей). (Это осуществимо, во-первых, в отношении образных ФЕ, главным образом фразеологических единств, сохранивших достаточно свежей метафоричность (в истинных идиомах – фразеологических сращениях – образная основа почти не воспринимается, и кальки с них кажутся бессмыслицами); калькировать можно, во-вторых, ряд пословиц и, в первую очередь, таких, которые не обладают подтекстом. Этим приемом можно, в-третьих, передать и некоторые устойчивые сравнения, но только убедившись, что носитель ПЯ воспримет их правильно. К калькам прибегают и в таких случаях, когда «семантический эквивалент» отличается от исходной ФЕ по колориту, или при «оживлении» образа. Многие кальки можно отнести к переводу фразеологическому. Например, англ. caution is the parent of safety можно перевести почти дословно и получить неплохую, вполне осмысленную русскую пословицу «осмотрительность – мать безопасности», т. е. по типу «повторение – мать учения» или «праздность – мать всех пороков». Описательный перевод ФЕ сводится, по сути дела, к переводу не самого фразеологизма, а его толкования, как это часто бывает вообще с единицами, не имеющими эквивалентов в ПЯ. Это могут быть объяснения, сравнения, описания, толкования – все средства, передающие в максимально ясной и краткой форме содержание ФЕ, все с тем же неизменным стремлением к фразеологизации или хотя бы намеку и на коннотативные значения. В контексте этот путь перевода самостоятельного значения не имеет, так как в любом случае переводчик постарается вплести содержание ФЕ в общую ткань таким образом, чтобы правильно были переданы все элементы текста в целом, т. е. прибегнет к контекстуальному переводу. Говоря о приемах перевода ФЕ и выборе между ними, остается оговорить еще два понятия: контекстуальный перевод и выборочный перевод. В применении контекстуального перевода к фразеологии А.В. Куний пользуется термином «обертональный перевод», а Я.И. Рецкер – «контекстуальная замена». Чаще всего о контекстуальном переводе мы вспоминаем, конечно, при отсутствии эквивалентов и аналогов – когда фразеологизм приходится передавать нефразеологическими средствами. Выборочный перевод у Ю. Катцера и А. Кунина противопоставлен моноэквивалентному переводу и свободному переводу; в этой плоскости он имеет свое оправдание. Мы же предпочитаем рассматривать его в несколько ином плане: не как перевод «устойчивого сочетания слов посредством одного из возможных фразеологических синонимов», а несколько шире – как неизбежный начальный этап любого перевода устойчивого сочетания, да и перевода вообще. Выбирают, опираясь обычно на словарные (известные, общепринятые – за ними не обязательно обращаться к словарю) соответствия, в первую очередь варианты, т. е. синонимы или близкие значения многозначных ФЕ. Например, «рукой подать» переводится на большинство языков только в пространственном значении – близко, но, как и само наречие «близко», эта ФЕ может иметь и временное значение: «до начала спартакиады рукой подать» (как и «сейчас же», которое обычно – наречие времени, а употребляется и в значении места: «сейчас же за околицей начинаются луга»). Может случиться, что контекст «не принимает» наличные соответствия, в том числе и фразеологические эквиваленты, и в таком случае приходится искать иные, нефразеологические средства. Французскую идиому deferrer des quatres pieds можно перевести фразеологизмами «поставить в тупик», «припереть к стенке», описательным глагольным выражением «привести кого-либо. В смущение», обычным глаголом «озадачить»; но возможны и «привести в замешательство», «выбить почву из-под ног», «смутить»; не исключается и «сбить с толку», «сбить с панталыку» и еще десятки фразеологических и нефразеологических решений. При выборе учитываются все показатели исходной ФЕ и, не в последнюю очередь, ее стиль и колорит; иногда именно стилистическое несоответствие или наличие колорита не допускает в перевод казалось бы самую подходящую единицу.

Итак, рассмотрев различные особенности перевода научного текста с английского языка на русский, можно сделать вывод, что переводчик, по сути, является творцом нового произведения, и, что перевод не есть набор механических действий. Основной стилистической чертой научно-технического текста является точное и четкое изложение материала при почти полном отсутствии тех выразительных элементов, которые придают речи эмоциональную насыщенность, главный упор делается на логической, а не на эмоционально-чувственной стороне излагаемого. Автор научно-технической статьи стремится к тому, чтобы исключить возможность произвольного толкования существа трактуемого предмета, вследствие чего в научной литературе почти не встречаются такие выразительные средства, как метафоры, метонимии и другие стилистические фигуры, которые широко используются в художественных произведениях для придания речи живого, образного характера. Авторы научных произведений избегают применения этих выразительных средств, чтобы не нарушить основного принципа научно-технического языка – точности и ясности изложения мысли.

Это приводит к тому, что научно-технический текст кажется несколько суховатым, лишенным элементов эмоциональной окраски. Переводчик творит, затрачивая при этом не меньше усилий, чем автор того или иного произведения или научной статьи, работа переводчика, скорее, сложнее, так как он должен передать средствами переводного языка ту атмосферу и эмоциональность и тот информационный потенциал, который заложен в оригинале, причем, передать не с буквалистичной, а со смысловой точностью. Ведь перевод не может быть равен оригиналу, но должен быть равен ему по воздействию на читателя.

Контрольные вопросы

1. Подумайте, что является основной задачей переводчика научно-технического текста.
2. Перечислите основные черты научно-технического стиля в русском языке.
3. Конкретизируйте особенности английского текста по сравнению со стилем русской научно-технической литературы.
4. Подумайте, какие обязательства должен выполнять переводчик при переводе монографии.
5. Объясните, как передаются термины при переводе, не имеющие соответствий в англоязычной литературе.
6. Поясните, от чего зависит полноценный перевод фразеологических единиц.
7. Перечислите виды перевода фразеологических единиц.
8. Поясните, что значит нефразеологический перевод и почему его используют в крайнем случае.
9. Дайте определение понятию «калькирование» и подумайте, когда оно возможно.
10. Поразмышляйте, используются ли в научно-техническом тексте выразительные средства языка и почему.

ГЛАВА 3. ПРАКТИКА ПЕРЕВОДА

Text 1
ALTERNATIVE ENERGY

There is a great deal of information and enthusiasm today about the development and increased production of our global energy needs from alternative energy sources. Solar energy, wind power and moving water are all traditional sources of alternative energy that are making progress. The enthusiasm everyone shares for these developments has in many ways created a sense of complacency that our future energy demands will easily be met.

Alternative energy is an interesting concept when you think about it. In our global society, it simply means energy that is produced from sources other than our primary energy supply: fossil fuels. Coal, oil and natural gas are the three kinds of fossil fuels that we have mostly depended on for our energy needs, from home heating and electricity to fuel for our automobiles and mass transportation.

The problem is, fossil fuels are non-renewable. They are limited in supply and will one day be depleted. There is no escaping this conclusion. Fossil fuels formed from plants and animals that lived hundreds of millions of years ago and became buried way underneath the Earth’s surface where their remains collectively transformed into the combustible materials we use for fuel.

Despite the promise of alternative energy sources – more appropriately called renewable energy, collectively they provide only about seven percent of the world’s energy needs. This means that fossil fuels along with nuclear energy – a controversial, non-renewable energy source – are supplying 93 % of the world’s energy resources.

Nuclear energy, which is primarily generated by splitting atoms, only provides six percent of the world’s energy supplies. And it is not likely to be a major source of world energy consumption because of public pressure and the relative dangers associated with unleashing the power of atom. Yet, governments such as the United States see its vast potential and are placing pressure on the further exploitation of nuclear energy.

Fossil fuels exist, and they provide a valuable service. It is not so much that we use fossil fuels for energy, but it is the side effects of using them that causes all of the problems. Burning fossil fuels creates carbon dioxide, the number one greenhouse gas contributing the global warming. Combustion of these fossil fuels is considered to be the largest contributing factor to the release of greenhouse gases into the atmosphere. In the 20th century, the average temperature of Earth rose one degree Fahrenheit (1 F). This was a period that saw the most prolific population growth and industrial development in Earth’s history.

The impact of global warming on the environment is extensive and affects many areas. In Arctic and Antarctica, warmer temperatures are causing the ice to melt which will increase sea level and change the composition of the surrounding sea water. Rising sea levels alone can impede processes ranging from settlement, agriculture, and fishing both commercially and recreationally. Air pollution is also a direct result of the use of fossil fuels, resulting in smog and the degradation of human health and plant growth.

But there's also the great dangers posed to natural ecosystems that result from collecting fossil fuels, particularly coal and oil. Oil spills have devastated ecosystems and coal mining has stripped lands of their vitality. The oil, coal and natural gas companies know these are serious problems. But until our renewable energy sources become more viable as major energy providers, the only alternative for our global population is for these companies to continue tapping into the fossil fuel reserves to meet our energy needs. And, you can pretty much count on these companies being there providing energy from renewable sources when the fossil fuels are depleted. Many oil companies, for example, are involved in the development of more reliable renewable energy technologies. For instance, British Petroleum Company (BP) has become one of the world's leading providers of solar energy through its BP Solar division, a business that they are planning on eclipsing their oil production business in the near future.

Just how limited are our fossil fuel reserves? Some estimates say our fossil fuel reserves will be depleted within 50 years, while others say it will be 100 – 120 years. Nobody really knows when the last drop of oil, lump of coal or cubic foot of natural gas will be collected from the Earth. All of it will depend on how well we manage our energy demands along with how well we can develop and use renewable energy sources.

Therefore, sun, wind and water are perfect energy sources… depending on where you are. They are non-polluting, renewable and efficient. They are simple: all you need is sunlight, running water and or wind. Not only do the use of renewable energy sources help produce global carbon dioxide emissions, but they also add some much-needed flexibility to the energy resource mix by decreasing our dependence on limited reserves of fossil fuels.

Essentially, these renewable energy sources create their own energy. The object is to capture and harness their mechanical power and convert it to electricity in the most effective and productive manner possible. There's more than enough renewable energy sources to supply all of the world's energy needs of forever; however, the challenge is to develop the capability to effectively and economically capture, store and use the energy when needed.

Exercise 1

Выполните перевод текста на русский язык.

Exercise 2

Переведите выражения на русский язык:

solar energy
wind power
moving water
sense of complacency
non-renewable
buried way
underneath
appropriately
controversial
unleashing the power
greenhouse gases
prolific population
change the composition
impede
recreationally
devastate
vitality
viable
eclipsing
carbon dioxide emissions
much-needed flexibility
challenge

Exercise 3

Переведите выражения на английский язык:

альтернативные источники энергии
ископаемое топливо
сгораемый материал
слияние атомов
парниковый эффект
оценка
надежный
истощенный
улавливать
преобразовывать
хранить
ограниченные источники

Exercise 4

Составьте план текста.

Exercise 5

Выполните реферирование текста.

Text 2
INCREASING AMERICA’S USE OF RENEWABLE AND ALTERNATIVE ENERGY

A sound national energy policy should encourage a clean and diverse portfolio of domestic energy supplies. Such diversity helps to ensure that future generations of Americans will have access to the energy they need. Renewable energy can help provide for our future needs by harnessing abundant, naturally occurring sources of energy, such as the sun, the wind, geothermal heat, and biomass. Effectively harnessing these renewable resources requires careful planning and advanced technology. Through improved technology, we can ensure that America will lead the world in the development of clean, natural, renewable and alternative energy supplies.

Renewable and alternative energy supplies not only help diversify our energy portfolio; they do so with few adverse environmental impacts. While the current contribution of renewable and alternative energy resources to America’s total electricity supply is relatively small – only 9 percent – the renewable and alternative energy sectors are among the fastest growing in the United States. Non-hydropower only account for 2 percent of our electricity needs. However, electricity generation from non-hydropower renewable energy grew by nearly 30 percent in the 1990s. Continued growth of renewable energy will continue to be important in delivering larger supplies of clean, domestic power for America’s growing economy.

Renewable energy resources tap naturally occurring flows of energy to produce electricity, fuel, heat, or a combination of these energy types. One type of renewable energy, hydropower, has long provided a significant contribution to the U.S. energy supply and today is competitive with other forms of conventional electricity. However, there is limited growth potential for hydropower. Non-hydropower renewable energy is generated from four sources: biomass, geothermal, wind, and solar. The United States has significant potential for renewable resource development. These non-depletable sources of energy are domestically abundant and often have less impact on the environment than conventional sources. They can provide a reliable source of energy at a stable price, and they can also generate income for farmers, landowners, and others who harness them.

Both renewable and alternative energy resources can be produced centrally or on a distributed basis near their point of use. Providing electricity, light, heat, or mechanical energy at the point of use diminishes the need for some transmission lines and pipelines, reducing associated energy delivery losses and increasing energy efficiency. Distributed energy resources may be renewable resources, such as biomass cogeneration in the lumber and paper industry or rooftop solar photovoltaic systems on homes, or may be alternative uses of traditional energy, such as natural gas micro- turbines (small combustion turbines approximately the size of a refrigerator with outputs of 25 to 500 kilowatts).

Exercise 1

Выполните перевод текста на русский язык.

Exercise 2

Переведите выражения на русский язык:

renewable resource development
harnessing abundant
to help diversify
a significant contribution
conventional electricity
domestically abundant
transmission lines and pipelines
impact on the environment
distributed energy resources
biomass cogeneration
industry or rooftop

Exercise 3

Переведите выражения на английский язык:

возобновляемые источники энергии
поощрять
разнообразие
нуждаться
передовые технологии
влияние
вклад
поставлять
обычный
конкурентоспособный
когенерация

Exercise 4

Составьте план текста.

Exercise 5

Выполните реферирование текста.

Text 3
SOLAR ENERGY

Solar cells convert solar rays directly into electricity. Non-polluting photovoltaic cells use no fuel, mechanical turbine, or generator to produce electric current, and solar energy is renewable, clean, and abundant. The solar power industry has enjoyed double-digit growth in recent years, but solar energy has historically suffered from inexpensive oil, which has been cheap and easy to produce. As air pollution worsens and global petroleum supplies get squeezed tighter in the future, the world's energy providers will look to the Sun for a clean, renewable, and decentralized energy source.

Every day, the surface of planet Earth is blasted with so much solar energy that, if harnessed, 60 seconds' worth could power the world's total energy requirements for one year. The Sun is a colossal fusion reactor that has been burning for more than 4 billion years. By some estimates, the amount of solar radiation striking the earth every 72 hours is equivalent to all the energy stored in the planet's coal, oil, and natural gas reserves.

Solar radiation is a free and unlimited natural resource, yet converting it into an energy source is a relatively new idea. Using solar power for heat seems simple enough today, but it wasn't until 1767 that Swiss scientist Horace de Saussure built the first thermal solar collector. He used his solar collector to heat water and cook food. It wasn't until 1891 that the first commercial patent for a solar water heater was awarded to US inventor Clarence Kemp. The patent rights to this system were later purchased by two California executives who, by 1897, had installed the solar-powered water heaters in one-third of the homes in Pasadena, California.

Solar energy has great potential for providing clean and unlimited electricity in many regions of the world. This renewable resource has largely been ignored by many US energy providers because there has been little economic motivation due to the abundance of cheap coal and oil. Corporate shareholders want their profits today, not sometime in the distant future. In the last few decades, however, global energy demand has surged, as have the environmental problems associated with burning coal and oil and the storage of nuclear-generated radioactive waste. In the late 1990s, more governments, utilities, and corporations were embracing renewable energy sources as environmentalists, consumers, and voters pressure them to do so. More importantly, many consumers are willing to pay for “green energy”, so suppliers see future profit in non-polluting renewable energy production. Some governments and energy suppliers have been slow to recognize the potential of solar power. Historically, research and development in photovoltaics has progressed erratically, in short-lived bursts of interest. For example, the US Department of Energy (DOE) funded the installation and testing of over 3,000 PV cell systems during the 1973 – 1974 oil embargo. By the late 1970s, energy companies and government agencies were investing in the PV industry, and an acceleration in module development took place. But solar power remained far behind oil, coal, nuclear, and other non-renewable energy sources. Serious interest in photovoltaics increased again during the 1990s after several military conflicts in the oil-rich Persian Gulf.

There are advantages to photovoltaic solar power that make it one of the most promising renewable energy sources. The system is non-polluting, has no moving parts to break down, and requires little maintenance and no supervision. The average unit produces energy for 20 – 30 years with low operating costs. Solar energy systems are especially unique because they require no extra construction or developed land area, and function safely and quietly. Remote or underdeveloped communities can produce their own supply of electricity by constructing as small or as large a system as needed. When communities grow, more solar energy capacity can then be added as necessary.

There are only two primary disadvantages to using solar power: a limited amount of sunlight and the cost of equipment. The value of sunlight a location receives varies greatly depending upon geographical location, time of day, season, and average cloud cover. The southwestern United States is one of the world's best areas for persistent sunshine. Globally, other areas receiving very high solar intensities include developing nations in Asia, Africa, and Latin America. Although solar energy technologies have made impressive cost improvements over the years, solar energy is currently still more expensive than traditional fossil fuel sources. However, solar energy is renewable and non-polluting, and the equipment will eventually pay for itself in 2 to 5 years, depending on how much Sun a particular location receives. Then the user will have a virtually free energy source until the end of the equipment's working life. Future improvements are projected to decrease the payback time down to 1 – 3 years.

As the price of solar-generated electricity decreases and as the environmental and dollar costs of petroleum increases, photovoltaics will expand its international market. Solar power will be an excellent energy option, long after Hydrocarbon Man fades away into the sunset. Clean, renewable photovoltaic-generated power enjoys obvious advantages when compared to coal, oil, natural gas, or nuclear power.

Exercise 1
Выполните перевод текста на русский язык.

Exercise 2
Переведите выражения на русский язык:
non-polluting photovoltaic cells
turbine
abundant
double-digit growth
purchase
due to
nuclear-generated radioactive waste
voters pressure
photovoltaic
erratically
burst
supervision
underdeveloped communities
persistent sunshine

Exercise 3
Переведите выражения на английский язык:
солнечные батареи
колоссальный термоядерный реактор
неограниченный природный ресурс
корпоративные акционеры
коммунальные услуги
функционировать безопасно и спокойно
исчезнуть

Exercise 4
Составьте план текста.

Exercise 5
Выполните реферирование текста.

Text 4
CONCENTRATING SOLAR POWER: ENERGY FROM MIRRORS

Mirror on the wall, what's the greatest energy source of all? The sun. Enough energy from the sun falls on the Earth everyday to power our homes and businesses for almost 30 years. Yet we are only just begun to tap its potential. You may have heard about solar electric power to light homes or solar thermal power used to heat water, but did you know there is such a thing as solar thermal-electric power? Electric utility companies are using mirrors to concentrate heat from the sun to produce environmentally friendly electricity for cities, especially in the southwestern United States. The southwestern United States is focusing on concentrating solar energy because it's one of the world's best areas for sunlight. The Southwest receives up to twice the sunlight as other regions in the country. This abundance of solar energy makes concentrating solar power plants an attractive alternative to traditional power plants, which burn polluting fossil fuels such as oil and coil. Fossil fuels also must be continually purchased and refined to use.

Unlike traditional power plants, concentrating solar power systems provide an environmentally benign source of energy, produce virtually no emissions, and consume no fuel other than sunlight. About the only impact concentrating solar power plants have on the environment is land use. Although the amount of land a concentrating solar power plant occupies is larger than that of a fossil fuel plant, both types of plants use about the same amount of land because fossil fuel plants use additional land for mining and exploration as well as road building to reach the mines.

Other benefits of concentrating solar power plants include low operating costs, and the ability to produce power during high-demand energy periods and to help increase our energy security – our country's independence from foreign oil imports. Because they store energy, they can operate in cloudy weather and after sunset. When combined with fossil fuels as a hybrid system, they can operate around the clock regardless of weather. Concentrating solar power plants also create two and a half times as many skilled jobs as traditional plants.

Exercise 1

Выполните перевод текста на русский язык.

Exercise 2

Переведите выражения на русский язык:

to power
utility companies
solar power plants
to tap
a fossil fuel plant
solar thermal power
abundance
low operating costs
to burn fossil fuels
to store energy

mining and exploration
benefit
a hybrid system
benign source of energy

Exercise 3

Переведите выражения на английский язык:

нагревать воду
строительство дорог
освещать дома
сосредотачиваться на
исследование
электростанция на органическом топливе
избыток
неопасная энергия
загрезнять
сохранять энергию

Exercise 4

Составьте план текста.

Exercise 5

Выполните реферирование текста.

Text 5

WIND TURBINE

A wind turbine, windmill or wind generator is a device for converting wind power to mechanical rotation with a low velocity turbine designed for compressible fluids (air). It is a device for producing renewable energy in the form of electric power and is a component of one of the newest forms of power plant to be put into operation.

A wind turbine strongly resembles a propeller, but has subtle differences. The turbine is perpendicular to the wind, mounted on a tower. With small wind generators the tower height is usually at least twenty meters. In the case of large generators, the tower height is about twice as great as the propeller radius. Power output from a wind generator is proportional to the cube of the wind speed. As wind speed doubles,the capacity of wind generators increases eightfold. There is usually a means of stalling the turbine's blades to reduce its wind resistance when the wind is extremely strong. For a given survivable wind speed, the mass of a turbine is approximately proportional to the cube of its blade-length. The maximum blade-length of a turbine is limited by the strength and stiffness of its material.

Labor and maintenance costs increase only with increasing turbine size, so given all these factors to minimize costs, wind farm turbines are basically limited by the strength of materials, and siting. One of the best construction materials is graphite-fiber in epoxy. Graphite composites enable turbines of sixty meters to be built, enough to trap a few megawatts of power. Smaller turbines can be made of lightweight fiberglass, aluminum, or sometimes laminated wood. Smaller machines are pointed into the wind by a vane. Large machines have a wind-sensor driving a servomotor. When it turns to face the wind, the turbine acts like a gyroscope. When a turbine pivots to face the wind, precession tries to twist the turbine into a forward somersault. For each blade on a wind generator's turbine, precessive force is at a minimum when the blade is horizontal and at a maximum when the blade is horizontal and at a maximum when the blade is vertical. This cycling twisting can quickly fatigue and crack the blade roots, hub, and axle of the turbine. To reduce the precessive stresses, modern turbines have three blades, only one of which is in a maximum stress position (vertical) at a time. The major historical design defect is to have an even number of blades, so that two blades are vertical at the same time. Two-bladed turbines have the highest cyclic stresses.

Home-made wind turbines often have two blades. Two-bladed turbines thus often avoid the need for using a hub with linkages to individual blades. Three-bladed turbines, which are much more efficient, and more quiet, must usually be assembled onsite.

There are a number of vibrations that decrease in peak intensity as the number of blades increases. Some of the vibrations, besides operate at a higher Reynolds number of blades, so the optimum number of blades turns out to be three.

Since a tower produces turbulence behind it, the turbine is usually placed in front. The turbine has to be placed a considerable distance in front and sometimes tilted up a small amount to ensure that the lower blade doesn't need an additional pointing device and in high winds, the blades can be allowed to bend which reduces their wind resistance.

Sails were originally used on early windmills. Unfortunately, they have a short service life. Also, they have a relatively high drag for the force they capture. They turn the generator slowly, waste much of the available wind power and have a large wind resistance for their power output, requiring a strong wind tower. For these reasons they were suspended with solid airfoils.

When the turbine is spun by the wind, it adds a rotation to the wind, increasing the apparent wind on the blade. Since blades are really designed to work like an airplane wing, this increases the toque produced by the turbine. But this also increases the force in the wind direction on the blade and therefore on the tower. The mechanical stress is significantly higher when the turbine rotates. That's why wind turbines are stopped during high wind.

Wind has been used to grind grain, pump water, heat water and produce electricity. In modern times, almost all turbines either pump water or generate electricity.

A wind generator usually consists of an aerodynamic mechanism for converting the movement of air into a mechanical motion, which is then converted with a generator into electrical power.

Wind generators are impractical in many areas as the available power grows as the cube of the average wind speed. A site with prevailing winds of 30 km/h is eight times as valuable as a site with only 15 km/h. As a general rule, wind generators are practical where the average wind speed is greater than 20 km/h. Another lesser-known factor is the prevailing temperature – the lower the temperature, the greater the density of the air and thus, the greater the energy contained for the same given wind.

Wind is powered by a temperature differential. It is slowed by obstructions and is generally stronger at high altitudes. Plains have high winds because they have few obstructions. Mountain passes have high winds mostly because they funnel high-altitude winds. Some passes have winds powered by a temperature differential between the sides of the ridges. Coastal areas have high winds because water has few obstructions and because of the temperature difference between the land and the sea. Off-shore also generally has high winds for the same reason.

In urban locations, where it is difficult to obtain large amounts of wind energy, smaller systems may still be used to run low power equipment. Distributed power from rooftop mounted wind turbines can also alleviate power distribution problems, as well as provide resilience to power failures. Important equipment such as wireless internet gateways may be powered by a wind turbine that charges a small battery.

Exercise 1

Выполните перевод текста на русский язык.

Exercise 2

Переведите выражения на русский язык:

wind turbine
compressible fluids
stalling the turbine’s blades
survivable wind speed
graphite-fiber in epoxy
pivot
somersault
precessive force
precessive stress

cyclic stress
solid airfoil
spun
apparent wind
grind grain
obstruction
funnel high-altitude winds

Exercise 3

Переведите выражения на английский язык:

ветряная мельница
скорость
радиус пропеллера
жесткость
легкий
ламинированная древесина
паруса
короткий срок службы
вращаться
непроходимость

Exercise 4

Составьте план текста.

Exercise 5

Выполните реферирование текста.

Text 6

WIND ENERGY

In the 1960s, popular American folk musician Bob Dylan wrote, “You don't need a weatherman to know which way the wind blows”. Today the wind represents more than weather; it means money and energy. High-tech wind turbines as tall as the Statue of Liberty are now producing megawatts of electricity, enough power to supply thousands of homes. Wind is the oldest source of renewable energy, and it will play an important role as a nonpolluting energy provider in the 21st century.

Humans have taken advantage of wind power for thousands of years. The first known use occurred in 5000 BC when people used sails to navigate the Nile River. By 900 AD, Persians were using windmills to pump water and grind grain. The Chinese have written documentation of windmill use by 1219 but had probably acquired the technology centuries before. Agrarian communities on the island of Crete depended on hundreds of sail-rotor windmills to pump water for crops and livestock. By the 16th century, some 10,000 windmills were in use in the Netherlands. The Dutch were responsible for many refinements of the windmill, which was used primarily for pumping excess water off flooded land. As early as 1390, they had connected the mill to a multi-story tower with separate floors devoted to grinding grain kernels, removing chaff, and storing the processed grain. Living quarters for the windmills were arranged on the lowest floor. The system was so efficient that eventually there were thousands of such windmills operating in England.

But it took almost 500 years to perfect the windmill's efficiency to the point that it had the major features recognized by contemporary designers as being crucial to the performance of modern wind turbine blades. By then, applications ranged from saw-milling timber to processing spices, tobacco, cocoa, paints, and dyes.

The windmill was further refined in the United States during the late 19th century. Heavy, inefficient wooden blades were replaced by lighter, faster steel blades around 1870. Over the next century, more than six million small windmills were erected in the western US, where they pumped ground water for livestock and provided the domestic supply for families living on remote ranches. The first large windmill to produce electricity was a multi-blade design built in 1888. Modern 70 – 100 kilowatt wind turbines blow away its meager 12-kilowatt capabilities.

Today, individuals and corporations are realizing that not only wind power does mean weather but it is a promising clean energy resource that can serve as an alternative to fossil-fuel-generated electricity.

In 1999, global wind-generated electricity exceeded 10,000 megawatts, which is approximately 16 billion kilowatt-hours of electricity. That's more than enough to serve five cities the size of Miami. In a world where more than 2 billion people live without electricity, decentralized wind power is projected to be one of the developing world's most important sources of electricity. Wind-generated energy also has a bright future in industrialized nations like the United States and Europe. According to the American Wind Energy Association, wind energy could provide 20 % of America's electricity with turbines installed on less than 1 % of the nation's land area. Within that area, less than 5 % of the land would be occupied by wind equipment – the remaining 95 % could continue to be used for farming or ranching. By the year 2010, 10 million American homes may be supplied by wind power, preventing 100 million metric tons worth of CO2 emissions every year.

Although wind energy is now more affordable, more available, and still pollution-free, it does hold some drawbacks. Wind power suffers from the same lack of energy density as direct solar radiation. The fact that it is a very diffuse source means that large numbers of wind generators (and thus large land areas) are required to produce useful amounts of heat or electricity. Wind turbines cannot be erected everywhere simply because many places are not breezy enough for suitable power generation. When an appropriate place is found, building and maintaining a wind farm can be costly. It is a highly capital-intensive technology. If the interest rates charged for manufacturing equipment and constructing a plant are high, then a consumer will have to pay more for that energy. One study found that were wind plants financed on the same terms as natural gas power plants, their cost would drop by nearly 40 %. Fortunately, as more facilities are built, the cheaper wind energy will become. The cost of wind-generated electricity has dropped by 15 % with each doubling of installed capacity worldwide, and capacity has doubled three times during the 1990s.

Overall, the advantages of wind power heavily outweigh the disadvantages. Although it can only supplement other sources of energy for now, it provides skilled jobs for people in rural communities, replaces environmentally harmful energy sources, and is inexhaustible. Wind energy will never be subject to embargoes or price shocks caused by international conflicts, and, unlike oil energy, clean wind power is renewable year after year.

Exercise 1

Выполните перевод текста на русский язык.

Exercise 2

Переведите выражения на русский язык:

high-tech wind turbine
refinement of wind mills
sail-rotor windmill
wind-turbine performance
lack of energy density
saw-milling timber
dye
fossil-fuel-generated electricity
affordable
drawback
diffuse source
breezy

Exercise 3

Переведите выражения на английский язык:

метеоролог
экологически чистая энергия
преимущество ветроэнергетики

аграрное сообщество
урожай и скот
затопленная земля
многоэтажная башня
прямое солнечное излучение
перевешивать
неисчерпаемый

Exercise 4

Составьте план текста.

Exercise 5

Выполните реферирование текста.

Text 7

DISTRIBUTED WIND ENERGY TECHNOLOGY

Distributed energy refers to small, modular power-generating technologies that can be located at or near the location where the energy is used. Small, distributed wind turbines can be used to power ranches, farms, homes, and businesses. Distributed wind technology is especially attractive in rural areas where access to transmission lines is limited.

The purpose of the distributed wind technology activity is to work with the small wind turbine industry to develop advanced technology to make distributed wind technology cost-effective in much wider regions of the country and for a wide variety of applications. Similar to low wind speed technology research, the distributed wind technology activity is focusing on technological innovation that can lessen the requirement for average wind speed, moving the design focus from Class 5 to Class 3. The program will focus on turbines smaller than 100 kilowatts.

The U.S. small wind turbine industry offers a wide assortment of products for various applications and environments. Machines range in size from those that generate 400 watts of electricity for specific small loads such as battery charging for sailboats and small cabins, to 3 to 15 kilowatt systems for a home, to those that generate up to 100 kW of electricity for large loads such as a small commercial operation. Small wind turbines can operate effectively in large portions of the rural areas of the United States. It is estimated by industry that small wind turbines could meet 3 % of U.S. electricity consumption by 2020.

Small wind turbines, though seemingly simple, must overcome many of the same technical barriers as those facing larger utility-scale machines. Because of the need for simplicity and high reliability, small machines face other technical challenges. Many issues remain poorly understood when it comes to the specific behavior of small wind turbines, such as furling behavior, thrust measurements, yaw behavior, and blade and tower loads.

It is a substantial challenge to design, manufacture, and install small wind turbines that are low in cost and yet rugged enough to withstand 20 to 30 years of operations in weather that is often severe. Small wind turbine technology development is both art and science. The true measure of a new design is often not known until several years of operation at dozens of sites. At present, there is no way to effectively duplicate the wear and tear of the real world during the product development stage. As a result, reliability has historically been a concern for small wind turbine technology.

In support of the distributed wind technology objectives, the program will select public/private partnerships through competitive solicitations to develop small turbine technology for lower wind regimes. These partnerships will develop cost-effective components such as inverters, rotors, and tall towers, and develop conceptual designs to guide future technology innovation.

The contracts with industry resulting from these public/private partnerships will be supported by laboratory researchers who will perform design review and support, field tests, and laboratory tests. In addition to the public/private partnerships, the program will pursue a number of research efforts that industry has identified in its roadmap as being important for the ultimate success of small wind turbines.

Exercise 1

Выполните перевод текста на русский язык.

Exercise 2

Переведите выражения на русский язык:

distributed energy
various applications
the requirement for wind speed
furling behavior
thrust measurements
to overcome
rural areas
a substantial challenge
to face other technical challenge
competitive solicitations
utility-scale machines
the product development stage

Exercise 3

Переведите выражения на английский язык:

первичный источник энергии
вытекать из
приносить пользу
исходить
вращаться
экономически эффективным
государственно-частное партнерство

Exercise 4

Составьте план текста.

Exercise 5

Выполните реферирование текста.

Text 8
GEOTHERMAL POWER

Energy from the Earth itself will play an important part in the renewable energy equation of the 21st century. Ever since the world's first geothermal-generated electricity was produced at Larderello, Italy, in 1904, humans have tapped this primordial power source. Geothermal energy is derived from the heat contained within the planet, heat being very intense in some places, it melts mantle rock to create molten magma. Experts believe that the ultimate source of geothermal energy is radioactive decay occurring deep within the Earth. Geothermal heat is a renewable energy source primarily produced when ground water descending from the Earth's surface meets molten magma rising toward it. Some of this geothermal water circulates back up through faults and cracks and reaches the Earth's surface as hot springs or geysers, but most of it stays deep underground, trapped in cracks and porous rock. In most regions of the world, this heat reaches the surface in a very diffuse state; however, in some areas, including substantial portions of the western United States, geothermal reservoirs exist close to the surface and are easily tapped for power generation.

Today, Americans benefit in a much different way from this important natural resource. Tapping the heat emanating from beneath the Earth's crust can generate electricity without harmful fossil fuel emissions. In geothermal power plants, steam, heat, or hot water provides the physical force that spins turbine blades to generate electricity. Engineers have developed several methods for converting geothermal energy into electricity, primarily dry steam, hot water, and binary systems. "Dry steam" reservoirs produce steam but little water. The steam is piped to where it can spin turbine generators that produce electricity. Hot water reservoirs form where magma flowing relatively close to the surface directly heats groundwater. Naturally pressurized, hot water flows to the surface via the production well, where a separator flashes the water into steam and turns turbines. When geothermal-heated water is not hot enough to flash into steam, it can still produce electricity in a “binary” power plant. In a binary system, the geothermal water is passed through a heat exchanger, where its heat is transferred into a second liquid, which boils at a lower temperature than water. When heated, the binary liquid flashes to vapor that expands across the turbine blades. The vapor is then recondensed into a liquid and reused repeatedly. In this closed-loop cycle, there are no emissions released into the air.

Another commercial geothermal-energy-extraction technique utilizes heat pumps. Ground-source heat pumps use the Earth or groundwater as a heat source in winter and a heat sink in summer. Heat pumps move warmth from one place to another, with the heat transferring from the soil to the house in winter and from the dwelling into the ground in summer. Similar to the temperature range in a cave, the temperature within the ground maintains a constant average in contrast to the constantly changing air above. The geothermal heat pump is one of the most efficient and nonpolluting home cooling systems available. This method reduces reliance on the electrical grid, resulting in significant environmental benefits and reduced energy costs. It is estimated that between 10,000 to 40,000 heat pump systems are installed every year.

Geothermal energy is a reliable, decentralized power source for some regions, but like all renewable energy sources, inexpensive oil supplies undermine its potential. Despite the fact that this energy source is clean and renewable and can reduce our dependence on imported fuels, the fact remains that fields of sufficient quality to produce dependable electricity economically are relatively rare in the US. Environmental concerns also cloud the implementation of geothermal facilities. Many of the most highly active areas are located in protected wilderness zones that environmentalists want to preserve. And although no combustion occurs, some systems produce carbon dioxide and hydrogen sulfide emissions, require the cooling of as much as 100,000 gallons of water per megawatt per day, and must dispose of toxic waste and dissolved solids.

Geothermal energy alone won’t solve the energy problem, but it does help reduce reliance on fossil fuels. In 1999, geothermal-generated electricity saved the US 60 million barrels of oil. Considering the health and environmental costs from burning that much oil, this natural hotbed of energy should not be overlooked. US geothermal electric power generation was approximately 2200 MW in 1999, or about the same as four large nuclear power plants but without the radioactive waste. Geothermal energy currently ranks third among renewables, following hydroelectricity and biomass gasification, and ahead of rapidly expanding solar and wind power. The heat of the Earth contributes to our arsenal of clean and renewable energy sources, but it still can’t come close to replacing our reliance on petroleum.

Exercise 1

Выполните перевод текста на русский язык.

Exercise 2

Переведите выражения на русский язык:

geothermal-generated electricity
primordial power source
derive
descend
diffuse state
crust
binary systems
Naturally pressurized
recondensed
closed-loop cycle
cave
decentralized power source
dependable
implementation of geothermal facilities
wilderness zones

Exercise 3

Переведите выражения на английский язык:

уравнение
выводить мантийный камень
расплавленная магма
радиоактивный распад
горячие источники или гейзеры
трещина и пористая порода
двоичные системы
внедрение геотермальных объектов
опора

Exercise 4

Составьте план текста.

Exercise 5

Выполните реферирование текста.

Text 9
BIOMASS ENERGY

The term “biomass” refers to organic matter that has stored solar energy through the process of photosynthesis. It exists in one form as plants and may be transferred through the food chain to animals' bodies and their wastes, all of which can be converted for energy use through simple processes, such as combustion and decomposition, which release the carbon dioxide stored in the plant matter. Burning fossil fuels uses “old” biomass and converts it into “new” carbon dioxide that contributes to the greenhouse effect and depletes a nonrenewable resource. Burning “new” biomass contributes no new carbon dioxide to the atmosphere because if we replant harvested biomass, carbon dioxide is returned to the cycle of new growth.

Most of the biomass fuels in use today come from wood products, dried vegetation, crop residues, and aquatic plants. Biomass has become one of the most commonly used renewable sources of energy in the last two decades, second only to hydropower in the generation of electricity. Due to its low cost and renewable nature, biomass now accounts for almost 15 % of the world's total energy supply and as much as 35 % in developing countries, where it is mostly used for cooking and heating.

When evaluating biomass as a viable solution to the global energy problem, one must consider that although emissions associated with the factory conversion of biomass into usable energy or electricity are reduced, they do exist. Another consideration must be where will all the wood and other plant material for fuel come from? Some worry that it may cause accelerated deforestation practices by developing nations. The problems associated with widespread clear cutting can lead to groundwater contamination, floods, and irreversible erosion patterns that could literally change the structure of the world ecology.

Biomass will succeed at some level as an alternative source of renewable energy because it is capable of being implemented at all levels of society. Tree and grass plantations show considerable promise in supplying a biomassed-based energy source, but the commercial use of plantation-grown fuels for power generation in the US has been stifled by an IRS tax code that denies a tax credit for electricity produced from scrap wood and agricultural waste or from standing timber planted before 1992.

Supplying the United States' enormous energy needs would require a planted area of one million square miles. That's roughly one-third of the area of the 48 contiguous states. There is no way that plantations could be implemented at this scale, not to mention the soil exhaustion that would eventually occur. Biomass alone cannot replace our current dependence on coal, oil, and natural gas; but it can complement other renewables such as solar and wind energy.

Chris Flavin, Senior Vice President of the Worldwatch Institute, states, “If the contribution of biomass to the world energy economy is to grow, technological innovations will be needed, so that biomass can be converted to usable energy in ways that are more efficient, less polluting, and at least as economical as today's practices”. Biomass needs more government support and financial incentives in order to compete with cheap but polluting fossil fuels. Only after biomass-based fuel crops are well established might we have a successful form of alternative energy. But as long as worldwide prices of coal, oil, and gas are relatively low, the establishment of plantations dedicated to supplying electric power or other higher forms of energy will occur only where financial subsidies or incentives exist or where other sources of energy are not available.

Although it retains potential as better processing technologies emerge, biomass energy is still somewhat limited and clearly not capable of sustaining the world's increasing energy needs on its own.

Exercise 1

Выполните перевод текста на русский язык.

Exercise 2

Переведите выражения на русский язык:

organic matter
deplete
replant
harvested biomass
dried vegetation
crop residues
viable solution
groundwater contamination
floods
irreversible erosion patterns
literally change
plantation-grown fuel
tax code
tax credit
scrap wood
financial incentives
biomass-based fuel crop

Exercise 3

Переведите выражения на английский язык:

процесс фотосинтеза
сжигание и разложение
высушенная растительность
вырубка леса
загрязнение грунтовых вод
металлолом
полезная энергия

Exercise 4

Составьте план текста.

Exercise 5

Выполните реферирование текста.

Text 10
HYDROGEN & FUEL CELLS

Hydrogen is the most abundant element known to man, and the supply is virtually limitless. Hydrogen can be made from fresh or salt water by electrolysis, which uses electricity to split the water molecule into its elemental components of hydrogen and oxygen. Because hydrogen energy has long been considered the ultimate universal fuel source, it is no wonder scientists have been working on hydrogen energy cells for more than 150 years. The technology hasn't slipped by NASA either, where such fuel cells have supplied power in all manned space missions since Project Gemini in 1965. Fuel cells provide astronauts with heat, electricity, and drinking water.

Hydrogen fuel cells are making big headlines in the new millennium, but this technology has actually been around for a long time. Ever since the British physicist and judge Sir William Grove constructed a prototype fuel cell in 1839, researchers have been improving the system. Grove demonstrated that hydrogen and oxygen could be compelled to bind together to form water while, at the same time, producing an electric current. Later in the 19th century, a hydrogen-rich gas was extracted from coal and used in the gas lamps and heaters of European and American towns and cities. Known as “town gas”, it consisted of 50 % hydrogen and 50 % carbon monoxide, and its distribution helped lay the foundation for the safe use of hydrogen as an energy source.

In 1932, Francis Bacon, a descendant of the famed English scientist and philosopher Sir Francis Bacon, developed the first modern fuel cell. The cell was later refined and upgraded until a five-kilowatt system was successfully demonstrated in 1952. A few years later, scientists and engineers involved in America's nascent space program were attracted to fuel cell technology because it was compact and lighter than any type of battery and infinitely less dangerous than any known nuclear application. NASA employs hydrogen fuel cells in all its modern efforts, such as the US Space Shuttle and Space Lab projects. Using hydrogen today for commercial energy production and transportation makes good economic, political, and environmental sense.

The real news is that hydrogen fuel cells are being designed that will replace gasoline and diesel to power your vehicle and your home, hospital, or community center. The advantages to the typical internal combustion engine are significant. Hydrogen fuel cells power vehicles cleanly and will dramatically reduce the health hazards and the billions of dollars of medical costs associated with conventional automobile exhaust. Additionally, fuel cells and the hydrogen that energizes them can be produced in the United States, as opposed to importing politically risky Persian Gulf oil.

Exercise 1

Выполните перевод текста на русский язык.

Exercise 2

Переведите выражения на русский язык:

abundant
element
virtually limitless
fresh or salt water
to split
ultimate universal fuel source
slip
manned space missions
compel
bind
extract
upgrade
nascent space program
automobile exhaust

Exercise 3

Переведите выражения на английский язык:

водород
электролиз
богатый водородом газ

потомок
бензин
средство передвижения
двигатель внутреннего сгорания
выхлоп

Exercise 4

Составьте план текста.

Exercise 5

Выполните реферирование текста.

ТЕКСТЫ ДЛЯ САМОСТОЯТЕЛЬНОГО ИЗУЧЕНИЯ

Text 1

HOW DOES A GENERATOR CREATE ELECTRICITY? HOW GENERATORS WORK

Generators are useful appliances that supply electrical power during a power outage and prevent discontinuity of daily activities or disruption of business operations. Generators are available in different electrical and physical configurations for use in different applications. In the following sections, we will look at how a generator functions, the main components of a generator, and how a generator operates as a secondary source of electrical power in residential and industrial applications.

How does a generator work?

An electric generator is a device that converts mechanical energy obtained from an external source into electrical energy as the output.

It is important to understand that a generator does not actually “create” electrical energy. Instead, it uses the mechanical energy supplied to it to force the movement of electric charges present in the wire of its windings through an external electric circuit. This flow of electric charges constitutes the output electric current supplied by the generator. This mechanism can be understood by considering the generator to be analogous to a water pump, which causes the flow of water but does not actually “create” the water flowing through it.

The modern-day generator works on the principle of electromagnetic induction discovered by Michael Faraday in 1831–32. Faraday discovered that the above flow of electric charges could be induced by moving an electrical conductor, such as a wire that contains electric charges, in a magnetic field. This movement creates a voltage difference between the two ends of the wire or electrical conductor, which in turn causes the electric charges to flow, thus generating electric current.

The main components of an electric generator can be broadly classified as follows: engine, alternator, fuel system, voltage regulator, cooling and exhaust systems, lubrication system, battery charger, control panel, main assembly / frame

A description of the main components of a generator is given below.

Engine. The engine is the source of the input mechanical energy to the generator. The size of the engine is directly proportional to the maximum power output the generator can supply. There are several factors that you need to keep in mind while assessing the engine of your generator. The manufacturer of the engine should be consulted to obtain full engine operation specifications and maintenance schedules.

Type of Fuel Used – Generator engines operate on a variety of fuels such as diesel, gasoline, propane (in liquefied or gaseous form), or natural gas. Smaller engines usually operate on gasoline while larger engines run on diesel, liquid propane, propane gas, or natural gas. Certain engines can also operate on a dual feed of both diesel and gas in a bi-fuel operation mode. Overhead Valve (OHV) Engines versus non-OHV Engines – OHV engines differ from other engines in that the intake and exhaust valves of the engine are located in the head of the engine’s cylinder as opposed to being mounted on the engine block. OHV engines have several advantages over other engines such as: compact design; simple roperation mechanism; durability; user-friendly in operations; low noise during operations; low emission levels. However, OHV-engines are also more expensive than other engines. Cast Iron Sleeve (CIS) in Engine Cylinder – The CIS is a lining in the cylinder of the engine. It reduces wear and tear, and ensures durability of the engine. Most OHV-engines are equipped with CIS but it is essential to check for this feature in the engine of a generator. The CIS is not an expensive feature but it plays an important role in engine durability especially if you need to use your generator of tenor for long durations.

Alternator. The alternator, also known as the “genhead”, is the part of the generator that produces the electrical output from the mechanical input supplied by the engine. It contains an assembly of stationary and moving parts encased in a housing. The components work together to cause relative movement between the magnetic and electric fields, which in turn generates electricity.

Stator – This is the stationary component. It contains a set of electrical conductors wound in coils over an iron core.

Rotor / Armature – This is the moving component that produces a rotating magnetic field in any one of the following three ways.

By induction – These are known as brushless alternators and are usually used in large generators.

By permanent magnets – This is common in small alternator units. By using an exciter – An exciter is a small source of direct current (DC) that energizes the rotor through an assembly of conducting slip rings and brushes.

The rotor generates a moving magnetic field around the stator, which induces a voltage difference between the windings of the stator. This produces the alternating current (AC) output of the generator.

The following are the factors that you need to keep in mind while assessing the alternator of a generator.

Metal versus Plastic Housing – An all-metal design ensures durability of the alternator. Plastic housings get deformed with time and cause the moving parts of the alternator to be exposed. This increases wear and tear and more importantly, is hazardous to the user.

Ball Bearings versus Needle Bearings – Ball bearings are preferred and last longer.

Brushless Design – An alternator that does not use brushes requires less maintenance and also produces cleaner power.

Fuel System. The fuel tank usually has sufficient capacity to keep the generator operational for 6 to 8 hours on an average. In the case of small generator units, the fuel tank is a part of the generator’s skid base or is mounted on top of the generator frame. For commercial applications, it may be necessary to erect and install an external fuel tank. All such installations are subject to the approval of the City Planning Division.

Common features of the fuel system include the following.

Pipe connection from fuel tank to engine – The supply line directs fuel from the tank to the engine and the return line directs fuel from the engine to the tank.

Ventilation pipe for fuel tank – The fuel tank has a ventilation pipe to prevent the build-up of pressure or vacuum during refilling and drainage of the tank. When you refill the fuel tank, ensure metal-to-metal contact between the filler nozzle and the fuel tank to avoid sparks.

Overflow connection from fuel tank to the drain pipe – This is required so that any overflow during refilling of the tank does not cause spillage of the liquid on the generator set.

Fuel pump – This transfers fuel from the main storage tank to the day tank. The fuel pump is typically electrically operated.

Fuel Water Separator / Fuel Filter – This separates water and foreign matter from the liquid fuel to protect other components of the generator from corrosion and contamination.

Fuel Injector – This atomizes the liquid fuel and sprays the required amount of fuel into the combustion chamber of the engine.

Voltage Regulator. As the name implies, this component regulates the output voltage of the generator. The mechanism is described below against each component that plays a part in the cyclical process of voltage regulation.

Voltage Regulator. Conversion of AC Voltage to DC Current – The voltage regulator takes up a small portion of the generator’s output of AC voltage and converts it into DC current. The voltage regulator then feeds this DC current to a set of secondary windings in the stator, known as exciter windings.

Exciter Windings. Conversion of DC Current to AC Current – The exciter windings now function similar to the primary stator windings and generate a small AC current. The exciter windings are connected to units known as rotating rectifiers.

Rotating Rectifiers. Conversion of AC Current to DC Current – These rectify the AC current generated by the exciter windings and convert it to DC current. This DC current is fed to the rotor / armature to create an electromagnetic field in addition to the rotating magnetic field of the rotor / armature.

Rotor / Armature. Conversion of DC Current to AC Voltage – The rotor / armature now induces a larger AC voltage across the windings of the stator, which the generator now produces as a larger output AC voltage.

This cycle continues till the generator begins to produce output voltage equivalent to its full operating capacity. As the output of the generator increases, the voltage regulator produces less DC current. Once the generator reaches full operating capacity, the voltage regulator attains a state of equilibrium and produces just enough DC current to maintain the generator’s output at full operating level.

When you add a load to a generator, its output voltage dips a little. This prompts the voltage regulator into action and the above cycle begins. The cycle continues till the generator output ramps up to its original full operating capacity.

Cooling & Exhaust Systems. Cooling System Continuous usage of the generator causes its various components to get heated up. It is essential to have a cooling and ventilation system to withdraw heat produced in the process.

Raw/fresh water is sometimes used as a coolant for generators, but these are mostly limited to specific situations like small generators in city applications or very large units over 2250 kW and above. Hydrogen is sometimes used as a coolant for the stator windings of large generator units since it is more efficient at absorbing heat than other coolants. Hydrogen removes heat from the generator and transfers it through a heat exchanger into a secondary cooling circuit that contains de-mineralized water as a coolant. This is why very large generators and small power plants often have large cooling towers next to them. For all other common applications, both residential and industrial, a standard radiator and fan is mounted on the generator and works as the primary cooling system.

It is essential to check the coolant levels of the generator on a daily basis. The cooling system and raw water pump should be flushed after every 600 hours and the heat exchanger should be cleaned after every 2,400 hours of generator operation. The generator should be placed in an open and ventilated area that has adequate supply of fresh air. The National Electric Code (NEC) mandates that a minimum space of 3 feet should be allowed on all sides of the generator to ensure free flow of cooling air.

Exhaust System. Exhaust fumes emitted by a generator are just like exhaust from any other diesel or gasonline engine and contain highly toxic chemicals that need to be properly managed. Hence, it is essential to install an adequate exhaust system to dispose of the exhaust gases. This point can not be emphasized enough as carbon monoxide poisoning remains one of the most common causes for death in post hurricane affected areas because people tend to not even think about it until it’s too late.

Exhaust pipes are usually made of cast iron, wrought iron, or steel. These need to be freestanding and should not be supported by the engine of the generator. Exhaust pipes are usually attached to the engine using flexible connectors to minimize vibrations and prevent damage to the generator’s exhaust system. The exhaust pipe terminates outdoors and leads away from doors, windows and other openings to the house or building. You must ensure that the exhaust system of your generator is not connected to that of any other equipment. You should also consult the local city ordinances to determine whether your generator operation will need to obtain an approval from the local authorities to ensure you are conforming to local laws a protect against fines and other penalties.

Lubricating System. Since the generator comprises moving parts in its engine, it requires lubrication to ensure durability and smooth operations for a long period of time. The generator’s engine is lubricated by oil stored in a pump. You should check the level of lubricating oil every 8 hours of generator operation. You should also check for any leakages of lubricant and change the lubricating oil every 500 hours of generator operation.

Battery Charger. The start function of a generator is battery-operated. The battery charger keeps the generator battery charged by supplying it with a precise “float” voltage. If the float voltage is very low, the battery will remain undercharged. If the float voltage is very high, it will shorten the life of the battery. Battery chargers are usually made of stainless steel to prevent corrosion. They are also fully automatic and do not require any adjustments to be made or any settings to be changed. The DC output voltage of the battery charger is set at 2.33 Volts per cell, which is the precise float voltage for lead acid batteries. The battery charger has an isolated DC voltage output that does interfere with the normal functioning of the generator.

Control Panel. This is the user interface of the generator and contains provisions for electrical outlets and controls. Different manufacturers have varied features to offer in the control panels of their units. Some of these are mentioned below.

Electric start and shut-down – Auto start control panels automatically start your generator during a power outage, monitor the generator while in operation, and automatically shut down the unit when no longer required.

Engine gauges – Different gauges indicate important parameters such as oil pressure, temperature of coolant, battery voltage, engine rotation speed, and duration of operation. Constant measurement and monitoring of these parameters enables built-in shut down of the generator when any of these cross their respective threshold levels.

Generator gauges – The control panel also has meters for the measurement of output current and voltage, and operating frequency.

Other controls – Phase selector switch, frequency switch, and engine control switch (manual mode, auto mode) among others.

Main Assembly / Frame. All generators, portable or stationary, have customized housings that provide a structural base support. The frame also allows for the generated to be earthed for safety.

Text 2

MAGLEV TRAINS

The need for fast and reliable transportation is increasing throughout the world. High-speed rail has been the solution for many countries. Trains are fast, comfortable, and energy-efficient. The United States is years behind European countries in high-speed rail research and development. Meanwhile, in Germany and Japan, magnetic levitation may be an even better solution.

Maglev research and development began in Germany and Japan during the early 1970′s. After laboratory tests in both countries, a test track was constructed in Japan during the mid-1970′s and in Germany during the mid-1980′s.

The construction of a 7-km test track began in Miyazaki Prefecture in Japan in 1975 and was completed in April of 1977. Test runs of the ML-500 began on the Miyazaki Test Track in July of 1977 and a 517 km/hour run was attained in December 1979. Two-car train sets began testing in 1981 and three-car train sets in 1986. The manned two-vehicle train MLU001 reached a speed of 400.8 km/hour in 1987. In 1990, the Minister of Transport of Japan authorized construction of the Yamanashi Maglev Test Line. It was to be the final test to confirm the practicality of maglev. The 42.8 km line between Sakaigawa and Akiyama of Yamanashi Prefecture opened in 1996 and the first running test of the MLX01 was in April of 1997.

Germany was testing their Transrapid 07 maglev at the TVE (Transrapid Versuchsanlage im Emsland) test track between Nordschleife and Sudschleife. Both test vehicles have traveled more than 400,000 km on the test track as of December 1996. The longest nonstop test has been 1,674 km in May of 1993. In June of the same year, the Transrapid 07 set a new maglev speed record of 450 km/hour. In 1991, Germany's government certified the operation of the first maglev train for the public. A maglev route was to be constructed between Hamburg and Berlin.

In the United States, scientists James R. Powell and Gordan T. Danby patented the first design for magnetic levitation trains in 1969. In 1970, the United States Federal Railroad Administration studied high-speed ground transportation. Little maglev research was accomplished in the United States and in 1986, the government stopped all funding toward maglev technology. Four years later, the United States Federal Government and the Federal Railroad Administration began to officially support maglev technology. (Lotti-Chun, On-line) They began the National Maglev Initiative in 1990, a cooperative effort of the U.S. Department of Transportation, the U.S. Army Corps of Engineers, and the U.S. Department of Energy. The purpose of the initiative was to evaluate possible improvements for intercity transportation with magnetic levitation. The tasks included "planning, analyzing, and assessing maglev technology" to make it a viable option for future transportation. The initiative should also determine the role that the Federal Government should have in the development of maglev systems. Significant effort has been devoted to the understanding of maglev's technical and market potential, however the key issue is whether such research and development warrants federal investment. The Intermodal Surface Transportation Efficiency Act of 1991 offered more support by recognizing the goals of future transportation systems. Section 1036 of the Act established a Maglev Prototype Development Program which specified the requirements for the design and construction of a U.S. maglev system. (University of Alabama in Huntsville, On-line)

The support and guidance systems of German magnetic levitation are based on the attractive powers between electromagnets on the vehicle and reaction plate rails on the underside of the guideway. (Lotti-Chun, On-line) The levitation and guidance magnets are controlled individually. An electronic control system keeps the vehicle levitating at a constant distance of 10 mm from its guideway. The propulsion and braking systems are based on a rotating electric motor with a split stationary core (stator). The vehicle is then propelled by the traveling magnetic field which is created with support magnets serving as the exciters. The energy flow is reversed to brake the vehicle without any contact to the guideway. This method of propulsion requires the motor to be installed on the guideway rather than on the vehicle. Unlike conventional transportation systems in which a vehicle has to carry the total power needed for the most demanding sections, the power of the maglev motor is dependent on the local conditions such as flat or uphill grades. The linear induction motor installed in the guideway is divided into sections. Power is only supplied to sections where a vehicle is currently located.

This method conserves energy and prevents safety concerns because all vehicles in a section of track must be traveling at the same speed in the same direction. The power for the German Transrapid is supplied from Germany's 110 kV national grid system. Separate substations provide the power independently to each side of the guideway motor. The placement of these substations is dependent on local route conditions. The support and guidance systems and the onboard power is supplied via linear generators in the support magnets resulting in an entirely contactless technology. If the national grid power supply fails, onboard batteries which are powered during the journey will provide power to levitate the vehicle until it reaches the next terminal. If the next terminal is too far away, the vehicle is stopped at the next power station. Braking is supplied by the onboard batteries to slow the vehicle to 10 km/hour. The vehicle is then lowered onto skids and stops after a few meters. The skids are coated with a special material to create low friction while sliding on a steel surface. There is no reason to leave the vehicle for such a motor failure.

The heat generated by the friction will melt a thin layer of ice when running in winter conditions. The materials used to construct maglev vehicles are non-combustible, poor transmitters of heat, and able to withstand fire penetration. In the unlikely event that a fire and power loss occurred simultaneously, the vehicle is automatically slowed down so that it stops at a predefined emergency power station. Research has shown that the German Transrapid is about 20 times safer than airplanes, 250 times safer than conventional railroads, and 700 times safer than automobile travel. Despite the speeds up to 500 km/hour, passengers can move about freely in the vehicles at all times. Maglev vehicles cannot be derailed because they surround the guideway. Collision is impossible because there will be no intersections and other transportation systems will cross at different levels. A collision between two maglev trains is nearly impossible because the linear induction motors prevent trains running in opposite directions or different speeds within the same power section. There is not a solution against all vandalism and sabotage, however many precautions have been taken. (Thyssen, On-line)

Japanese maglev development is similar to the German Transrapid in many ways but uses a different principle of levitation, guidance, and propulsion. Instead of surrounding the guideway as the German Transrapid does, Japan's maglev vehicles are enclosed by the guideway on the bottom and part way up the sides. (RTRI, On-line) They start on pneumatic wheels until reaching a speed of about 100 km/hour before the electromagnetic force levitates the vehicle. (China Daily, On-line) Levitation coils are installed on the sidewalls of the guideway. Superconducting magnets are installed on the vehicles several centimeters below the center of these guideway coils. When the onboard magnets pass the coils at high-speed, an electric current is induced in the coils and they serve as electromagnets. The forces then push the superconducting magnet upwards and levitate the vehicle. The coils on either sidewall of the guideway face each other and are connected under the guideway to create a loop. The electric current changes in the loop result in attracting and repulsive forces that keep the vehicle in the center of the guideway. The propulsion coils on the sidewalls of the guideway are energized by a three-phase alternating current from a local substation. The shifting magnetic field which is created attracts and pushes the onboard superconducting magnets. The maglev vehicle is then propelled along the guideway. (RTRI, On-line)

The guideway, or track, that the maglev trains run on can be raised above the ground or be at ground level. The elevated guideway for Germany’s Transrapid is normally 31 meters tall and the ground level guideway is normally six meters tall. This flexibility plus the ability for substantially sharper turns and steeper grades than railroads allow maglev guideways to be located in many different conditions. As with conventional railroads, trains are made up of several individual vehicles coupled together. The smallest train requires two vehicles and the maximum length is only determined by the length of station platforms, approximately ten sections. This enables trains to be constructed depending upon demand and the frequency increased when needed. Germany’s proposal for the Berlin to Hamburg route is to use six section trains with trains every ten to fifteen minutes. The end sections of a maglev train can contain between 56 and 110 seats depending upon the density of the seating layout. Center sections can contain between 64 and 140 seats. Neither the number of seats per section nor the number of sections comprising a train affect the performance of a maglev train. The high speeds of a maglev system make it suitable for transporting urgent goods with container sections. These container sections can form their own trains or be coupled with passenger sections to form “mixed-traffic” trains. During peak hours, freight trains sharing a passenger route will have long journey times because they will often have to wait in sidings for passenger trains to pass. Because of this problem, German maglev research is investigating the possibility of exclusive passenger routes and exclusive freight routes. (Thyssen, On-line)

Conventional railroads have achieved speeds above 500 km/hour during special laboratory speed tests, yet their normal operating speed is below 300 km/hour. Maglev vehicles are designed for operating speeds of up to 500 km/hour. Besides the speed improvements over other methods of transportation, maglev trains have many benefits at slower speeds too. Maglev trains experience lower energy consumption, less wear, lower noise levels, and much faster acceleration without affecting passenger comfort. Maglev trains can accelerate from 0 to 300 km/hour within 5 km compared to the German ICE high-speed train which requires about 30 km to reach the same speed. Because of these advantages, maglev trains are planned for three areas of transportation: local connections such as airport links; medium-distance inter-city connections; and long-distance national and international connections. (Thyssen, On-line)

Even with much faster journey times, comfort was a key consideration during maglev development. There are no jolts during acceleration, braking, or passing at any speed. High pressure fluctuations occur in tunnels and when passing opposing traffic. Extensive measurements, computer models, and experience from high-speed rail have resulted in an advanced technology for keeping the vehicles pressure-tight. A variety of business services and entertainment provide passengers with an even greater comfort than high-speed rail travel.

A major advantage of conventional rail systems versus other methods of transportation is their ability to operate in almost all weather conditions. Maglev systems are even better prepared for icy conditions because they do not require overhead power lines nor pantographs – parts that are subject to freezing on conventional railroads. The guidance and propulsion components are mounted below the guideway where they are protected from ice and driving snow. Snow will rarely accumulate on the guideway because of the frequency of trains and the wind that will easily remove it from elevated sections. The gap of 150 mm between the bottom of the vehicle and the top of the guideway allows operation even if snow builds up on the guideway. In especially poor weather conditions, snow clearance vehicles can be deployed to clear the guideway. (Thyssen, On-line)

As well as the many other positive effects of maglev, maglev trains are more environmentally-friendly than alternative forms of transportation. They operate at lower noise levels, consume less energy, require little land for the guideway, and release low magnetic fields. Noise is reduced by the contactless technology used and air pollution is reduced because of no emissions of exhaust gasses. A maglev train at a distance of 25 m and speed of 250 km/hour results in vibrations, or oscillations, below the “human threshold of perception” (KB value of 0.1). At a distance of one meter from the side of a maglev train running at 350 km/hour, the wind speed is only 8 km/hour. Less land is required for both the ground-level and elevated guideway and leaves the ground beneath the elevated guideway suitable for other purposes such as agriculture and traffic. In areas utilizing a ground-level guideway, there is still enough clearance for small animals and microorganisms to pass underneath so there will be little effect on the environment. This guideway construction also eliminates animal collisions that frequently occur with roadways. Unlike conventional railroads, a maglev guideway does not dissect the landscape.

The landscape requires fewer changes and does not have to be free of all natural growth as they do for conventional railroads. Maglev trains release no pollution into the ground they run above nor do they affect local water. Raft foundations will be used for most guideway supports which are not even as deep as the basement of normal houses. A well-developed construction plan will result in less damaging effects during construction than during that of conventional railroads and roads. Maglev routes will be grouped with existing transportation wherever possible. The German Transrapid releases an extremely low magnetic field. The magnetic field, even inside a passenger compartment, is considerably less than that of a hair dryer, toaster, or electric sewing machine. It will therefore have no negative influence on cardiac pacemakers or magnetic cards such as credit cards. (Thyssen, On-line)

The cost of making the guideway is a high percentage of the total investment for a maglev system. These costs are no higher than those of other high-speed rail systems and the comparison looks even better for maglev when the terrain becomes difficult. Many of the tunnels, embankments, and cuttings necessary for roads and railroads are avoided because maglev guideways can be easily adapted to the topography. (Thyssen, On-line)

The operating costs of a maglev system are approximately half that of conventional long-distance railroads. There is no friction because of the contactless technology, resulting in very little mechanical wear. The guideway receives little pressure because the weight of each maglev vehicle is not transferred to the guideway at specific points like the axles of conventional trains. Energy consumption is lower per seat than other comparable means of transportation and faster turnaround times mean fewer vehicles and operating staff are required. (Thyssen, On-line)

Germany is the furthest into their development efforts and closest to beginning construction of a commercial maglev route. Planning permission for an initial section of the Berlin to Hamburg line is expected by the end of 1998. Construction will then begin immediately and the final section should be approved by the end of 1999. After five years of construction, the route should be completed in 2004. The Transrapid can then begin operation over the 292-km route in 2005. The journey time from Lehrter Station in Berlin to Hamburg Central Station will be a maximum of 60 minutes. Transrapid trains will run in both directions every 10 to 15 minutes during peak times. The two terminals will be closely integrated with other intercity services and local transportation. Nearly two-thirds of the route will follow roadways with other parts following existing railroads and power lines. More than half of the route, 161 km, will run at ground level. This maglev proposal is half-owned by the Federal Government and half-owned by private industry. (Thyssen, On-line)

In Japan, the Central Japan Railway Company (JR Tokai) is leading their maglev project. They believe that conventional railroad technology has reached its peak performance. Japan currently has research and development into many applications of superconductors including the Superconducting Generator (Super GM), superconducting storage devices, and the magnetic levitating train. Their government's budget for superconductivity research in 1996 was 20 trillion yen (approximately $180 billion US). Early reports propose a maglev route from Tokyo to Osaka to be completed by 2005.

The United States, which was once a leader in transportation including railroads, has spent years debating the possibility of high-speed rail and maglev. Much of the research and proposals have been done by organizations such as the High-Speed Rail/Maglev Association. Some airlines including USAir have a positive interest in the development of maglev. The U.S. government has supported airlines but ignored most proposals for high-speed rail and maglev until the past couple of years. The poor condition of Amtrak has created a public feeling that railroads cannot be successful in the United States. High-speed rail supporters believe the contrary is true because of the metropolises that are spread across the United States. There has also been a public idea that the airline industry is private enterprise and receives no government subsidy. In reality, the airline industry receives billions of dollars of subsidies each year. In the process, Amtrak has lost much of their funding and service cutbacks have been the result. There has been little improvement in U.S. rail travel during the past couple of decades. Many European countries have profitable national railroad networks with millions of dollars in profits each year.

Few will argue that high-speed rail and maglev can alleviate many of America's transportation problems. The operational costs are cheaper than the current rail system. The main issue is now the investment costs to build such a transportation network. Private funding from investors is plentiful for high-speed rail and maglev development. The Channel Tunnel became the largest privately financed engineering project in history with an expense of $14 billion. As America's transportation problems grow worse every year, the public realization of the importance of high-speed rail and maglev will grow. Amtrak's testing of European high-speed rail technology is the furthest that actual testing has gotten in the United States. Many see the high-speed rail plans developed by Amtrak to be a very limited success, and some high-speed rail advocates see its current drawbacks. Because of the poor state of current railroad track, the new high-speed rail that Amtrak is investigating will result in minimal performance improvements. The public may view this as the limit to high-speed rail’s capability.

In conclusion, while America appears to be many years from the first maglev demonstration, this practical form of high-speed transportation will soon be a reality in Germany and Japan. High-speed rail and maglev advocates hope that Germany’s Transrapid maglev system will set the stage for new maglev development projects around the world.

Text 3

POWER PLANTS (POWER STATIONS)

Not so long ago, alchemists dreamed of turning cheap and ugly metals into valuable ones like gold. Power plants(also called power stations) pull off a similar trick, converting lumps of coal and drops of oil into zaps of electric current that can cook your dinner or charge your phone. If it weren't for power plants, I wouldn't be writing these words now – and you wouldn't be reading them. In fact, most of the things we do every day and much of the stuff we use owes a hidden debt of gratitude to these gigantic energy factories, which turn “fossil fuels” (coal, natural gas, and oil) into electric power.

This energy-alchemy is a pretty amazing trick – and quite a recent one too, since the very first practical power station was built in only 1882 (by Thomas Edison). Yet amazement is often the last thing we feel when we think about generating electricity at the start of the 21st century. In an age when caring for the environment is (quite rightly) more important than ever, it's fashionable to sneer at power plants as evil, dirty places pumping pollution into our air, land, and water. One day, we might be able to make all our electricity in a completely clean and green way. Until then, power plants are vital for keeping our schools, hospitals, homes, and offices light, warm, and buzzing with life; modern life would be impossible without them. How do they work? Let's take a closer look!

Chart: large, centralized fossil-fueled power plants are very inefficient, wasting about two thirds of the energy in the fuel. Here's a typical scenario: about 62 percent is lost in the plant itself as waste heat. A further 4 percent disappears in the power lines and transformers that carry electricity from a power plant to your home. Once the electricity has arrived, your home appliances waste a further

13 percent. All told, only 22 percent of the original energy in the fuel (green slice) turns into energy you can actually use. Source: figures from "Decentralizing Power: An Energy Revolution for the 21st Century", Greenpeace, 2005.

A single large power plant can generate enough electricity (about 2 gigawatts, 2,000 megawatts, or 2,000,000,000 watts) to supply a couple of hundred thousand homes, and that's the same amount of power you could make with about 1000 large wind turbines. But the splendid science behind this amazing trick has less to do with the power plant than with the fuel it burns. The real magic isn't that power plants turn fuel into electricity: it's that even small amounts of fossil fuels contain large amounts of energy. A kilogram of coal or a liter of oil contains about 30MJ of energy – a massive amount, equivalent to a good few thousand 1.5-volt batteries! A power plant's job is to release this chemical energy as heat, use the heat to drive a spinning machine called a turbine, and then use the turbine to power a generator (electricity making machine). Power plants can make so much energy because they burn huge amounts of fuel – and every single bit of that fuel is packed full of power.

Unfortunately, most power plants are not very efficient: in a typical old plant running on coal, only about a third of the energy locked inside the fuel is converted to electricity and the rest is wasted. Newer designs, such as combined cycle power stations (which we'll explore in a minute) may be up to 50 percent efficient. As the chart here shows, even more electricity is squandered on the journey from the power plant to your home. Adding all the losses together, only about a fifth of the energy in the fuel is available as useful energy in your home.

How does a power plant work?

A power plant's a bit like an energy production line. Fuel feeds in at one end, and electricity zaps out at the other. What happens in between? A whole series of different steps, roughly along these lines.

Fuel. The energy that finds its way into your TV, computer, or toaster starts off as fuel loaded into a power plant. Some power plants run on coal, while others use oil, natural gas, or methane gas from decomposing rubbish.

Furnace. The fuel is burned in a giant furnace to release heat energy.

Boiler. In the boiler, heat from the furnace flows around pipes full of cold water. The heat boils the water and turns it into steam.

Turbine. The steam flows at high-pressure around a wheel that's a bit like a windmill made of tightly packed metal blades. The blades start turning as the steam flows past. Known as a steam turbine, this device is designed to convert the steam's energy into kinetic energy (the energy of something moving). For the turbine to work efficiently, heat must enter it at a really high temperature and pressure and leave at as low a temperature and pressure as possible.

Cooling tower. The giant, jug-shaped cooling towers you see at old power plants make the turbine more efficient. Boiling hot water from the steam turbine is cooled in a heat exchanger called a condenser. Then it's sprayed into the giant cooling towers and pumped back for reuse. Most of the water condenses on the walls of the towers and drips back down again. Only a small amount of the water used escapes as steam from the towers themselves, but huge amounts of heat and energy are lost.

Generator. The turbine is linked by an axle to a generator, so the generator spins around with the turbine blades. As it spins, the generator uses the kinetic energy from the turbine to make electricity.

Electricity cables. The electricity travels out of the generator to a transformer nearby.

Step-up transformer. Electricity loses some of its energy as it travels down wire cables, but high-voltage electricity loses less energy than low-voltage electricity. So the electricity generated in the plant is stepped-up (boosted) to a very high voltage as it leaves the power plant.

Pylons. Hugh metal towers carry electricity at extremely high voltages, along overhead cables, to wherever it is needed.

Step-down transformer. Once the electricity reaches its destination, another transformer converts the electricity back to a lower voltage safe for homes to use.

Homes. Electricity flows into homes through underground cables.

Appliances. Electricity flows all round your home to outlets on the wall. When you plug in a television or other appliance, it could be making a very indirect connection to a piece of coal hundreds of miles away!

Types of power plants

Steam turbine

Most traditional power plants make energy by burning fuel to release heat. For that reason, they're called thermal (heat-based) power plants. Coal and oil plants work much as I've shown in the artwork above, burning fuel with oxygen to release heat energy, which boils water and drives a steam turbine. This basic design is sometimes called a simple cycle.

Gas turbine

Natural gas plants work in a slightly different way that's quite similar to how a jet engine works. Instead of making steam, they burn a steady stream of gas and use that to drive a slightly different design of turbine (called a gas turbine) instead.

Combined designs

Every power plant ever built has had one main objective: to get as much useful electricity as possible from its fuel – in other words, to be as efficient as possible. When jet engines scream through the sky firing hot gases like rocket jets in their wake, they're wasting energy. There's not much we can about that in a plane, but we can do something about it in power station. We can take the hot exhaust gases coming from a gas turbine and use them to power a steam turbine as well in what's called a combined cycle. That allows us to produce as much as 50 percent more electricity from the fuel compared to an ordinary, simple cycle plant. Alternatively, we can improve the efficiency of a power plant by passing waste gases through a heat exchanger so they heat up water instead. This design is called combined heat and power (CHP) or cogeneration, and it's rapidly becoming one of the most popular designs (it can also be used for very small-scale power production in units roughly the same size as car engines).

Nuclear

Nuclear power plants work in a similar way to simple cycle coal or oil plants but, instead of burning fuel, they smash atoms apart to release heat energy. This is used to boil water, generate steam, and power a steam turbine and generator in the usual way. For more details, see our main article on how nuclear power plants work.

Hydro

While all these types of power plants are essentially thermal (generating and releasing heat to drive a steam or gas turbine), two other very common types don't use any heat whatsoever. Hydroelectric and pumped storage plants are designed to funnel vast amounts of water past enormous water turbines (think of them as very efficient water wheels), which drive generators directly. In a hydroelectric plant, a river is made to back up behind a huge concrete dam. The water can escape through a relatively small opening in the dam called a penstock and, as it does so, it makes one or more turbines spin around. For as long as the river flows, the turbines spin and the dam generates hydroelectric power. Although they produce no pollution or emissions, hydroelectric stations are very damaging in other ways: they degrade rivers by blocking their flow and they flood huge areas, forcing many people from their homes (the Three Gorges Dam in China displaced an estimated 1.2 million people).

Pumped storage generates electricity in a similar way to a hydroelectric plant, but shuttles the same water back and forth between a high-level lake and a lower one. At times of peak demand, the water is allowed to escape from the high lake to the lower one, generating electricity at a high price. When demand is lower, in the middle of the night, the water is pumped back up again from the low lake to the high one using low-rate electricity. So pumped storage is really a way of taking advantage of how electricity is worth more at some times than at others.

Energy Laboratory

How electricity gets to your home

One of the great things about electricity is that we can make it almost anywhere and transmit it vast distances along power lines to our homes. That makes it possible for us to power huge cities without building enormous dirty power plants right in the middle of them or to site power plants where there are convenient coal deposits or fast-flowing rivers to feed them. Now it takes energy to send an electric current down a wire, because even the very best wires, made from substances like gold, silver, and copper, have what's called resistance – they obstruct the flow of electricity. The longer the wire, the greater the resistance, and the more energy that's wasted. So you might think sending electricity down enormously long power cables would be a very stupid and wasteful thing to do.

There is a simple way around this, however. It turns out that the bigger the current flowing through a wire, the more energy gets wasted. By making the current as small as possible, we can keep the energy to a minimum – and we do that by making the voltage as big as possible. Power stations produce electricity at something like 14,000 volts, but they use transformers (voltage increasing or decreasing devices) to “step up” the voltage by anything from three to fifty times, to roughly 44,000 – 750,000 volts, before sending it down power lines to the towns and cities where it'll be consumed. Generally, power is transmitted over long distances using overhead lines strung between supporting frames called pylons; it's much quicker and cheaper to do that than to bury lines underground, which is commonly done in towns and cities. The pylons supply substations, which are effectively mini supply points devoted to powering perhaps a large factory or a small residential area. A substation uses “step-down” transformers to convert the high-voltage electricity from the power line to one or more lower voltages suitable for factories, offices, homes, or whatever it has to supply.

How the power grid works

Substations get their name from the time when power stations supplied very clearly defined local areas: each station fed a number of nearby substations, which passed the power on to homes and other buildings. The trouble with this arrangement is that if a power station suddenly fails, lots of homes have to go without electricity. There are other problems with running power stations independently. One power station might be able to make electricity very cheaply (perhaps because it's very new and using natural gas) while another one (using old technology based on coal) could be much more expensive, so it might make sense to use the cheaper station whenever possible. Unfortunately, power stations aren't like car engines: they have to keep going all the time; generally, they can't start and stop altogether, whenever we want them to. For these and various other reasons, electricity utilities have found that it makes sense to connect all their power stations into a vast network called a grid. Highly sophisticated, computerized control centers are used to raise or lower the output of stations to match the demand from minute to minute and hour to hour (so more stations will be working flat out in the evening, for example, when most people cook their dinner).

What does the future hold for power plants?

We'll always need energy and especially electricity – a very versatile kind of energy we can easily use in many different ways – but that doesn't mean we'll always need power plants like the ones we have today. Environmental pressures are already forcing many countries to close coal-fired power plants that produce the greatest carbon dioxide emissions (responsible for climate change and global warming). Although nuclear plants might offer the cleanest route to a low-carbon future, there are grave concerns over whether we can build them fast enough or overcome people's fears about pollution and safety (whether those fears are rational or not).

Dash for gas

In the short term, it's fairly clear what the future holds: there's a worldwide “dash for gas”. The majority of new electric power generating plants now use natural gas, which is significantly cheaper, relatively abundant (for now), and produces lower emissions than other fossil-fueled stations. Natural gas stations are also quicker and cheaper to build than more complex alternatives like nuclear plants, and face less public opposition. In 2011, the United States made about a quarter of its electricity from natural gas; by 2040, that's predicted to rise to about a third.

CHP

Other trends are also becoming important, notably a shift toward smaller plants driven by combined heat and power (CHP). A 2016 report by the US DOE's Energy Information Administration suggested the United States has the potential to build almost 300,000 small CHP plants (many just powering individual buildings or complexes), which would avoid the need to construct about 100 large coal or nuclear plants. Since some of these will be fueled by biomass (such as trees or “energy crops” grown specifically for the purpose) or waste, that illustrates three different trends at work: the shift to smaller plants and more of them, and the transition from fossil fuels to renewables.

Renewables

In the longer term, the future must be renewable because fossil fuel supplies will either run out or (more likely) be deemed too dirty or expensive to use. We've already seen a huge expansion of wind power over the last couple of decades and solar power is likely to increase dramatically in coming years. The big drawback, as I mentioned earlier, is that you need about 1000 wind turbines (rated at 2MW) or 400,000 solar roofs (rated at 5KW) to make the same power as one large power plant (2GW), so if we're going to switch from power plants to green energy, we need an awful lot of it covering a massive area. Whatever drawbacks power plants might have, they certainly use land very efficiently (though you could argue that the vast land-take of coal mines or oil and gas fields should be considered as well).

Charts. The changing nature of power plants. These two charts break down the total population of US electric power industry power plants by the type of fuel or other energy that they use for 2003 and 2015. Fossil fueled plants are shown in blue, nuclear plants in orange, renewable plants in green, and other power plants in yellow. You can see that there has been a significant reduction in coal and petroleum plants, a slight increase in natural gas plants, and a huge increase in renewables (though hydro plants remain about the same). Drawn using data from How many and what kind of power plants are there in the United States?, US Energy Information Administration, December 1, 2016.

Efficiency and demand management

Some argue that we can save our way out of building power plants through energy efficiency, for example, by using more efficient home appliances and better insulation. Many utility companies have embraced this idea with simple initiatives like giving out free energy-saving lightbulbs to householders. In theory, if you give out 50 million low-energy lamps and they each save 50 watts of power, you completely avoid the need to build one large (2.5GW) power plant. (This idea is sometimes called “negawatts”, a word coined by Amory Lovins of the Rocky Mountain Institute.) We can also reduce the need for new power plants by storing energy more sensibly and managing demand so we don't have such huge peaks in power use. Unfortunately, this approach only takes us so far. The problem is that our total energy needs are constantly growing – and our need for electricity is bound to grow too as we shift from fossil-fueled automobiles and diesel trains to electric alternatives. Moreover, there's the issue of growing energy needs in developing countries: people in those countries cannot save energy they're not already using, and it would be immoral to try to stop them using energy to climb out of poverty. Ultimately, the world as a whole is going to need to harness much more energy and much more electricity and, though efficiency has a crucial part to play, it's only a small part of the solution.

In the short term, the dash for gas helps if it shifts us away from coal. CHP also helps if it improves efficiency, but not if it locks us into fossil fuels for decades to come. Carbon-capture and storage (CCS) might help us make older, coal-fired plants more environmentally friendly, but it remains largely unproven and expensive. The long-term future must certainly be a renewable one and energy efficiency could make a greener future, powered by the sun and the wind, easier to achieve. Even so, for now and for decades to come, conventional, fossil-fueled power plants will remain the bedrock of our energy and electricity supply. We should admire them, respect them for powering our lives, and make them as clean and green as we possibly can.

Don't be a fool, stay cool – and keep away from power plants!

Electricity is brilliant, but it's also very dangerous.

As we've just seen, power plants and transmission lines carry electricity at incredibly high voltages – thousands of times greater than those used in your home.

Playing in, on, or anywhere near power equipment is extremely stupid and dangerous. Touch a power line and you'll very likely to be burned to death in a particularly slow and horrible way. Don't fly a kite near power lines or play soccer nearby. If you happen to kick a ball or something like that into a substation, leave it there and forget it. Your life is worth more than a silly bit of plastic.

Working near power lines can also be much more dangerous than you might think – so take care! According to the US CDC, electrocution is the fifth leading cause of work-related death and the second most common cause of death in the construction trade. Research by the US National Institute for Occupational Safety and Health (NIOSH) discovered that at least 154 people were killed between 1992 and 2005 by touching power lines with metal ladders they were using or working with.

Text 4
ELECTRICITY

If you've ever sat watching a thunderstorm, with mighty lightning bolts darting down from the sky, you'll have some idea of the power of electricity. A bolt of lightning is a sudden, massive surge of electricity between the sky and the ground beneath. The energy in a single lightning bolt is enough to light 100 powerful lamps for a whole day or to make a couple of hundred thousand slices of toast!

Electricity is the most versatile energy source that we have; it is also one of the newest: homes and businesses have been using it for not much more than a hundred years. Electricity has played a vital part of our past. But it could play a different role in our future, with many more buildings generating their own renewable electric power using solar cells and wind turbines. Let's take a closer look at electricity and find out how it works!

What is electricity?

Electricity is a type of energy that can build up in one place or flow from one place to another. When electricity gathers in one place it is known as static electricity (the word static means something that does not move); electricity that moves from one place to another is called current electricity.

Static electricity

Static electricity often happens when you rub things together. If you rub a balloon against your pullover 20 or 30 times, you'll find the balloon sticks to you. This happens because rubbing the balloon gives it an electric charge (a small amount of electricity). The charge makes it stick to your pullover like a magnet, because your pullover gains an opposite electric charge. So your pullover and the balloon attract one another like the opposite ends of two magnets.

Have you ever walked across a nylon rug or carpet and felt a slight tingling sensation? Then touched something metal, like a door knob or a faucet (tap), and felt a sharp pain in your hand? That is an example of an electric shock. When you walk across the rug, your feet are rubbing against it. Your body gradually builds up an electric charge, which is the tingling you can sense. When you touch metal, the charge runs instantly to Earth – and that's the shock you feel.

Lightning is also caused by static electricity. As rain clouds move through the sky, they rub against the air around them. This makes them build up a huge electric charge. Eventually, when the charge is big enough, it leaps to Earth as a bolt of lightning. You can often feel the tingling in the air when a storm is brewing nearby. This is the electricity in the air around you.

How static electricity works

Electricity is caused by electrons, the tiny particles that “orbit” around the edges of atoms, from which everything is made. Each electron has a small negative charge. An atom normally has an equal number of electrons and protons (positively charged particles in its nucleus or center), so atoms have no overall electrical charge. A piece of rubber is made from large collections of atoms called molecules. Since the atoms have no electrical charge, the molecules have no charge either – and nor does the rubber.

Suppose you rub a balloon on your pullover over and over again. As you move the balloon back and forward, you give it energy. The energy from your hand makes the balloon move. As it rubs against the wool in your pullover, some of the electrons in the rubber molecules are knocked free and gather on your body. This leaves the balloon with slightly too few electrons. Since electrons are negatively charged, having too few electrons makes the balloon slightly positively charged. Your pullover meanwhile gains these extra electrons and becomes negatively charged. Your pullover is negatively charged, and the balloon is positively charged. Opposite charges attract, so your pullover sticks to the balloon.

Current electricity

When electrons move, they carry electrical energy from one place to another. This is called current electricity or an electric current. A lightning bolt is one example of an electric current, although it does not last very long. Electric currents are also involved in powering all the electrical appliances that you use, from washing machines to flashlights and from telephones to MP3 players. These electric currents last much longer.

Have you heard of the terms potential energy and kinetic energy? Potential energy means energy that is stored somehow for use in the future. A car at the top of a hill has potential energy, because it has the potential (or ability) to roll down the hill in future. When it's rolling down the hill, its potential energy is gradually converted intokinetic energy (the energy something has because it's moving).

Static electricity and current electricity are like potential energy and kinetic energy. When electricity gathers in one place, it has the potential to do something in the future. Electricity stored in a battery is an example of electrical potential energy. You can use the energy in the battery to power a flashlight, for example. When you switch on a flashlight, the battery inside begins to supply electrical energy to the lamp, making it give off light. All the time the light is switched on, energy is flowing from the battery to the lamp. Over time, the energy stored in the battery is gradually turned into light (and heat) in the lamp. This is why the battery runs flat.

Electric circuits

For an electric current to happen, there must be a circuit. A circuit is a closed path or loop around which an electric current flows. A circuit is usually made by linking electrical components together with pieces of wire cable. Thus, in a flashlight, there is a simple circuit with a switch, a lamp, and a battery linked together by a few short pieces of copper wire. When you turn the switch on, electricity flows around the circuit. If there is a break anywhere in the circuit, electricity cannot flow. If one of the wires is broken, for example, the lamp will not light. Similarly, if the switch is turned off, no electricity can flow. This is why a switch is sometimes called a circuit breaker.

You don't always need wires to make a circuit, however. There is a circuit formed between a storm cloud and the Earth by the air in between. Normally air does not conduct electricity. However, if there is a big enough electrical charge in the cloud, it can create charged particles in the air called ions (atoms that have lost or gained some electrons). The ions work like an invisible cable linking the cloud above and the air below. Lightning flows through the air between the ions.

How electricity moves in a circuit

Materials such as copper metal that conduct electricity (allow it to flow freely) are called conductors. Materials that don't allow electricity to pass through them so readily, such as rubber and plastic, are called insulators. What makes copper a conductor and rubber an insulator?

A current of electricity is a steady flow of electrons. When electrons move from one place to another, round a circuit, they carry electrical energy from place to place like marching ants carrying leaves. Instead of carrying leaves, electrons carry a tiny amount of electric charge.

Electricity can travel through something when its structure allows electrons to move through it easily. Metals like copper have “free” electrons that are not bound tightly to their parent atoms. These electrons flow freely throughout the structure of copper and this is what enables an electric current to flow. In rubber, the electrons are more tightly bound. There are no “free” electrons and, as a result, electricity does not really flow through rubber at all. Conductors that let electricity flow freely are said to have a high conductance and a low resistance; insulators that do not allow electricity to flow are the opposite: they have a low conductance and a high resistance.

For electricity to flow, there has to be something to push the electrons along. This is called an electromotive force (EMF). A battery or power outlet creates the electromotive force that makes a current of electrons flow. An electromotive force is better known as a voltage.

Direct current and alternating current

Electricity can move around a circuit in two different ways. In the big picture up above, you can see electrons racing around a loop like race cars on a track, always going in the same direction. This type of electricity is called direct current (DC) and most toys and small gadgets have circuits that work this way.

Top: in a direct current (DC) circuit, electrons always flow in the same direction. Bottom: in an alternating current (AC) circuit, the electrons reverse direction many times each second.

The bigger appliances in your home use a different kind of electricity called alternating current (AC). Instead of always flowing the same way, the electrons constantly reverse direction – about 50 – 60 times every second. Although you might think that makes it impossible for energy to be carried round a circuit, it doesn't! Take the flashlight bulb in the circuit above. With direct current, new electrons keep streaming through the filament (a thin piece of wire inside the bulb), making it heat up and give off light. With alternating current, the same old electrons whiz back and forth in the filament. You can think of them running on the spot, heating up the filament so it still makes bright light we can see. So both types of current can make the lamp work even though they flow in different ways. Most other electric appliances can also work using either direct or alternating current, though some circuits do need AC to be changed to DC (or vice versa) to work correctly.

Electromagnetism

Electricity and magnetism are closely related. You might have seen giant steel electromagnets working in a scrapyard. An electromagnet is a magnet that can be switched on and off with electricity. When the current flows, it works like a magnet; when the current stops, it goes back to being an ordinary, unmagnetized piece of steel. Scrapyard cranes pick up bits of metal junk by switching the magnet on. To release the junk, they switch the magnet off again.

Electromagnets show that electricity can make magnetism, but how do they work? When electricity flows through a wire, it creates an invisible pattern of magnetism all around it. If you put a compass needle near an electric cable, and switch the electricity on or off, you can see the needle move because of the magnetism the cable generates. The magnetism is caused by the changing electricity when you switch the current on or off.

This is how an electric motor works. An electric motor is a machine that turns electricity into mechanical energy. In other words, electric power makes the motor spin around – and the motor can drive machinery. In a clothes washing machine, an electric motor spins the drum; in an electric drill, an electric motor makes the drill bit spin at high speed and bite into the material you're drilling. An electric motor is a cylinder packed with magnets around its edge. In the middle, there's a core made of iron wire wrapped around many times. When electricity flows into the iron core, it creates magnetism. The magnetism created in the core pushes against the magnetism in the outer cylinder and makes the core of the motor spin around.

Make an electromagnet

You can make a small electromagnet using a battery, some insulated (plastic-covered) copper wire, and a nail.

Making electricity

Just as electricity can make magnetism, so magnetism can make electricity. A dynamo is a bit like an electric motor inside. When you pedal your bicycle, the dynamo clipped to the wheel spins around. Inside the dynamo, there is a heavy core made from iron wire wrapped tightly around – much like the inside of a motor. The core spins freely inside some large fixed magnets. As you pedal, the core rotates inside these outer magnets and generates electricity. The electricity flows out from the dynamo and powers your bicycle lamp.

The electric generators used in power plants work in exactly the same way, only on a much bigger scale. Instead of being powered by someone's legs, pedaling furiously, these large generators are driven by steam. The steam is made by burning fuels or by nuclear reactions. Power plants can make enormous amounts of electricity, but they waste quite a lot of the energy they produce. The energy has to flow from the plant, where it is made, to the homes, offices, and factories where it is used down many miles of electric power cable. Making electricity in a power plant and delivering it to a distant building can waste up to two thirds of the energy that was originally present in the fuel!

Another problem with power plants is that they make electricity by burning “fossil fuels” such as coal, gas, or oil. This creates pollution and adds to the problem known as global warming (the way Earth is steadily heating up because of the energy people are using). Another problem with fossil fuels is that supplies are limited and they are steadily running out.

There are other ways to make energy that are more efficient, less polluting, and do not contribute to global warming. These types of energy are called renewable, because they can last indefinitely. Examples of renewable energy include wind turbines and solar power. Unlike huge electric power plants, they are often much more efficient ways of making electricity. Because they can be sited closer to where the electricity is used, less energy is wasted transmitting power down the wires.

Wind turbines are effectively just electric generators with a propeller on the front. The wind turns the propeller, which spins the generator inside, and makes a study current of electricity.

Unlike virtually every other way of making electricity, solar cells (like the ones on calculators and digital watches) do not work using electricity generators and magnetism. When light falls on a solar cell, the material it is made from (silicon) captures the light's energy and turns it directly into electricity. Potentially, this means solar cells are an extremely efficient way to make electricity. A home with solar electric panels on the roof might be able to make most of its own electricity, for example.

Electricity and electronics

Electricity is about using relatively large currents of electrical energy to do useful jobs, like driving a washing machine or powering an electric drill. Electronics is a very different kind of electricity. It's a way of controlling things using incredibly tiny currents of electricity – sometimes even individual electrons! Suppose you have an electronic clothes washing machine. Large currents of electricity come from the power outlet (mains supply) to make the drum rotate and heat the water. Smaller currents of electricity operate the electronic components in the washing machine's programmer unit. These tiny currents control the bigger currents, making the drum rotate back and forth, starting and stopping the water supply, and so on. Read more in our main article on electronics.

The power of electricity

Before the invention of electricity, people had to make energy wherever and whenever they needed it. Thus, they had to make wood or coal fires to heat their homes or cook food. The invention of electricity changed all that. It meant energy could be made in one place then supplied over long distances to wherever it was needed. People no longer had to worry about making energy for heating or cooking: all they had to do was plug in and switch on – and the energy was there as soon as they wanted it.

Another good thing about electricity is that it's like a common “language” that all modern appliances can “speak”. You can run a car using the energy in gasoline, or you can cook food on a barbecue in your garden using charcoal, though you can't run your car on charcoal or cook food with gasoline. But electricity is quite different. You can cook with it, run cars on it, heat your home with it, and charge your cellphone with it. This is the great beauty and the power of electricity: it's energy for everyone, everywhere, and always.

Measuring electricity

We can measure electricity in a number of different ways, but a few measurements are particularly important.

Voltage

The voltage is a kind of electrical force that makes electricity move through a wire and we measure it in volts. The bigger the voltage, the more current will tend to flow. So a 12-volt car battery will generally produce more current than a 1.5-volt flashlight battery.

Current

Voltage does not, itself, go anywhere: it's quite wrong to talk about voltage “flowing through” things. What moves through the wire in a circuit is electrical current: a steady flow of electrons, measured in amperes (or amps).

Power

Together, voltage and current give you electrical power. The bigger the voltage and the bigger the current, the more electrical power you have. We measure electric power in units called watts. Something that uses 1 watt uses 1 joule of energy each second.

The electric power in a circuit is equal to the voltage × the current (in other words: watts = volts × amps). So if you have a 100-watt (100 W) light and you know your electricity supply is rated as 120 volts (typical household voltage in the

United States), the current flowing must be 100/120 = 0.8 amps. If you're in Europe, your household voltage is more likely 230 volts. So if you use the same 100-watt light, the current flowing is 100/230 = 0.4 amps. The light burns just as brightly in both countries and uses the same amount of power in each case; in Europe it uses a higher voltage and lower current; in the States, there's a lower voltage and higher current. (One quick note: 120 volts and 230 volts are the “nominal” or standard household voltages – the voltages you're supposed to have, in theory. In practice, your home might have more or less voltage than this, for all sorts of reasons, but mainly because of how far you are from your local power plant or power supply.)

Energy

Power is a measurement of how much energy you're using each second. To find out the total amount of energy an electric appliance uses, you have to multiply the power it uses per second by the total number of seconds you use it for. The result you get is measured in units of power × time, often converted into a standard unit called the kilowatt hour (kWh). If you used an electric toaster rated at 1000 watts (1 kilowatt) for a whole hour, you'd use 1 kilowatt hour of energy; you'd use the same amount of energy burning a 2000 watt toaster for 0.5 hours or a 100-watt lamp for 10 hours. See how it works?

Electricity meters (like the one shown in the photo above, from my house) show the total number of kilowatt hours of electricity you've used. 1 kilowatt hour is equal to 3.6 million joules (J) of energy (or 3.6 megajoules if you prefer).

You can measure your energy consumption automatically with an energy monitor.

Electricity is amazingly useful – but it can be really dangerous as well. When electricity zaps from power plants to your home, it's at thousands of times higher voltages and massively more dangerous than the electricity in your home. If you are silly enough to touch or play near power equipment, you could die an extremely nasty and unpleasant death – electricity doesn't just shock you, it burns you alive. Heed warnings like this one and stay well away.

Electricity can also be dangerous in your home. Household electric power can kill you, so be sure to treat it with respect too. Don't play with household power sockets or push things into them. Don't take apart electrical appliances, because dangerous voltages can linger inside for a long time after they are switched off.

It's generally okay to use small (1.5 volt) flashlight batteries for your experiments if you want to learn about electricity; they make small and safe voltages and electric currents that will do you no harm.

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Составители: **Гилязиева Гузель Зофаровна,**
Демидкина Дарья Александровна

Кафедра иностранных языков КГЭУ

Редактор *С.Н. Чемоданова*
Компьютерная верстка *Т.И. Лунченкова*

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