Chapter 6
The Metric System and the United States

Abstract The United States is famously the largest of a very few nations whose everyday weights and measures are not metric. Less well known are the facts that the US was among the signatories of the Metre Convention in 1875 or that the meter and the kilogram have been the fundamental standards of length and mass in the US since the late nineteenth century. The US and the metric system have had several episodes of approach and avoidance over the whole of the lifetime of that system. This chapter describes briefly the history of the status of the metric system in the US. At present the system is legal in the US and is used in some applications; however, customary units remain the weights and measures most commonly employed by most people in the US for everyday purposes.

6.1 Introduction: The Metric System in the US Today

Imagine preparing for a picnic at a park or a beach in the US reached after an hour's drive in an automobile. The fruits and vegetables bought from a local market are priced by the pound or by the ounce. Gasoline or diesel fuel for the car is dispensed in gallons. The weather forecast for pleasant conditions gives the temperature in degrees Fahrenheit. And the road signs on the way display distances in miles. Similar preparations elsewhere in the world would encounter food priced by the kilogram or perhaps hectogram, fuel measured in liters, temperatures reported in degrees Celsius[1] and distances denominated in kilometers.[2]

The US is in many ways a non-metric[3] island in a metric ocean. It is not the only island in the non-metric archipelago, but it is by far the largest of a very small number of countries. It is commonly stated in books and on the internet that the only nations that do not use the metric system are the US, Liberia and Myanmar. Hector

[1] Kelvins are not used for mass media meteorology; however, degrees Celsius are an SI unit, albeit not a base unit.

[2] Road signs in the United Kingdom still use miles.

[3] I use "non-metric" to describe nations like the US in which customary non-metric units predominate in everyday use. In the twenty-first century there are no countries that don't use the metric system, as discussed below, and the metric system ***is*** used in the US.

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Vera's extensive 2011 study of metrication added four small Oceanian countries to that list: the Marshall Islands, the Federated States of Micronesia, Palau and Samoa [1]. Samoa has since adopted a metrology act that recognizes mainly metric units for trade, but permits some US customary units for weight and volume alongside metric ones [2]. US influence is strong in the other three Oceanian countries. After World War II they were part of the Trust Territory of the Pacific Islands, administered by the US. Now they are sovereign states formally associated with the US through a Compact of Free Association [3].

Whereas Vera criticized the assertion that only the US, Liberia and Myanmar do not use the metric system on the grounds that the list was incomplete, Elizabeth Benham disagrees with the premise that there are any countries that do not use the metric system. Benham, Metric Coordinator at NIST (the US National Institute of Standards and Technology, successor of the National Bureau of Standards, NBS), notes that use of the metric system in any nation is best described along a continuum; a simple yes or no classification is inadequate and misleading. In the US, she notes, customary units such as miles, gallons and pounds are in clear evidence on the surface; however, uses of the metric system lie beneath the surface, like an iceberg, mainly out of sight (Fig. 6.1) [4]. Some of the metric industry practices alluded to in Fig. 6.1 are visible. For example, packaged household products and foods in the US are required to show both metric and US customary units on the label [5]. The bottle of dish soap under my sink reads 19 fl oz and 561 mL, and the package of pasta in my pantry says 1 lb (454 g). The nutrition labels on such foods list quantities of components such as fats or sodium in grams or milligrams—but energy content in non-metric calories and serving sizes in both customary and metric units. Other metric industry practices are less visible: many products are made using metric machinery or specifications. I would add scientific practices alongside industry practices: science in the US—and everywhere else in the world—uses metric units, as does science education. The base of the iceberg in Fig. 6.1 states that the SI is the foundation of the US measurement system. This is largely invisible to the public. US customary units are defined in terms of metric standards. NIST is the key federal government agency in the US measurement system, tasked with promoting industry and innovation in the US through measurement science. At the same time, it is among the world's leading metrology laboratories and in that capacity contributed substantially to the measurements involved in the explicit-constant SI described in Sect. 5.3.

6.2 Metric Conversion in the US: A Decision Whose Time Has not yet Come

As seen in Sect. 1.6, the young US considered a decimal system of weights and measures at around the same time that the metric system was being devised in the late eighteenth century. At that time the national government did not use its authority to set uniform weights and measures, so the customary measures based on the British

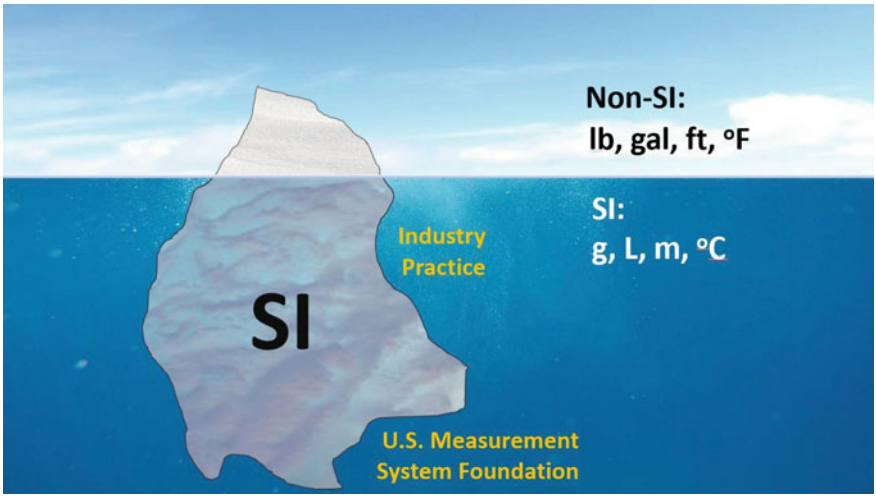

Fig. 6.1 US measurement infrastructure illustrated as an iceberg dependent on the SI. *Credit* Elizabeth Benham. Reprinted with permission courtesy of NIST. All rights reserved, US Secretary of Commerce

system continued in use under the regulation of the states. The US was not among the nations invited to participate in the conference that produced the first definitive meter and kilogram in 1799 (Sect. 2.7).

The next serious consideration of weights and measures by the US government came in the years just before and after 1820. In December 1816, near the end of his second term, President James Madison's annual message to Congress noted that no action had been taken to establish uniform weights and measures. Madison recommended the decimal system that had been proposed by Jefferson some 25 years earlier. The Senate quickly formed a committee. In 1817 it asked the Secretary of State, John Quincy Adams (1767–1848), to report on practices used in other countries on uniform weights and measures and on what practices might be beneficial for the US to adopt [6]; the House of Representatives made a similar resolution in December 1819 [7].

Adams's report, delivered in 1821, was thorough, treating foreign countries first, then regulations and standards in states of the US, and ending with proposals for the US. Adams was effusive in his praise of the metric system and of the basic science that came out of its invention [7]:

> This system approaches to the ideal perfection of *uniformity* applied to weights and measures; and, whether destined to succeed, or doomed to fail, will shed unfading glory upon the age in which it was conceived, and upon the nation by which its execution was attempted, and has been in part achieved.

Adams's comparison of the French and English systems reads like a comparison of the rational and the practical. Despite his admiration for the metric system, he is not sure that it is up to the task for which it was designed. In the end, Adams

counsels no change in the nation's units. He doubts whether the authority given by the Constitution to Congress "to fix the standard of weights and measures" permits it to *change* "the denominations and proportions already existing." A conversion to the metric system would also be difficult to implement. Adams noted that weights and measures seemed to be on the agendas of several "populous and commercial nations," namely France, Great Britain, Spain and the US. An agreement among them would obviously be advantageous, and it ought to be explored. Meanwhile, though, the Congress ought to declare what were the legal weights and measures currently in force in the US and to have standards made and distributed to the states [7]. Not even these modest recommendations were implemented [6].

The first weight standard established by the US government was a copy of the British imperial troy pound. The Mint Act of 1828 established that standard for use in the US Mint in Philadelphia. Thus, the standard was fixed for a limited and particular purpose; nevertheless, the act appears to have been the first act of Congress that specified a weight or measure for any purpose. The standard had been acquired in 1827 by US Minister to London Albert Gallatin (1761–1849) explicitly for use by the Philadelphia Mint [6].

Not long afterwards Congress initiated a series of actions that led to a greater uniformity of weights and measures across a branch of the US government, namely its custom houses. In 1830 it passed a resolution directing the Secretary of the Treasury to make comparisons among the weights and measures used at the main custom houses of the US in order to ensure the proper collection of revenue. The task was delegated to Ferdinand Hassler (1770–1843), Superintendent of the Coast Survey. He reported that there was some variation among the standards used, but on average they reflected the English standards in use at the time of the American Revolution. Standard yards, avoirdupois pounds, gallons and bushels were then constructed and distributed to the custom houses. In 1836, Congress directed the Secretary of the Treasury to have complete sets of the custom-house measures sent to each state. Although the purpose behind the resolution was to promote uniformity in weights and measures, it did not explicitly fix these standards as national standards [6].

The US was not immune to the influences and incentives in favor of uniform weights and measures among commercial nations described in Chap. 3. Its products were on display at the London and Paris international expositions in the 1850s and 1860s—albeit at a reduced scale in the 1862 London exhibition during the Civil War.

In 1866, the National Academy of Sciences committee on weights and measures issued a report urging the US government "to authorize and encourage by law the introduction and use of the metrical system of weights and measures." Not included in the report, but communicated to the Secretary of the Treasury along with the report, was the minority opinion of the committee that it would be difficult for "a government like ours" to mandate such a change, and that if the US and UK worked out a system between them, it would quickly be adopted widely. Later that year, the US passed a law that made metric measures legal throughout the country. A bill that would have made the metric system mandatory after a transition period had been introduced but withdrawn. When the House Committee of Coinage, Weights and Measures reported on the permissive metric bill, it expressed a hope that it was only

the first step of a reform that a later Congress would extend before too much longer [8].

When Congress legalized the metric system, it also directed the Secretary of the Treasury to have sets of metric standards fabricated and distributed to the states.[4] The Office of Weights and Measures had on hand standards of respectable provenance, known as the "Committee meter" and the "Arago kilogram," from which to make copies. The meter standard was an iron copy of the French meter of the archives made under the supervision of the international committee that produced the definitive metric standards in 1799. This copy was given by J.-G. Trallès, the commissioner from the Helvetian Republic (that is, Switzerland), to his friend Hassler. Hassler, mentioned above as the Superintendent of the US Coast Survey, was born in Switzerland. When he came to the US in 1805, he brought the meter bar with him [9]. A few years later, his fellow Swiss, Gallatin, then Secretary of the Treasury, introduced Hassler to President Jefferson, who appointed Hassler to oversee the new Coast Survey. Hassler resigned that post before the appropriate instruments could be made, but he regained it decades later in 1832 [10]. Gallatin was directly involved in procuring the "Arago kilogram" when he was US Minister to France. He obtained a platinum meter in addition to this platinum kilogram. Both of Gallatin's standards were compared to the French standards of the archives and certified by the French physicist François Arago [9].

Vera writes that 1866 was a propitious time for the US to adopt metric measurements for several reasons. Many nations have adopted the metric system during times of great upheaval or in their aftermath, and the recently concluded Civil War certainly fits that category. In addition, some of the caution expressed by Jefferson and Adams over being early adopters of a system that might not catch on were much less salient. Many more nations had adopted the system since Adams's report, including several in the Western Hemisphere. The UK was also seriously considering metrication at the time. If they had converted, then the ties of trade and of a similar measures tradition might well have influenced the US [1].

The 1870s saw the US participate in the International Commission of the Meter and sign the 1875 Meter Convention. At home pro-metric organizations such as the American Metrological Society engaged in advocacy and education. They realized that Congress was unlikely to pass a law mandating use of the metric system unless the public urged it to do so [8]. Such advocacy was vocal at times, but so was that of anti-metric organizations. America's first anti-metric organization was the International Institute for Preserving and Perfecting Anglo-Saxon Weights and Measures, founded in Boston in 1879. It branded the metric system as the devil's work and claimed that Anglo-Saxon measures derived from the Great Pyramid. This group's wild fantasies did not draw many adherents, but pro-metric sentiment was not very broad-based either [11]. In the absence of widespread or influential advocacy for the metric system, the US government took no measures to promote or adopt it. The next step envisioned

[4] Actually, the resolution to distribute metric standards to the states came a day *before* the vote to legalize the system [9].

and hoped for by the House Committee of Coinage, Weights and Measures in 1866 did not come to pass [8].

In the 1890s, the US once again came close to converting to the metric system, and in 1893 the metric system was put at the foundation of US customary units (Fig. 6.1). The "Mendenhall order" of April 1893, made by Superintendent of Weights and Measures Thomas Mendenhall with the approval of Secretary of the Treasury J. G. Carlisle, was an administrative order, not a law. It formally stated that the office of weights and measures would regard the copies of the new international prototype meter and kilogram recently received by the US as fundamental standards of length and mass. (As a signatory of the Metre Convention, the US received copies of the new standards.) US customary units, the yard and pound, would be derived from these new standards [9].

The Mendenhall order, an effort to promote inter-American trade and the perceived likelihood that the UK was about to convert to the metric system led to US legislative attempts to convert to the metric system in the 1890s and the following years. In April 1896, a bill that mandated metric measures briefly passed the House of Representatives. The bill set dates by which first the federal government and then more general commercial and legal applications would have to be metric. It was adopted by a very narrow margin, but then immediately defeated upon reconsideration and reported back to committee. The House Committee on Coinage, Weights and Measures advanced metric bills each year between 1897 and 1901 without success. After the Great War, advocacy groups on both sides of the metric debate turned directly to the public to attempt to generate political support. Although the issue was discussed in Congressional committees, no bills reached the floor of Congress. The Great Depression sapped the coffers of the groups, and metrication lay mostly dormant until the late 1950s [8].

The launch of Sputnik by the Soviet Union in 1957 prompted much reassessment of science and science education in the US. It is not surprising that weights, measures, and standards received part of that attention in the years immediately following. One action around weights and measures was only indirectly metric, namely an agreement among Australia, Canada, New Zealand, South Africa, the UK and the US to define an international yard and international avoirdupois pound in terms of the meter and the kilogram, respectively. This had the effect of giving the customary units in use in these nations the same value. In late 1958, the British Association for the Advancement of Science began a study of the costs and benefits of metric conversion for the UK, and in early 1959 the American Association for the Advancement of Science started a similar investigation. In that year and most of the next 10 years, resolutions were introduced in Congress to initiate a study of metric conversion and other resolutions to adopt the metric system. None passed until the 1968 Metric Study Act, which required the Department of Commerce to report on the desirability and practicability of increased use of metric weights and measures in the US [8].

The study published 12 volumes on the topic in 1971 [1], including a detailed history of the topic in the US from which much information in this chapter was drawn [8]. The main summary report of the study was titled "A Metric America: A Decision Whose Time Has Come." The study noted that use of the metric system

in the US was already increasing, although slowly, and it predicted that US weights and measures would become predominantly metric someday. It considered two main alternative courses of action. One was laissez faire, in which each business or other user of weights and measures decides on its own the timing and extent of metrication without either encouragement or discouragement from the government. The other was a coordinated plan with set timetables within which individual sectors would work out the details and timing of their conversion programs. Notice that compulsory conversion by government fiat was not considered, or at least not presented as a practical alternative. One of the strongest recommendations of the study was that the US increase its participation in international standards-making bodies such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), regardless of any decision on metric conversion [12].

The report found a broad consensus on three questions.

- Is increased metric usage in the best interests of the United States?
- If so, should there be a coordinated national program to change to metric?
- Over how many years should the change be made?

The consensus answers were, yes, increased metric usage would benefit the US, that the nation ought to change to metric in a coordinated way, and that the transition period ought to be about 10 years, at the end of which the nation would be predominantly metric. This set of answers is the bottom-line recommendation of the report. The study presented an interesting set of comparisons that attempted to estimate the costs and benefits of a coordinated metric conversion over 10 years versus an assumed 50-year transition period of drift toward predominant metric use. One of the main benefits of the coordinated approach in this estimate was to reduce the time during which companies and organizations would have to support two measurement systems. Essentially, the coordinated approach would cost more during the transition period than would drift, but the benefits of conversion begin to accrue sooner [12].

From the perspective of 50 years after the issuance of the report, one can see that the assumption of a 50-year period for uncoordinated metric conversion failed to come to pass—although, as will be discussed in Sect. 6.3, the assumption was not unreasonable at the time. Indeed, the subsequent history of the metric system in the US makes clear that the report's title was mistaken: the time for a decision to make the US a predominantly metric nation had clearly not yet come.

Late in 1975 Congress passed the Metric Conversion Act and President Gerald Ford signed it. The Act states [13]:

> It is therefore declared that the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system.

In case the word voluntary[5] in the policy statement is not clear enough, the Act later states "Unless otherwise provided by the Congress, the Board shall have no

[5] In the context of this chapter, voluntary refers to the free choice of a business or other user of weights and measures in contrast to legal compulsion imposed by the sovereign government in

compulsory powers." The Board was to be abolished when Congress deemed its mission accomplished.

The Act has been described as a compromise between those who favored compulsory metric conversion and those who wanted no government action on the matter. Subsequent events favored the latter group. The Metric Board did not begin its activities until 1978 after the Senate confirmed President Jimmy Carter's nominees to it; the Senate had not acted on Ford's nominees to the Board before his term expired in 1977. Metric Board publications included a sort of disclaimer: that it had no compulsory power, that there was no target date for conversion, and that conversion was voluntary. The Board was not funded beyond 30 September 1982 [14].

Apparently there was considerable confusion among businesses in the late 1970s about US policy toward metric conversion. So reported a 1978 report by the General Accounting Office (GAO). The report stated that US policy was not to favor one system of measures over another and that the Metric Board's job was to assist entities when and if they decided to convert. One of the GAO report's early headings states "A Decision has not been made" [15]. It seems to me, though, that the plain words of the 1975 Act state that a decision had been made about a policy preference—that the US would benefit from conversion to the metric system—but that no decision had been made to design adequate mechanisms of bringing that preference about. And clearly no decision had been made about when any particular sector ought to convert. The policy preference was reiterated in the Omnibus Trade and Competitiveness Act of 1988, which amended the 1975 Metric Conversion Act by designating "the metric system of measurement as the preferred system of weights and measures for United States trade and commerce." The 1988 Act also required the agencies of the federal government to use the metric system "to the extent economically feasible" by the end of fiscal year 1992 [16]. The 1975 Act remains in effect—albeit ineffective; it has never been repealed but it has been amended as recently as 2021 [17].[6] Conversion to metric units even within the federal government continues slowly. For example, the metric policy page of NIST reports that "the final decision to retire the U.S. survey foot was published in the Federal Register (October 5, 2020) announcing the deprecation date of December 31, 2022." After that time, it is to be superseded by the international foot (defined as 0.3048 m exactly) in all applications. "The preferred measurement unit of length is the meter (m) and surveyors, map makers, and engineers are encouraged to adopt the International System of Units (SI) for their work" [18].

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which the business operates. In Chap. 3, recall, voluntary refers to a free choice of a sovereign government in contrast to a colonial or other occupying force.

[6] The 2021 amendment within the National Defense Authorization Act for Fiscal Year 2022 made no substantial changes, simply updating references to other parts of US law.

6.3 Conclusion: Why is the US Still not Predominantly Metric?

As noted above, the US Metric Study report of 1971 expected that the US would be predominantly metric by now, some 50 years after the report. The report included a map titled "Islands in a Metric World." On that map, nations that had not already become primarily metric or committed to doing so were few and—with the exception of the US—small [12]. Fifty years later, the list of non-metric nations is even shorter, but a world map would look much the same: the US stands out as the visible non-metric exception. Given that the US has held out as an island in a metric world for 50 years, there appears to be no strong sign that it will change.

At the time of the study, though, the situation looked much different—not in the snapshot of the world map, but in the change in that map over the previous decade. The 1960s saw a great expansion of nations converting to the metric system, as can be seen in Vera's compilation of metrication dates [1]. The decade began with newly independent nations, mainly in Africa, adopting the metric system. It ended with a group of English-speaking industrial nations with which the US had strong ties of trade and alliance committing to convert. That group started with the UK (1965), followed shortly by Australia (1969), New Zealand (1969) and Canada (1970). Small wonder that the Metric Study expected that the US would become metric eventually.

Why has it not done so? Vera cites "failure to centralize" and "aversion to compulsion" as the main reasons for the failure of US metrication. No nation adopted the system voluntarily, he points out, so the US efforts to facilitate voluntary conversion were doomed to failure [1]. Steven Treese's analysis is similar. He identifies three aspects of the Metric Conversion Act that made progress toward metrication slow. The costs of conversion (of retooling, for example, and retraining) were to be borne primarily by businesses; conversion was voluntary; and there was no timetable. "The metric system has never been adopted voluntarily in any country, including its native France," he notes. In sum "high cost, no incentives, and voluntary commitment to an open schedule have basically doomed attempts at metrication so far in many sectors of the U.S." [19].

The unwillingness of the federal government to impose a system of measures on its citizens is not limited to recent decades. Recall that Secretary of State Adams questioned the authority of the government to make wholesale changes in the nation's customary measures [7] and that advisors to the Congress that made metric measures legal acknowledged that mandating its use was antithetical to US governmental traditions [8]. Despite a stated preference for adopting the metric system in a coordinated way, the US government has not implemented programs that have moved the nation toward that preference any faster than an expected drift toward it. And having drifted this long as an island in a metric ocean, it appears unlikely that the US will change its course anytime soon.

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